INSPIRE
Infrastructure for Spatial Information in Europe

D2.8.II/III.20 Data Specification on Energy Resources – Draft Guidelines

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Foreword
How to read the document?

This document describes the *"INSPIRE data specification on Energy Resources – Guidelines"* version 2.0 as developed by the Thematic Working Group (TWG) *Energy Resources* using both natural and a conceptual schema language. This version is now available for the public consultation. Based on the results of the consultation (received comments and the testing reports), the final version 3.0 will be prepared by the TWGs.

The data specification is based on a common template used for all data specifications and has been harmonised using the experience from the development of the Annex I data specifications.

This document provides guidelines for the implementation of the provisions laid down in the draft Implementing Rule for spatial data sets and services of the INSPIRE Directive.

This document includes two executive summaries that provide a quick overview of the INSPIRE data specification process in general, and the content of the data specification on *Energy Resources* in particular. We highly recommend that managers, decision makers, and all those new to the INSPIRE process and/or information modelling should read these executive summaries first.

The UML diagrams (in Chapter 5) offer a rapid way to see the main elements of the specifications and their relationships. The definition of the spatial object types, attributes, and relationships are included in the Feature Catalogue (also in Chapter 5). People having thematic expertise but not familiar with UML can fully understand the content of the data model focusing on the Feature Catalogue. Users might also find the Feature Catalogue especially useful to check if it contains the data necessary for the applications that they run. The technical details are expected to be of prime interest to those organisations that are/will be responsible for implementing INSPIRE within the field of *Energy Resources.*

The technical provisions and the underlying concepts are often illustrated by examples. Smaller examples are within the text of the specification, while longer explanatory examples and descriptions of selected use cases are attached in the annexes.

In order to distinguish the INSPIRE spatial data themes from the spatial object types, the INSPIRE spatial data themes are written in *italics.*

Interoperability of Spatial Data Sets and Services – General Executive Summary

The challenges regarding the lack of availability, quality, organisation, accessibility, and sharing of spatial information are common to a large number of policies and activities and are experienced across the various levels of public authority in Europe. In order to solve these problems it is necessary to take measures of coordination between the users and providers of spatial information. The Directive 2007/2/EC of the European Parliament and of the Council adopted on 14 March 2007 aims at establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) for environmental policies, or policies and activities that have an impact on the environment.

INSPIRE will be based on the infrastructures for spatial information that are created and maintained by the Member States. To support the establishment of a European infrastructure, Implementing Rules addressing the following components of the infrastructure are being specified: metadata, interoperability of spatial data themes (as described in Annexes I, II, III of the Directive) and spatial data services, network services and technologies, data and service sharing, and monitoring and reporting procedures.

INSPIRE does not require collection of new data. However, after the period specified in the Directive[1] Member States have to make their data available according to the Implementing Rules.

Interoperability in INSPIRE means the possibility to combine spatial data and services from different sources across the European Community in a consistent way without involving specific efforts of humans or machines. It is important to note that “interoperability” is understood as providing access to spatial data sets through network services, typically via Internet. Interoperability may be achieved by either changing (harmonising) and storing existing data sets or transforming them via services for publication in the INSPIRE infrastructure. It is expected that users will spend less time and efforts on understanding and integrating data when they build their applications based on data delivered within INSPIRE.

In order to benefit from the endeavours of international standardisation bodies and organisations established under international law their standards and technical means have been utilised and referenced, whenever possible.

To facilitate the implementation of INSPIRE, it is important that all stakeholders have the opportunity to participate in specification and development. For this reason, the Commission has put in place a consensus building process involving data users, and providers together with representatives of industry, research and government. These stakeholders, organised through Spatial Data Interest Communities (SDIC) and Legally Mandated Organisations (LMO)[2], have provided reference materials, participated in the user requirement and technical[3] surveys, proposed experts for the Data Specification Drafting Team[4] and Thematic Working Groups[5].

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[1] For all 34 Annex I,II and III data themes: within two years of the adoption of the corresponding Implementing Rules for newly collected and extensively restructured data and within 5 years for other data in electronic format still in use

[2] Number of SDICs and LMOs on 8/6/2011 was 461 and 249 respectively

[3] Surveys on unique identifiers and usage of the elements of the spatial and temporal schema,

[4] The Data Specification Drafting Team has been composed of experts from Austria, Belgium, Czech Republic, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Switzerland, UK, and the European Environmental Agency

[5] The Thematic Working Groups of Annex II and III themes have been composed of experts from Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Netherlands, Norway, Poland, Romania, Slovakia, Spain, Sweden, Switzerland, Turkey, UK, the European Commission, and the European Environmental Agency

This open and participatory approach was successfully used during the development of the data specification on Annex I data themes as well as during the preparation of the Implementing Rule on Interoperability of Spatial Data Sets and Services[6] for Annex I spatial data themes.,

The development framework elaborated by the Data Specification Drafting Team aims at keeping the data specifications of the different themes coherent. It summarises the methodology to be used for the data specifications and provides a coherent set of requirements and recommendations to achieve interoperability. The pillars of the framework are four technical documents:

- The Definition of Annex Themes and Scope[7] describes in greater detail the spatial data themes defined in the Directive, and thus provides a sound starting point for the thematic aspects of the data specification development.

- The Generic Conceptual Model[8] defines the elements necessary for interoperability and data harmonisation including cross-theme issues. It specifies requirements and recommendations with regard to data specification elements of common use, like the spatial and temporal schema, unique identifier management, object referencing, a generic network model, some common code lists, etc. Those requirements of the Generic Conceptual Model that are directly implementable will be included in the Implementing Rule on Interoperability of Spatial Data Sets and Services.

- The Methodology for the Development of Data Specifications[9] defines a repeatable methodology. It describes how to arrive from user requirements to a data specification through a number of steps including use-case development, initial specification development and analysis of analogies and gaps for further specification refinement.

- The “Guidelines for the Encoding of Spatial Data”[10] defines how geographic information can be encoded to enable transfer processes between the systems of the data providers in the Member States. Even though it does not specify a mandatory encoding rule it sets GML (ISO 19136) as the default encoding for INSPIRE.

Based on these framework documents and following the successful development of the Annex I Data specifications (Technical Guidelines) and the Implementing Rules, the new Thematic Working Groups have created the INSPIRE data specification for each Annex II and III theme. These documents – at the version 2.0 – are now publicly available for INSPIRE stakeholders for consultation. The consultation phase covers expert review as well as feasibility and fitness-for-purpose testing of the data specifications.

The structure of the data specifications is based on the “ISO 19131 Geographic information - Data product specifications” standard. They include the technical documentation of the application schema, the spatial object types with their properties, and other specifics of the spatial data themes using natural language as well as a formal conceptual schema language[11].

A consolidated model repository, feature concept dictionary, and glossary are being maintained to support the consistent specification development and potential further reuse of specification elements. The consolidated model consists of the harmonised models of the relevant standards from the ISO 19100 series, the INSPIRE Generic Conceptual Model, and the application schemas[12] developed for

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[6] Commission Regulation (EU) No 1089/2010 implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services, published in the Official Journal of the European Union on 8th of December 2010.
[7] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.3_Definition_of_Annex_Themes_and_scope_v3.0.pdf*
[8] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.5_v3.3.pdf*
[9] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.6_v3.0.pdf*
[10] *http://inspire.jrc.ec.europa.eu/reports/ImplementingRules/DataSpecifications/D2.7_v3.2.pdf*
[11] UML – Unified Modelling Language
[12] Conceptual models related to specific areas (e.g. INSPIRE themes)

each spatial data theme. The multilingual INSPIRE Feature Concept Dictionary contains the definition and description of the INSPIRE themes together with the definition of the spatial object types present in the specification. The INSPIRE Glossary defines all the terms (beyond the spatial object types) necessary for understanding the INSPIRE documentation including the terminology of other components (metadata, network services, data sharing, and monitoring).

By listing a number of requirements and making the necessary recommendations, the data specifications enable full system interoperability across the Member States, within the scope of the application areas targeted by the Directive. They will be published (version 3.0) as technical guidelines and will provide the basis for the content of the Amendment of the Implementing Rule on Interoperability of Spatial Data Sets and Services for data themes included in Annex II and III of the Directive. The Implementing Rule Amendment will be extracted from the data specifications keeping in mind short and medium term feasibility as well as cost-benefit considerations. The Implementing Rule will be legally binding for the Member States.

In addition to providing a basis for the interoperability of spatial data in INSPIRE, the data specification development framework and the thematic data specifications can be reused in other environments at local, regional, national and global level contributing to improvements in the coherence and interoperability of data in spatial data infrastructures.

Energy Resources – Executive Summary

Purpose

The INSPIRE Directive (2007/2/EC, 14.03.2007) defines the spatial data theme Energy Resources as the: "**Energy Resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource.**" *Energy Resources* are included in Annex III with the aim to provide an essential thematic frame, allowing exchange of Energy Resources related spatial information across Europe in an interoperable way.

The main purpose of this specification is to allow identification of geographical locations of Energy Resources, providing information about their extent (where possible and relevant). The topic of *Energy Resources* plays a very important role nowadays and this data specification reflects all the main aspects of this domain providing a harmonised structure for various energy resource types across the member states as well as links to the other related domains.

Information about location and the potential of Energy Resources can have significant impact on the environment. This impact can be represented by positive as well as negative aspects, therefore appropriate knowledge about the extent, distribution and volumes of the resources plays an important role.

The provision and implementation of this harmonised data specification should significantly contribute to the main priorities, targets and flagship initiatives of Europe 2020 strategy[13] within the mechanisms of establishing a European spatial data infrastructure.

Scope and description

The data specification scope was delineated by the theme definition and further elaborated, taking into consideration reference material and use cases provided by the stakeholders as well as identified by the members of the INSPIRE Thematic Working Group for Energy Resources (TWG ER). Lack of available domain expertise, well-defined user requirements and use cases, especially related to those policies and activities that may have a direct or indirect impact on the environment, acted as a constraint on the TWG ER.

Despite these limitations detailed interpretation and description of the Energy Resources theme matured to create the core of the data specification with possibilities for extensions for specific sub-domain / national needs. The whole concept of the data specification was based on modelling needs to cover existing and potential Energy Resources. With this, the requirement distinguishing between renewable and non-renewable Energy Resources had to be taken into consideration. This concept generates requirements to cover feature as well as coverage spatial data representations.

A significant part of the detailed information under the domain covered by this theme falls within the private sector therefore aggregations and overview data are the main focus of this data specification. Nevertheless, where possible, this data specification retains the possibility to exchange detailed information on local level.

Energy Resources do not stand autonomously and there are a number of connections to other INSPIRE themes. Despite these linkages having been discussed across the themes and where possible implemented, there are still open issues, requiring further investigation. TWG ER would like to encourage testing and consultation participants to actively contribute with comments and suggestions as an important contribution for the final version 3.0.

Conclusion & Future

The main value of the INSPIRE *Energy Resources* data specification is in providing the framework for Energy Resources related spatial data exchange. In addition this framework is characterised by its versatile yet flexible structure. Data providers are thus able to publish their existing data in the most convenient way and users can easily discover, evaluate and use appropriate data for their specific

[13] Europe 2020 Strategy (*http://ec.europa.eu/europe2020/priorities/sustainable-growth/index_en.htm*)

needs. As soon as new generic or theme specific needs and requirements are identified, appropriate activities within the framework of INSPIRE implementation and maintenance should be taken (Data specifications updates).

Acknowledgements

Many individuals and organisations have contributed to the development of these Guidelines.

The Thematic Working Group Energy Resources (ER) included:
Martin Tuchyna (European Commission contact point, temporarily acting as TWG Facilitator), Diederik Tirry (TWG Editor), Pablo Burgos Casado, Radoslav Chudy, Søren Elkjær Kristensen, Gijs Remmelts, Chris Rhodes, Peter Semrad, Marcel Suri and Lisa Thomas.

Other contributors to the INSPIRE data specifications are the Drafting Team Data Specifications, the JRC data specifications team and the INSPIRE stakeholders - Spatial Data Interested Communities (SDICs) or Legally Mandated Organisations (LMOs).

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1 Scope

This document specifies a harmonised data specification for the spatial data theme *Energy Resources* as defined in Annex II/III of the INSPIRE Directive.

This data specification provides the basis for the drafting of Implementing Rules according to Article 7 (1) of the INSPIRE Directive [Directive 2007/2/EC]. The entire data specification will be published as implementation guidelines accompanying these Implementing Rules.

2 Overview

2.1 Name

INSPIRE data specification for the theme Energy Resources.

2.2 Informal description

Definition:

Energy resources including hydrocarbons, hydropower, bio-energy, solar, wind, etc., where relevant including depth/height information on the extent of the resource [Directive 2007/2/EC]

Description:

There are a variety of Energy Resources across the World but they can all be classified into two categories: renewable or non-renewable Energy Resources. Renewable Energy Resources are those that are naturally occurring, theoretically inexhaustible sources of energy that are not derived from fossil or nuclear fuel; solar, wind and hydropower are examples within this category. Non-renewable Energy Resources are again natural resources but which, due to long-term formation, cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate. These resources such as oil, coal and gas for example, exist in a fixed amount, or are consumed much faster than nature can replenish them. An important distinction when defining these terms is the use of the word 'natural'. Natural Energy Resources are also classified as primary Energy Resources, secondary Energy Resources refers to the more convenient forms of energy which are transformed from other, primary energy sources through energy conversion processes. The best known example of a secondary Energy Resource is electricity.

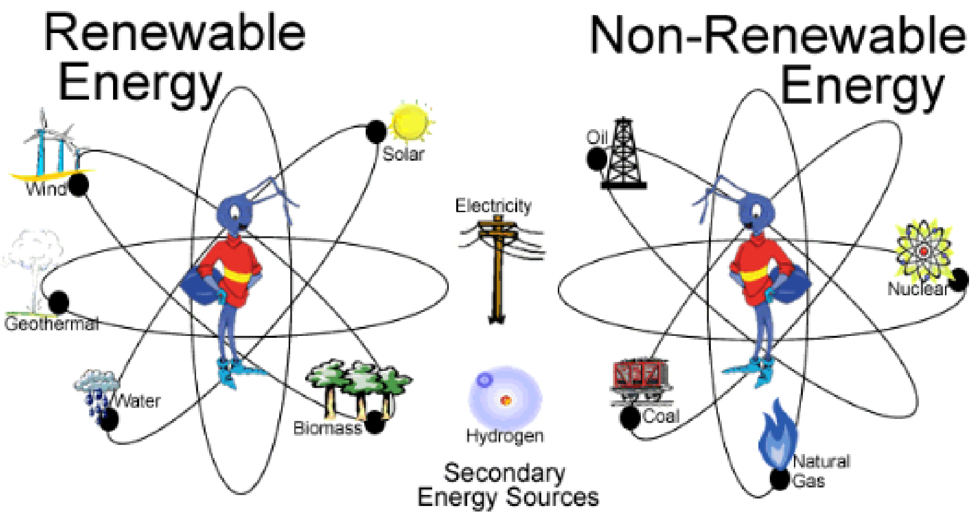


Figure 1 - Renewable and Non-Renewable Energy Types[14]

Data Specification Objective:

The INSPIRE Data Specification on Energy Resources provides an answer to the need for establishing a harmonised framework allowing the exchange of Energy Resources related spatial information across Europe and, where possible, at the wider international level.

Despite the occurrence of minor and major economic recessions, global energy consumption is increasing the dependency of society on energy as a whole. Whilst trying to find solutions as to where and how to investigate for further alternative Energy Resources, it is important to keep in mind the need to deal with this responsibly with appropriate initiatives and actions.

With the availability of non-renewable Energy Resources in decline and with limited utilisation of renewable Energy Resources, this underlines the importance for establishment of appropriate activities ensuring an effective utilisation of Energy Resources.

The data specification for Energy Resources provides the mechanism for exchanging and comparing Energy Resources information where it can be defined within a spatial context. This context can help to identify wider and more complex dependencies placed upon Energy Resources and their related activities in different countries as well as providing a synthetic overview of the state of play of Energy Resources.

Data Specification Process:

This Data Specification had to be defined following the requirements of the INSPIRE Directive, Commission Regulation implementing Directive 2007/2/EC of the European Parliament and of the Council as regards the interoperability of spatial data sets and services,

Data Specification framework documents, user requirements and use cases defined by stakeholders as well as TWG ER members, ongoing standardisation activities, including related projects and initiatives, as well as best practices from national, cross-border and international also played an important role in the creation of this data specification.

The INSPIRE data specification on *Energy Resources* has been prepared following the participative principle of consensus building process. The stakeholders, based on their registration as a Spatial Data

[14] U.S. Energy Information Administration (http://www.eia.doe.gov/kids/energyfacts/sources/whatsenergy.html)

Interest Community (SDIC) or a Legally Mandated Organisation (LMO)[15] had the opportunity to bring forward user requirements and reference materials, propose experts for the Thematic Working Groups (TWGs) responsible for the specification development, and to participate in the review of the data specifications.

TWG ER was composed of experts from Belgium, Netherlands, Norway, Spain, Slovakia, United Kingdom and the European Commission.

The specification process took place according to the methodology detailed for INSPIRE respecting the requirements and the recommendations of the INSPIRE Generic Conceptual Model, which is one of the elements that ensures coherent approach and cross theme consistency with other themes in the Directive.

The TWG ER has established connection with other initiatives within the field, such as the Expert Group on Resource Classification of the United Nations Economic Commission for Europe[16], EuroGeoSurveys[17] and EuroGeoSource project[18] as well as related INSPIRE TWGs.

Scope of the Energy Resources Theme:

The theme "Energy Resources" refers to geographical areas that have been, are currently, or will be in the future mapped to indicate the presence and (potential) availability of Energy Resources. The mapping of these areas is the result from both public and private initiatives and can be conducted at pan-European, national and local level. The concept of Energy Resources provides focus to the resource aspect and the extent/distribution of the resources.

Energy Resources may be located in terrestrial, aquatic and/or marine environments, and may be under either public or private ownership. Within the INSPIRE context Energy Resources can be of natural as well as anthropogenic origin, however only natural Energy Resources are considered within this Energy Resources data specification.

This theme covers the entire lifecycle of Energy Resources, irrespective of its viability in terms of economic, social and technological aspects. It takes into account resources that are depleted due to exploitation in the past and resources currently not viable but may become so in the future.

The central concept of this theme is to provide means for distributing and exchanging information on the spatial extent and type of previous, current or potential sources of energy. With this, the requirement distinguishing between renewable and non-renewable Energy Resources had to be taken into consideration:

- ***Non-renewable*** *Energy Resources:* Natural resources which, due to long-term formation, cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate. These resources exist in a fixed amount, or are consumed much faster than nature can replenish them.

- ***Renewable*** *Energy Resources:* Any naturally occurring, theoretically inexhaustible source of energy that is not derived from fossil or nuclear fuel. Renewable Energy Resources are derived from natural processes that are replenished constantly. They are widely abundant all over the Earth, but their energy intensity per unit area is typically smaller compared to non-renewable resources. In their various forms, they cover energy needs in all sectors: power generation, hot water and space heating, and transport fuels. They are the only sustainable form for providing rural (off-grid) energy services

There are different approaches to describe spatial features representing various types of Energy Resources. On the one hand the occurrence of Energy Resources can be considered as discrete, well-

[15] INSPIRE Stakeholders (*http://inspire.jrc.ec.europa.eu/index.cfm/pageid/181*)
[16] UNFC (*http://unece.org/energy/se/reserves.html*)
[17] EuroGeoSurveys (*http://www.eurogeosurveys.org/*)
[18] EuroGeoSource (*http://www.eurogeosource.eu/*)

defined features, on the other hand properties of Energy Resources, and in particular renewable energy, can be assessed in a continuous way within a domain of interest. As a consequence of these 2 different approaches it generated a requirement to cover both feature as well as coverage spatial data representations. To meet this requirement Energy Resources have been modelled via three application schemas providing a description of the semantic structure of the dataset:

- Energy Resources – Base: Reflecting a core set of common Energy Resource types.
- Energy Resources – Features: primarily for mapping purposes
- Energy Resources – Coverages: primarily for spatial analysis and modelling the potential of renewable energy sources

These application schemas contain definitions and descriptions of all the main energy resource types. A detailed description of the application schemas is provided in chapter 5.

Non-renewable Energy Resources:

- **Coal** is a family name for a variety of solid organic fuels and refers to a range of readily combustible black or brownish sedimentary rock, spanning a continuous quality range. Composed primarily of carbon and hydrocarbons, along with assorted other elements, including sulphur, it is formed from plant remains that have been compacted, hardened, chemically altered and metamorphosed by heat and pressure (Coalification). Coal is traditionally found in rock strata in layers or seams.

- **Crude oil** is a naturally occurring, complex mixture of liquid hydrocarbons that are found in geologic formations beneath the Earth's surface. It is recovered mostly through borehole drilling, however shale oil considered still as an unconventional oil, would be produced through pyrolysis, hydrogenation, or thermal dissolution. It is refined and separated, most easily by boiling point, into a large number of consumer products, from petrol and kerosene to asphalt and chemical reagents.

- **Natural gas** is a mixture of hydrocarbon gases generated below the Earth's surface and thus naturally occurring in geologic formations beneath the Earth's surface (traditional conventional gas) or tightly coupled with the rock environment (tight gas). It consists primarily of methane and ethane with small amounts of propane, butane, and higher hydrocarbons, and sometimes nitrogen, carbon dioxide, hydrogen sulphide, and helium. Natural gas occurs associated with other fossil fuels, in coal beds, as methane clathrates.

- **Peat** is a light to dark brown combustible soft, porous or compressed, sedimentary deposit of at least 30% (dry mass) of dead organic material with high water content (up to 90% in the raw state), having accumulated in a water saturated environment and in the absence of oxygen. Peat used for non-energy purposes is not included.

The main forms of renewable Energy Resources are:

- **Hydroelectricity:** Energy harvested from the natural cycle of water evaporating from the oceans and other areas, precipitating as rain, snow etc and surface runoff. The availability of Hydroelectricity is limited by topographic and hydrological conditions. Hydroelectricity is the most widely used form of renewable energy for power production. Countries which utilize Hydroelectricity as an energy resource usually make a national inventory of the actual power potential but these inventories can be performed at different scales and resolutions. Mapping of the energy potential is usually performed by governmental bodies or private companies.

- **Bio-energy:** Energy harvested from agricultural food and feed crops, wood and agricultural residues, dedicated energy crops and trees, aquatic plants, organic waste and municipal waste. Key elements in making biomass for energy commercially and economically feasible involve spatial correlation of resource information with other geospatial data to identify potential for a resource supply, and to optimize position and size of a processing plant in relation to the logistics of resource collection and management. The term "biomass" means any organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural crop wastes and residues, wood wastes and residues, and aquatic plants as well as animal, municipal, and other wastes. The energy derived from biomass is known as bio-energy.

- **Wind energy:** Energy harnessed from wind. The main driving factors of large scale winds are the differential heating between the equator and the poles and the rotation of the planet. When a difference in pressure exists, the air is accelerated from higher to lower pressure. Wind energy is the conversion of wind power into electricity, using wind turbines. The wind turbine is used to collect kinetic energy from the wind.

- **Thermal energy**: Thermal energy is defined as a flow of energy, or a means of energy that is moving from one system or state to another. As the energy moves from one state to another, a difference in temperature will occur. This difference in temperature is noted as the thermal energy. There are many forms of thermal energy that are considered as renewable Energy Resources. The most dominant form is Solar Energy, heat from the sun (described separately) but increasingly the use of Geothermal Energy, power extracted from heat stored in the Earth, is becoming more widely used. This energy originates from the original formation of the planet, from radioactive decay of minerals, from volcanic activity and from solar energy absorbed at the surface. The Earth's geothermal resources are theoretically more than adequate to supply humanity's energy needs, but only a very small fraction may be profitably exploited since drilling and exploration for deep resources is very expensive. Geothermal energy is being used in two basic ways: The first one is power generation and the second direct utilization comprising heating of pools and spas, greenhouses and aquaculture facilities, space heating and district heating, snow melting, agricultural drying, industrial applications and ground-source heat pumps.

- **Solar energy:** Solar energy is a form of thermal energy where power is extracted from the heat from the sun. This energy type is the most dominating resource and a wide spectrum of technologies already exists, having substantial potential for satisfying needs for electricity and heat. Even though many technologies are technologically mature (e.g. photovoltaics, concentrated solar power, solar heating of water and space), the market is missing in most countries. Therefore public incentive programmes are necessary in the market development stage. National or regional inventories of solar resources are one of the primary inputs in defining and management of solar energy policies, both by using heating by sunlight and by direct conversion of solar radiation to electricity.

- **Marine Energy**: Marine energy is renewable energy derived from the sea. Marine energy comes from two main sources: waves (originating from solar energy) and tides (resulting from the gravitational pull of the moon and sun). Wave and tidal energy devices convert the oceans' movement into electricity that is carried to shore using undersea cables and connected to the electricity grid. Although less well known, the marine environment has other types of energy resource for instance resulting from the large temperature differences between deep and cold ocean waters and sun-warmed surface waters, the chemical energy in ocean salinity gradients, and marine biomass.

Exclusions and anomalies within the theme scope:

The following features, which have correlations with other INSPIRE themes, have been assessed for inclusion within this theme but, following discussions with the relevant Thematic Working Group, it was concluded that, to avoid duplication they would not be covered within this theme if it was more relevant for the features to be included elsewhere. More information can be obtained within Chapter 5.

- Secondary Energy Resources, e.g. electricity, are not included within this theme.
- The technical constructions for abstraction, transport and treatment, these are largely covered by Production and industrial facilities.
- Energy use e.g. petrol consumption.
- Uranium and Thorium as energy resource types are modelled within the Mineral Resources data specification. These elements are exploited together with other minerals and therefore more relevant to the Mineral Resources Data Specification

- Basic data for wind and temperature distributions are modelled within the Atmospheric Conditions data specification
- Hydro-power plants is a candidate type inherited from the Annex I Hydrography specification. It was decided that this feature is not within the scope of this theme, but probably fits better in the Annex III production and industrial facilities.
- Aerothermal energy resource is covered by the Atmospheric Conditions theme.
- Anthropogenic energy e.g. Biogas from landfills: Although an energy resource type of biogas can be derived from a landfill feature type (currently modelled within Production and Industrial Facilities), biogas and liquid bio-fuels have been retained within the Energy Resources code lists in order that it is possible to define a future area of interest with an estimation of the energy production value.
- Smart grids have been assessed but regarded as not relevant for this theme.

2.3 Normative References

[Directive 2007/2/EC] 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)

[ISO 19107] EN ISO 19107:2005, Geographic Information – Spatial Schema

[ISO 19108] EN ISO 19108:2005, Geographic Information – Temporal Schema

[ISO 19108-c] ISO 19108:2002/Cor 1:2006, Geographic Information – Temporal Schema, Technical Corrigendum 1

[ISO 19111] EN ISO 19111:2007 Geographic information - Spatial referencing by coordinates (ISO 19111:2007)

[ISO 19113] EN ISO 19113:2005, Geographic Information – Quality principles

[ISO 19115] EN ISO 19115:2005, Geographic information – Metadata (ISO 19115:2003)

[ISO 19118] EN ISO 19118:2006, Geographic information – Encoding (ISO 19118:2005)

[ISO 19123] EN ISO 19123:2007, Geographic Information – Schema for coverage geometry and functions

[ISO 19135] EN ISO 19135:2007 Geographic information – Procedures for item registration (ISO 19135:2005)

[ISO 19138] ISO/TS 19138:2006, Geographic Information – Data quality measures

[ISO 19139] ISO/TS 19139:2007, Geographic information – Metadata – XML schema implementation

[OGC 06-103r3] Implementation Specification for Geographic Information - Simple feature access – Part 1: Common Architecture v1.2.0

NOTE This is an updated version of "EN ISO 19125-1:2006, Geographic information – Simple feature access – Part 1: Common architecture". A revision of the EN ISO standard has been proposed.

[Regulation 1205/2008/EC] Regulation 1205/2008/EC implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata

[Regulation 1089/2010/EC]	Regulation 1089/2010/EC implementing Directive 2007/2/EC of the European Parliament and of the Council as regards interoperability of spatial data sets and services

2.4 Terms and definitions

General terms and definitions helpful for understanding the INSPIRE data specification documents are defined in the INSPIRE Glossary[19].

Specifically, for the theme Energy Resources, the following terms are defined:

(1) Primary energy
Energy that has not been subjected to any conversion or transformation process.

(2) Non-renewable energy
Natural resources which, due to long-term formation, cannot be produced, grown, generated, or used on a scale which can sustain its consumption rate. These resources exist in a fixed amount, or are consumed much faster than nature can replenish them.

(3) Renewable energy
Any naturally occurring, theoretically inexhaustible, source of energy that is not derived from fossil or nuclear fuel. Renewable energy resources are derived from natural processes that are replenished constantly. They are widely abundant all over the Earth, but their energy intensity per unit area is typically smaller compared to non-renewable resources.

(4) Energy Resource
A concentration or occurrence of an energy source which may have been present in the past, is present currently or identified for the future.

2.5 Symbols and abbreviations

EC	European Commission
ER	Energy Resources
GCM	Generic Conceptual Model
TWG	Thematic Working Group

2.6 Notation of requirements and recommendations

To make it easier to identify the mandatory requirements and the recommendations for spatial data sets in the text, they are highlighted and numbered.

IR Requirement X	Requirements that are reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

[19] The INSPIRE Glossary is available from http://inspire-registry.jrc.ec.europa.eu/registers/GLOSSARY

DS Requirement X Requirements that are not reflected in the Implementing Rule on interoperability of spatial data sets and services are shown using this style.

Recommendation 1 Recommendations are shown using this style.

2.7 Conformance

DS Requirement 1 Any dataset claiming conformance with this INSPIRE data specification shall pass the requirements described in the abstract test suite presented in Annex A.

3 Specification scopes

This data specification does not distinguish different specification scopes, but just considers one general scope.

NOTE For more information on specification scopes, see [ISO 19131:2007], clause 8 and Annex D.

4 Identification information

NOTE Since the content of this chapter was redundant with the overview description (section 2) and executive summary, it has been decided that this chapter will be removed in v3.0.

5 Data content and structure

IR Requirement 1 Spatial data sets related to the theme *Energy Resources* shall be provided using the spatial object types and data types specified in the application schema(s) in this section.

IR Requirement 2 Each spatial object shall comply with all constraints specified for its spatial object type or data types used in values of its properties, respectively.

Recommendation 1 The reason for a void value should be provided where possible using a listed value from the VoidValueReason code list to indicate the reason for the missing value.

NOTEThe application schema specifies requirements on the properties of each spatial object including its multiplicity, domain of valid values, constraints, etc. All properties have to be reported, if the relevant information is part of the data set. Most properties may be reported as “void”, if the data set does not include relevant information. See the Generic Conceptual Model [INSPIRE DS-D2.5] for more details.

5.1 Basic notions

This section explains some of the basic notions used in the INSPIRE application schemas. These explanations are based on the GCM [DS-D2.5].

5.1.1 Stereotypes

In the application schemas in this sections several stereotypes are used that have been defined as part of a UML profile for use in INSPIRE [INSPIRE DS-D2.5]. These are explained in Table 1 below.

Table 1 – Stereotypes (adapted from [INSPIRE DS-D2.5])

Stereotype	**Model element**	**Description**
applicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model.
featureType	Class	A spatial object type.
type	Class	A conceptual, abstract type that is not a spatial object type.
dataType	Class	A structured data type without identity.
union	Class	A structured data type without identity where exactly one of the properties of the type is present in any instance.
enumeration	Class	A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list.
codeList	Class	A flexible enumeration that uses string values for expressing a list of potential values.
placeholder	Class	A placeholder class (see definition in section 5.1.2).
voidable	Attribute, association role	A voidable attribute or association role (see definition in section 5.1.3).
lifeCycleInfo	Attribute, association role	If in an application schema a property is considered to be part of the life-cycle information of a spatial object type, the property shall receive this stereotype.
version	Association role	If in an application schema an association role ends at a spatial object type, this stereotype denotes that the value of the property is meant to be a specific version of the spatial object, not the spatial object in general.

5.1.2 Placeholder and candidate types

Some of the INSPIRE Annex I data specifications (which were developed previously to the current Annex II+III data specifications) refer to types that thematically belong and were expected to be fully specified in Annex II or III spatial data themes. Two kinds of such types were distinguished:

- *Placeholder types* were created as placeholders for types (typically spatial object types) that were to be specified as part of a future spatial data theme, but which was already used as a value type of an attribute or association role in this data specification.

  Placeholder types received the stereotype «placeholder» and were placed in the application schema package of the future spatial data theme where they thematically belong. For each placeholder, a definition was specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these definitions in the specification work of the Annex II or III theme.

  If necessary, the attributes or association roles in the Annex I data specification(s) that have a placeholder as a value type shall be updated if necessary.

- *Candidate types* were types (typically spatial object types) for which already a preliminary specification was given in the Annex I data specification. Candidate types did not receive a specific stereotype and were placed in the application schema package of the future spatial data theme where they thematically belong. For each candidate type, a definition and attributes and association roles were specified based on the requirements of the Annex I theme. The Annex II+III TWGs were required to take into account these specifications in the specification work of the Annex II or III theme.

If the type could not be incorporated in the Annex II or III data specification according to its preliminary specification, it should be moved into the application schema of the Annex I theme where it had first been specified. In this case, the attributes or association roles in the Annex I data specification(s) that have the type as a value type shall be updated if necessary.

Open issue 1: For all Annex II+III themes for which placeholders and candidate types were specified in an Annex I data specification, it should be clearly indicated in the data specification, how the placeholder and candidate types were taken into account. If the proposed solution would require any changes to an Annex I data specification (and the corresponding section in the IR for interoperability of spatial data sets and services), this should also be clearly indicated.

A thorough investigation of the implications of the proposed changes of candidate types (in particular related to requirements of Annex I maintenance) will have to be performed for v3.0 of the data specifications.

5.1.3 Voidable characteristics

If a characteristic of a spatial object is not present in the spatial data set, but may be present or applicable in the real world, the property shall receive this stereotype.

If and only if a property receives this stereotype, the value of *void* may be used as a value of the property. A *void* value shall imply that no corresponding value is contained in the spatial data set maintained by the data provider or no corresponding value can be derived from existing values at reasonable costs, even though the characteristic may be present or applicable in the real world.

It is possible to qualify a value of void in the data with a reason using the VoidValueReason type. The VoidValueReason type is a code list, which includes the following pre-defined values:

– *Unpopulated*: The characteristic is not part of the dataset maintained by the data provider. However, the characteristic may exist in the real world. For example when the “elevation of the water body above the sea level” has not been included in a dataset containing lake spatial objects, then the reason for a void value of this property would be ‘Unpopulated’. The characteristic receives this value for all objects in the spatial data set.
– *Unknown*: The correct value for the specific spatial object is not known to, and not computable by the data provider. However, a correct value may exist. For example when the “elevation of the water body above the sea level” *of a certain lake* has not been measured, then the reason for a void value of this property would be ‘Unknown’. This value is applied on an object-by-object basis in a spatial data set.

NOTEIt is expected that additional reasons will be identified in the future, in particular to support reasons / special values in coverage ranges.

The «voidable» stereotype does not give any information on whether or not a characteristic exists in the real world. This is expressed using the multiplicity:

– If a characteristic may or may not exist in the real world, its minimum cardinality shall be defined as 0. For example, an if an Address may or may not have a house number, the multiplicity of the corresponding property shall be 0..1.
– If at least one value for a certain characteristic exists in the real world, the minimum cardinality shall be defined as 1. For example, if an Administrative Unit always has at least one name, the multiplicity of the corresponding property shall be 1..*.

In both cases, the «voidable» stereotype can be applied. A value (the real value or void) only needs to be made available for properties that have a minimum cardinality of 1.

5.1.4 Code lists and Enumerations

5.1.4.1. Style

All code lists and enumerations use the following modelling style:
- No initial value, but only the attribute name part, is used.
- The attribute name conforms to the rules for attributes names, i.e. is a lowerCamelCase name. Exceptions are words that consist of all uppercase letters (acronyms).

5.1.4.2. Governance of code lists

Two types of code lists are defined in INSPIRE. These two types are distinguished using the tagged value “extendableByMS” in the UML data model:
- *Code lists that **may not** be extended by Member States.* For these code lists, the tagged value is set to “false”. They shall be managed centrally in the INSPIRE code list register, and only values from that register may be used in instance data.
- *Code lists that **may** be extended by Member States.* For these code lists, the tagged value is set to “true”.

5.2 Application schemas for Energy Resources

The Energy Resources UML model is structured in three separate application schemas which are created to represent the different viewpoints to model Energy Resources:

- Energy Resources - Base
- Energy Resources - Features (primarily for mapping purposes)
- Energy Resources - Coverages (primarily for spatial analysis and modelling the potential of renewable energy sources)

Both the *Energy resources – Features* and the *Energy Resources – Coverages* application schemas depend on the *Energy Resources – Base* application schema, which provides a common overview of the different types of renewable and non-renewable Energy Resources. The dependencies between the application schemas are illustrated in Figure 2.

The figure depicted below also illustrates the dependencies between the different Energy Resources application schemas and other packages:
- The ‘*Base Types’* application schema from the Generic Conceptual Model, and the Annex I theme ‘Geographical Names’ datatype are used.
- The *Energy Resources – Coverages* application schema is based on the Generic Coverage (Domain and Range) model defined in the INSPIRE Generic Conceptual Model.

The three Energy Resources application schemas together define a general model that supports the identification and definition of a wide range of spatial objects that represent various types of energy resources. Besides these application schemas another package called *Coverages – Implementation Examples* was created. This package is purely informative and should help the reader of this document to understand how specialised types of coverages conceptually can be implemented.

Open issue 2: As the encoding and implementation of specialized types of coverages is still under discussion (due to missing implementations in the OGC standards), the package ‘*Coverages – Implementation Examples’* will be updated by version 3.0. Any support or suggestions with regard to a proper implementation of specialized coverages with different sets of rangetypes are most welcome to further elaborate this part.

During the development of the Annex I Hydrography data specifications the concept *HydroPowerPlant* was conceived as a candidate type/placeholder for theme Energy Resources. Within the thematic working group hydropower plants are considered as a technical construction for abstraction, transport and treatment of energy and, therefore it was decided that this concept does not fit the scope of this theme and will be disregarded in the following sections.

Open issue 3: There is ambiguous information whether HydroPowerPlant is a placeholder or candidate type (see also JIRA issue DS-1528). The thematic working group proposed to shift HydroPowerPlant back to the Hydrography theme, although it might already be taken up in the scope of Annex III theme Production and Industrial Facilities.

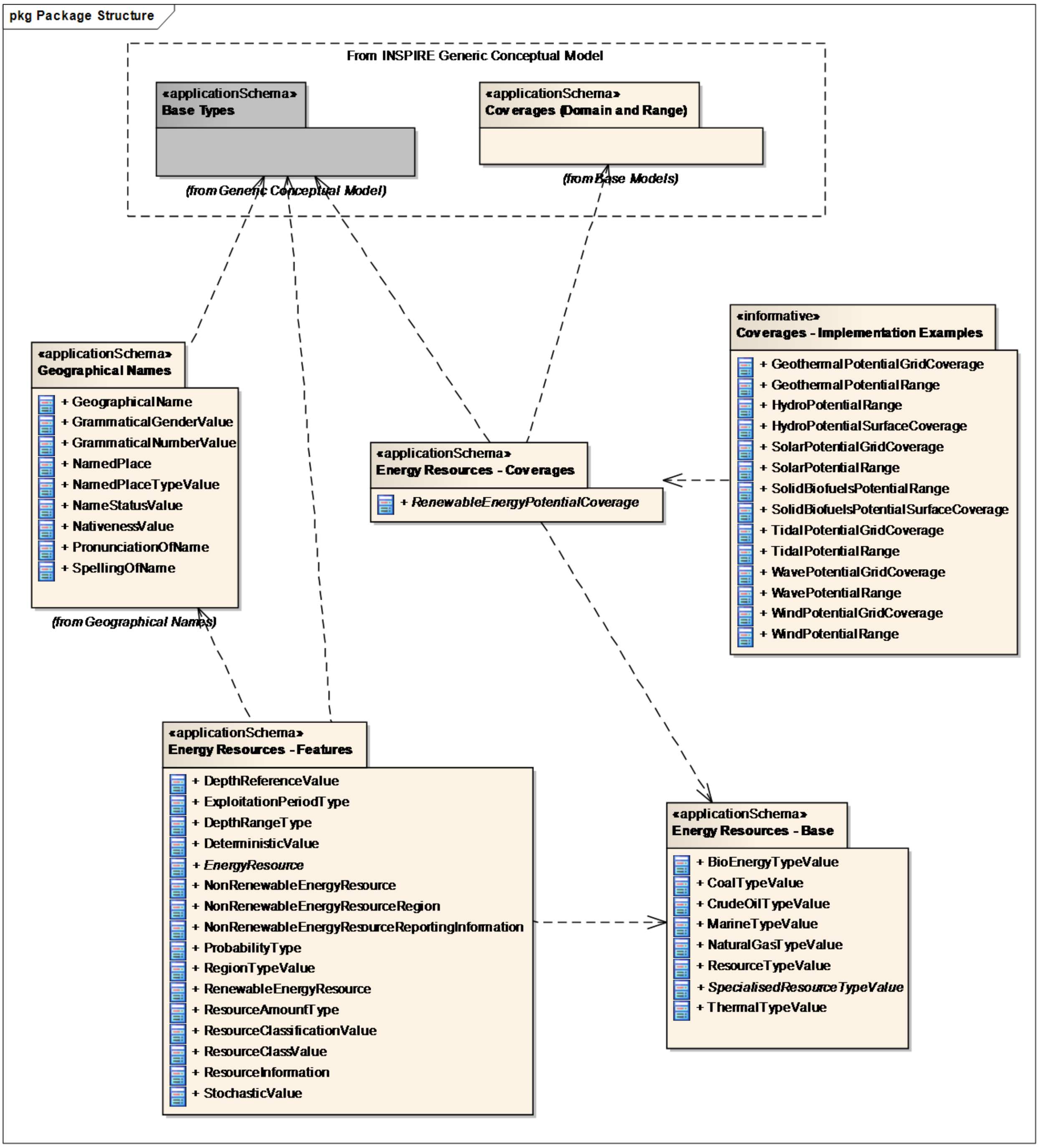


Figure 2 - Package structure of the Energy resources application schemas

5.3 Application schema Energy Resources - Base

5.3.1 Description

5.3.1.1. Narrative description

The *Energy Resources - Base* application schema provides a core set of common Energy Resource types. An initial list of Energy Resource types have been identified that fall within the scope of this theme. This list is not exhaustive, other types of (potential) Energy Resources can be added by extending the corresponding code list. During the development of the UML model it was discussed and decided with the Mineral Resources theme that fissile minerals such as Uranium and Thorium, which can be processed into nuclear fuel (applied for the production of nuclear energy), are within the scope of Mineral Resources. The reason for taking this decision is that the prospection and exploration of these minerals is similar to other non-fissile minerals, moreover fissile minerals are often considered as a by-product when mined together with other primary minerals. Finally, the typical key properties of fissile minerals seem to be more in line with other minerals and mineral classification schemes than with other renewable and non-renewable Energy Resources.

Open issue 4: Carbon Dioxide (CO2) Capture and Storage (CCS) — also known as CO2 sequestration — is a process whereby CO2 is captured from gases produced by fossil fuel combustion, compressed, transported and injected into geologic formations or structures for permanent storage. As such CCS cannot be considered as an Energy Resource, however it often reuses depleted Energy Resource accumulations to store CO2. It is still an open question if spatial objects from the Energy Resources should be referenced to delineate the spatial boundaries of C02 storage structures. The TWG would like to know if such datasets exist and how they were established?

5.3.1.2. UML Overview

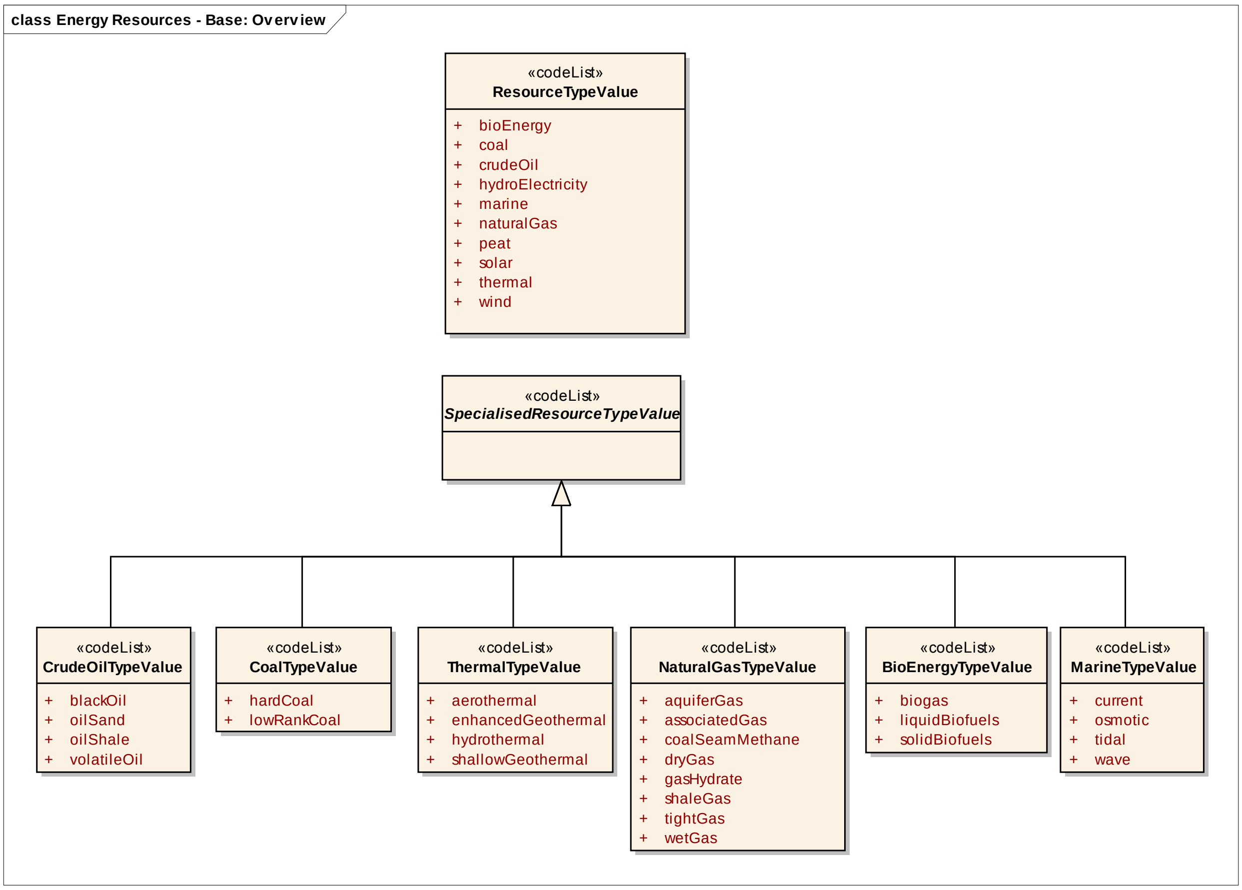


Figure 3 – UML class diagram: Overview of the *Energy Resources – Base* application schema

The base application schema as illustrated in Figure 3 basically describes two codelist classes: *ResourceTypeValue* and *SpecialisedResourceTypeValue.* The two codelists are established for the purpose of defining the type of Energy Resource. The *ResourceTypeValue* codelist contains a list with the main types of Energy Resources, whereas the abstract *SpecialisedResourceTypeValue* codelist can be specialised in order to provide an additional classification value relevant to the specific Energy Resources domain. The use of these codelists will be further explained in section 5.4 and section 5.5.

5.3.1.3. Consistency between spatial data sets

The *Energy Resources – Base* application schema does not require consistency rules.

5.3.1.4. Identifier management

The *Energy Resources – Base* application schema does not require identifier management.

5.3.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Energy Resources - Base
Scope	Energy Resources - Base
Version number	2.0
Version date	2011-06-15
Definition source	INSPIRE data specification Energy Resources - Base

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
BioEnergyTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.1
CoalTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.2
CrudeOilTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.3
MarineTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.4
NaturalGasTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.5
ResourceTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.6
SpecialisedResourceTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.7
ThermalTypeValue	Energy Resources - Base	«codeList»	5.3.2.1.8

5.3.2.1. Spatial object types

5.3.2.2. Code lists

5.3.2.2.1. BioEnergyTypeValue

BioEnergyTypeValue	
Name:	Bio Energy Type
Subtype of:	SpecialisedResourceTypeValue
Definition:	Specialised type of bio-energy resources.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/BioEnergyTypeValue
Value: biogas	
Definition:	Biogas is methane produced by the process of anaerobic digestion of organic material by anaerobes. It can be produced either from biodegradable waste materials or by the use of energy crops fed into anaerobic digesters to supplement gas yields.

BioEnergyTypeValue	
Description:	SOURCE Adapted from [AD]. NOTE 1 Anaerobic digestion is a series of processes in which microorganisms break down biodegradable material in the absence of oxygen, used for industrial or domestic purposes to manage waste and/or to release energy. NOTE 2 Anaerobic digestion is widely used as a source of renewable energy. The process produces a biogas, comprising of methane and carbon dioxide. This biogas can be used directly as cooking fuel, in combined heat and power gas engines[3] or upgraded to natural gas quality biomethane. The utilisation of biogas as a fuel helps to replace fossil fuels. EXAMPLE Landfill gas is a less clean form of biogas which is produced in landfills through naturally occurring anaerobic digestion.
Value: liquidBiofuels	
Definition:	Biofuels are a wide range of fuels which are in some way derived from biomass.
Description:	SOURCE Adapted from [UK NCBEFM]. NOTE 1 Bioethanol is an alcohol made by fermenting the sugar components of plant materials and it is made mostly from sugar and starch crops. With advanced technology being developed, cellulosic biomass, such as trees and grasses, are also used as feedstocks for ethanol production. Biodiesel is made from vegetable oils, animal fats or recycled greases. NOTE 2 Ethanol can be used as a fuel for vehicles in its pure form, but it is usually used as a gasoline additive to increase octane and improve vehicle emissions. Biodiesel can be used as a fuel for vehicles in its pure form, but it is usually used as a diesel additive to reduce levels of particulates, carbon monoxide, and hydrocarbons from diesel-powered vehicles. EXAMPLE Bioethanol, biodiesel
Value: solidBiofuels	
Definition:	Solid biofuels. Examples include wood, sawdust, grass cuttings, domestic refuse, charcoal, agricultural waste, non-food energy crops (see picture), and dried manure.
Description:	SOURCE Adapted from [UK NCBEFM].

5.3.2.2.2. CoalTypeValue

CoalTypeValue	
Name:	Coal Type
Subtype of:	SpecialisedResourceTypeValue
Definition:	Specialised type of coal resources.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/CoalTypeValue
Value: hardCoal	
Definition:	Hard Coal types, otherwise known as Black Coals or High Rank Coals and include Bituminous and Anthracite.
Description:	SOURCE Adapted from [WCA 2011]. NOTE These coal types have high organic maturity; they are high in carbon and therefore heat value, but low in hydrogen and oxygen.
Value: lowRankCoal	

CoalTypeValue

Definition:	Coal types with low organic maturity. These include Lignite and Sub-Bituminous.
Description:	SOURCE Adapted from [WCA 2011]. NOTE Low-rank coals are low in carbon and therefore have low heat value but are high in hydrogen and oxygen content.

5.3.2.2.3. *CrudeOilTypeValue*

CrudeOilTypeValue

Name:	Crude Oil Type
Subtype of:	SpecialisedResourceTypeValue
Definition:	Specialised type of crude oil resources.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/CrudeOilTypeValue

Value: blackOil

Definition:	Black Oil

Value: oilSand

Definition:	Oil sand is naturally occurring mix of bitumen, water, sand and clay.
Description:	SOURCE Adapted from [2]. NOTE The individual grains of sand are coated by a thin film of water of some µm and this in turn is surrounded by the high-viscosity oil. Bitumen has a density of more than 1 g/cm3 (?10° API) and a viscosity of more than 10 000 mPa·s. In the reservoir, bitumen is not capable of flowing.

Value: oilShale

Definition:	Oil shale is an immature petroleum source rock with a high proportion of organic material, which has not yet passed the geological conditions to turn into petroleum under natural conditions.
Description:	SOURCE Adapted from [2]. NOTE The organic material in oil shale, so-called kerogen, consists mainly of carbon, hydrogen and oxygen with small amounts of sulfur and nitrogen.

Value: volatileOil

Definition:	Volatile oil.

5.3.2.2.4. *MarineTypeValue*

MarineTypeValue

Name:	Marine Type
Subtype of:	SpecialisedResourceTypeValue
Definition:	Specialised type of marine energy resources.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/MarineTypeValue

Value: current

Definition:	Ocean current energy is energy generated by the continuous movement of surface or near-surface waters, driven primarily by wind and by solar heating of the ocean water.

MarineTypeValue	
Description:	SOURCE Adapted from [TWP OCEP 2006] and [OE 2011]. NOTE This technology is in the early stages of development. Energy can be extracted from the ocean currents using submerged turbines that are similar in function to wind turbines, capturing energy through the processes of hydrodynamic, rather than aerodynamic, lift or drag. EXAMPLE Ocean currents move slowly relative to typical wind speeds, they carry a great deal of energy because of the density of water. Water is more than 800 times denser than air, so for the same surface area, water moving 12 miles per hour exerts about the same amount of force as a constant 110 mph wind. Ocean currents thus contain an enormous amount of energy that can be captured and converted to a usable form.
Value: osmotic	
Definition:	Osmotic power or salinity gradient energy based on using the resources of osmotic pressure difference between fresh water and sea water.
Description:	SOURCE Adapted from [OP 2007]. NOTE The principle of osmotic power is utilising he entropy of mixing water with different salt gradients. In this process water is transported spontaneously through a semi-permeable membranef rom the side with the water with low to the water with the higher salt concentration and creates increased pressure due to osmotic forces. The increased pressure produced through the osmosis can be utilised in various forms, also easily in a turbine.
Value: tidal	
Definition:	Energy produced from tides and tidal currents that are generated by gravitational forces of the sun and moon on the earth's waters
Description:	SOURCE Adapted from [BMCE] and [OE glossary 2007]. NOTE There are two quite distinct categories of tidal resource: **tidal stream and tidal range**. The tidal stream resource is the kinetic energy contained in fast-flowing tidal currents, which are generally found in constrained channels. The tidal range resource refers to the gravitational potential energy that can be found in estuarine areas that exhibit a large difference in water height (their ‘tidal range’) between high and low tides. The technology used to exploit each of these resources is quite different. The two types of tidal resource are generally found in very different locations.
Value: wave	
Definition:	Energy produced directly from the surface motion of ocean waves or from pressure fluctuations below the surface
Description:	SOURCE Adapted from [OCS AE AUP] and [REA 2010]. NOTE Ocean waves are caused by the wind blowing over the surface of the ocean, and in some areas of the world these winds are both consistent enough, as well as powerful enough to provide continuous big waves. Big ocean waves are tremendous source of energy and extracting useful energy from big ocean waves has great potential to become significant source of renewable energy in some parts of the world in years to come.

5.3.2.2.5. NaturalGasTypeValue

NaturalGasTypeValue	
Name:	Natural Gas Type
Subtype of:	SpecialisedResourceTypeValue
Definition:	Specialised type of natural gas resources.

NaturalGasTypeValue	
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/NaturalGasTypeValue
Value: aquiferGas	
Definition:	Gas dissolved in ground water is called natural gas in aquifers or aquifer gas.
Description:	SOURCE Adapted from [2]. NOTE Nearly all porous rocks underneath the groundwater level contain small amounts of methane gas. Due to the limited solubility of methane in water, concentrations in the ground water are generally low. The solubility of methane as the main component of natural gas increases with increasing depth and thus with rising pressure, i.e. considerable amounts of dissolved gas can occur in deeper groundwater horizons.
Value: associatedGas	
Definition:	Associated Gas is a natural gas which is found in association with crude oil either dissolved in the oil or as a cap of free gas above the oil.
Description:	SOURCE Adapted from [WFOOGI glossary] NOTE Associated gas is a by-product of the petroleum production. Until today, this gas is frequently flared or released into the atmosphere unburnt. It could be re-injected into the deposit for maintaining pressure, for manufacturing fuel like liquefi ed gas or used locally for generating electricity. The main reason for fl aring or venting the gas is the lack of economic incentive for using or processing the gas.
Value: coalSeamMethane	
Definition:	Coal Seam Methane is the collective term for the recovery of methane from coal.
Description:	SOURCE Adapted from [CE 2004] and [WCA 2011]. NOTE Coal Seam Methane can be broken down into the following classifications: **Coal Bed Methane (CBM)** Methane recovered from un-mined coal seams. The coal seams may be mined in the future but this is largely dependent upon geological factors such as coal depth and quality. **Coal Mine Methane (CMM)** Methane recovered during mining activities as the coal is in the process of being extracted and thus emitting significant quantities of the gas. **Abandoned Mine Methane (AMM)** Methane recovered from mines that have been abandoned following the completion of mining operations. Significant amounts of methane may remain trapped in the mine or may continue to be emitted from openings.
Value: dryGas	
Definition:	Dry Gas.
Value: gasHydrate	
Definition:	Natural gas hydrate is natural gas bonded in ice.

NaturalGasTypeValue	
Description:	SOURCE Adapted from [2]. NOTE Water and gas can form a crystalline substance similar to ice at high pressures and low temperatures, which is called gas hydrate. The water molecules form a cage-like crystal structure (Clathrate), which might incorporate gas molecules, such as methane, but as minor components also other hydrocarbons (ethane, propane, butane) as well as carbon dioxide and hydrogen sulfide.
Value: shaleGas	
Definition:	Gas which had been generated in mudstone rock environment with very low permeability (below 0.1 milliDarcy) and thus never migrated from place of origin, i.e. source rock is also reservoir rock.
Description:	SOURCE Adapted from [2]. NOTE Value 0.1 mD can differ country by country (in DE it is 0.6)
Value: tightGas	
Definition:	Gas which had been generated in sandstone or carbonate rock environment with very low permeability (below 0.1 milliDarcy) and thus never migrated from place of origin, i.e. source rock is also reservoir rock.
Description:	SOURCE Adapted from [2]. NOTE 1 Tight gas refers to natural gas in underground reservoirs with low permeability. A generally accepted industry definition is reservoirs that do not produce economic volumes of natural gas without assistance from massive stimulation treatments or special recovery processes and technologies, such as horizontal wells. Low permeability is primarily due to the fine-grained nature of the sediments, compaction, or infilling of pore spaces by carbonate or silicate cements. NOTE 2 Value 0.1 mD can differ country by country (in DE it is 0.6)
Value: wetGas	
Definition:	Wet Gas.

5.3.2.2.6. ResourceTypeValue

ResourceTypeValue	
Name:	Resource Type
Definition:	Type of energy resource.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/ResourceTypeValue
Value: bioEnergy	
Definition:	Bioenergy is renewable energy made available from materials derived from biological sources. In its most narrow sense it is a synonym to biofuel, which is fuel derived from biological sources.

ResourceTypeValue

Description: SOURCE Adapted from [US DOE].

NOTE 1 Bioenergy comes from any fuel that is derived from biomass - recently living organisms or their metabolic byproducts. In its broader sense it includes biomass, the biological material used as a biofuel, as well as the social, economic, scientific and technical fields associated with using biological sources for energy.

NOTE 2 The term "biomass" means any organic matter available on a renewable basis, including dedicated energy crops and trees, agricultural crop wastes and residues, wood wastes and residues, and aquatic plants as well as animal, municipal, and other wastes. The energy derived from biomass is known as bioenergy.

EXAMPLE wood, wood waste, straw, manure, sugarcane, and many other byproducts from a variety of agricultural processes.

Value: coal

Definition: A combustible black or brownish-black sedimentary rock composed mostly of lithified plant remains.

Value: crudeOil

Definition: Crude oil is a collective term for a liquid, natural mixture of hydrocarbons, whose chemical composition and physical characteristics can vary significantly.

Description: SOURCE Adapted from [2].

NOTE Crude oil may have low to high viscosity; it may be straw-colored to black-brown and mostly has a density between 0.78 and 1.0 g/cm3. Important physical characteristics for oil are, besides density, viscosities and the pour point.

Value: hydroElectricity

Definition: Electricity generated by hydropower; the production of electrical power through the use of the gravitational force of falling or flowing water. It is the most widely used form of renewable energy.

Description: SOURCE Adapted from [HE].

NOTE Hydropower is usually utilized through 3 different generating methods. Conventional(reservoir), pumped-storage(reservoir) or run-of-the-river(no reservoir).

Value: marine

Definition: Energy from the marine environment consists of various types of energy, including wind-driven marine waves, gravitation-inducted marine tidal, marine currents, marine salinity gradient (osmotic energy) and the thermal gradient between warm surface water and deep cold water.

Description: SOURCE Adapted from [ETSAP 2010].

Value: naturalGas

Definition: Natural gas is a mix of different gases occurring in the earth's crust.

Description: SOURCE Adapted from [2].

NOTE Besides methane as main component of natural gas, further components such as ethane and propane as well as inflammable gases like nitrogen, carbon dioxide, hydrogen sulfide and helium can be contained.

Value: peat

ResourceTypeValue	
Definition:	A light to dark brown combustible soft, porous or compressed, sedimentary deposit of at least 30% (dry mass) of dead organic material with high water content (up to 90% in the raw state), having accumulated in a water saturated environment and in the absence of oxygen.
Description:	SOURCE Adapted from [Directive 2001/77/EC], [IPPC GNGGI 2006] and [3]. NOTE 1 Peat is sedentarily accumulated material consisting of at least 30% (dry mass) of dead organic material that has accumulated in a water-saturated environment and in the absence of oxygen. NOTE 2 Peat used for non-energy purposes is not included.
Value: solar	
Definition:	Solar energy is a resource that is used for heating of by direct conversion of solar radiation to electricity.
Value: thermal	
Definition:	Energy sources derived from the natural heat contained by air, or within land or water bodies.
Description:	SOURCE Adapted from [Directive 2009/28/EC] and [GEDB 2010]. NOTE1 This is a broad definition that encompasses a wide variety of resources. These range from those at low temperature in atmosphere or near the surface to high temperature resources that can be several kilometres deep. They can be exploited by a number of different technologies, ranging from those suitable for providing space heating for individual buildings based on low temperature resources, to substantial power stations exploiting high temperature resources. NOTE2 Geothermal energy is the most know type of energy within this class. Geothermal energy is stored in the form of heat beneath the surface of solid earth.
Value: wind	
Definition:	Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity.
Description:	SOURCE Adapted from [ECREWE] and [WP]. NOTE Wind energy is one of the most promising renewable energy technologies, and is an area in which there have already been many developments and improvements to make electricity generation more effective. Between 1995 and 2005, cumulative wind power capacity in the EU increased by an average of 32% per year. Wind power includes both onshore and offshore wind power installations. Wind speeds offshore are higher compared to onshore, and gives higher energy production per area unit.

5.3.2.2.7. SpecialisedResourceTypeValue

SpecialisedResourceTypeValue (abstract)	
Name:	Specialised Resource Type
Definition:	Additional classification value that defines the specialised type of enery resource.

SpecialisedResourceTypeValue (abstract)

Description: For some energy resources more information can be provided to indicate the specialised type of resource
EXAMPLE 1: Coal resources can be specialised as either:

- hardCoal
- lowRankCoal

Status: Proposed
Stereotypes: «codeList»
URI: null

5.3.2.2.8. ThermalTypeValue

ThermalTypeValue

Name: Thermal Type
Subtype of: SpecialisedResourceTypeValue
Definition: Specialised type of thermal energy resources.
Status: Proposed
Stereotypes: «codeList»
Governance: May not be extended by Member States.
URI: http://inspire-registry.jrc.ec.europa.eu/registers/CLR/ThermalTypeValue

Value: aerothermal

Definition: Aerothermal energy is energy stored in the form of heat in the ambient air.
Description: SOURCE Adapted from [Directive 2009/28/EC].

Value: enhancedGeothermal

Definition: Enhanced Geothermal Resources are engineered reservoirs that have been created to extract economical amounts of heat from low permeability and/or porosity geothermal resources and therefore are usually between 3-10km in depth.
Description: SOURCE Adapted from [UNGRA] and [FGE].

NOTE 1 Permeability can be enhanced by causing existing fractures to slip and propagate or creating new tensile cracks by raising fluid pressureThis definition can include coproduced hot water from oil and gas production as an unconventional EGS resource type that could be developed in the short term and possibly provide a first step to more classical EGS exploitation.

NOTE 2 In ground that is hot but dry, or where water pressure is inadequate, injected fluid can stimulate production. Developers bore two holes into a candidate site, and fracture the rock between them with explosives or high pressure water. Then they pump water or liquefied carbon dioxide down one borehole, and it comes up the other borehole as a gas. This approach is called "Hot dry rock geothermal energy" in Europe, or "Enhanced geothermal systems" in North America. Much greater potential may be available from this approach than from conventional tapping of natural aquifers

Value: hydrothermal

Definition: Hydrothermal energy is energy stored in the form of heat in surface water.

ThermalTypeValue	
Description:	SOURCE Adapted from [Directive 2009/28/EC] NOTE For hydrothermal systems, one normally needs to have large amounts of hot, natural fluids contained in an aquifer with high natural rock permeability and porosity to ensure long-term production at economically acceptable levels. When sufficient natural recharge to the hydrothermal system does not occur, which is often the case, a reinjection scheme is necessary to ensure production rates will be maintained. SOURCE Adapted from [FGE].
Value: shallowGeothermal	
Definition:	Shallow geothermal energy resource in the context of INSPIRE covers both shallow and medium depth geothermal systems where either closed or open loop technology is employed and can usually be found in a depth range between of less than 200 to 500m.
Description:	SOURCE Adapted from [GRF 2009]. NOTE This type of resource is most commonly used for individual or district level heating systems or at medium depths for power plants

5.4 Application schema Energy Resources - Features

5.4.1 Description

5.4.1.1. Narrative description

There are different viewpoints in order to describe spatial features representing various types of Energy Resources. On the one hand Energy Resources, and in particular non-renewable ones, are spatially delimited by a specific geologic environment having its typical processes and/or structures enabling the creation of fossil fuels. On the other hand, due to its subsurface character it is not possible to directly define the exact boundaries of a non-renewable Energy Resource. Therefore, boundaries delimiting the subsurface Energy Resources are often defined by human interaction, and consequently rely on the interpretation of a series of scientific and social-economic criteria in order to define the extent of the resource. Furthermore, detailed information on non-renewable Energy Resources such as its classification can only be gathered through exploration and exploitation projects of which the conditions (including the spatial extent of the activity) are defined by legally managed or regulated areas.

Also many renewable Energy Resources are modelled using similar viewpoints as for non-renewables. Due to the often ubiquitous and continuous character of renewable Energy Resources human interpretation is needed for delineation of Energy Resource features and to differentiate between areas of interest (for example, areas currently being exploited or areas of future interest) and areas that are not suitable as potential source of renewable energy.
Because of the heterogeneous viewpoints it can be expected that one generic application schema for Energy Resources shall not support all approaches maintained by different stakeholders.

The application schema "*Energy Resources - Features*" has been developed according the Rules for application schemas defined in ISO 19109. The abstract feature type 'EnergyResource' is the key spatial object type in this application schema for representing discrete geospatial features, representing either renewable or non-renewable Energy Sources. A coverage representation of Energy Resources is described in a separate and independent application schema (see section 5.5).

Detailed information on the Energy Resource type can be provided through the featuretypes *RenewableEnergyResource* and *nonRenewableEnergyResource*, and the datatype *ResourceInformation*.

Usually, information on the classification of a non-renewable Energy Resource is subject to separate and distinct projects that are at different stages of exploration or development. In order to classify and quantify non-renewable Energy Resources, the use of a classification scheme is proposed in these data specifications. A list of well-known classifications is taken up in the *Energy Resources - Features* application scheme, however it can be expected that not all classification systems are listed. Therefore an initial list of well-known classifications is created as a codelist and can be extended with other classification schemes, if the need should arise. It is on purpose that no common classification schema has been proposed in the application schema, since it is not straightforward or even possible to map from one classification scheme to another classification scheme of Energy Resources.

When applying this application schema it should be realized that strong links exist between the Energy Resources data specifications and the Annex III theme '*Area Management, Restriction and Regulation Zones*'. Geometric objects representing Energy Resources may partially or fully overlapping with geometric objects of the '*Area Management, Restriction and Regulation Zones*' Annex III theme mentioned above, nevertheless an independent geometry is needed since the delimitation and properties of a feature in one theme may change while it remains unchanged in another theme.

5.4.1.2. UML Overview

An overview of the complete '*Energy Resources –Features*' application schema is shown in Figure 4 and is described in detail below.

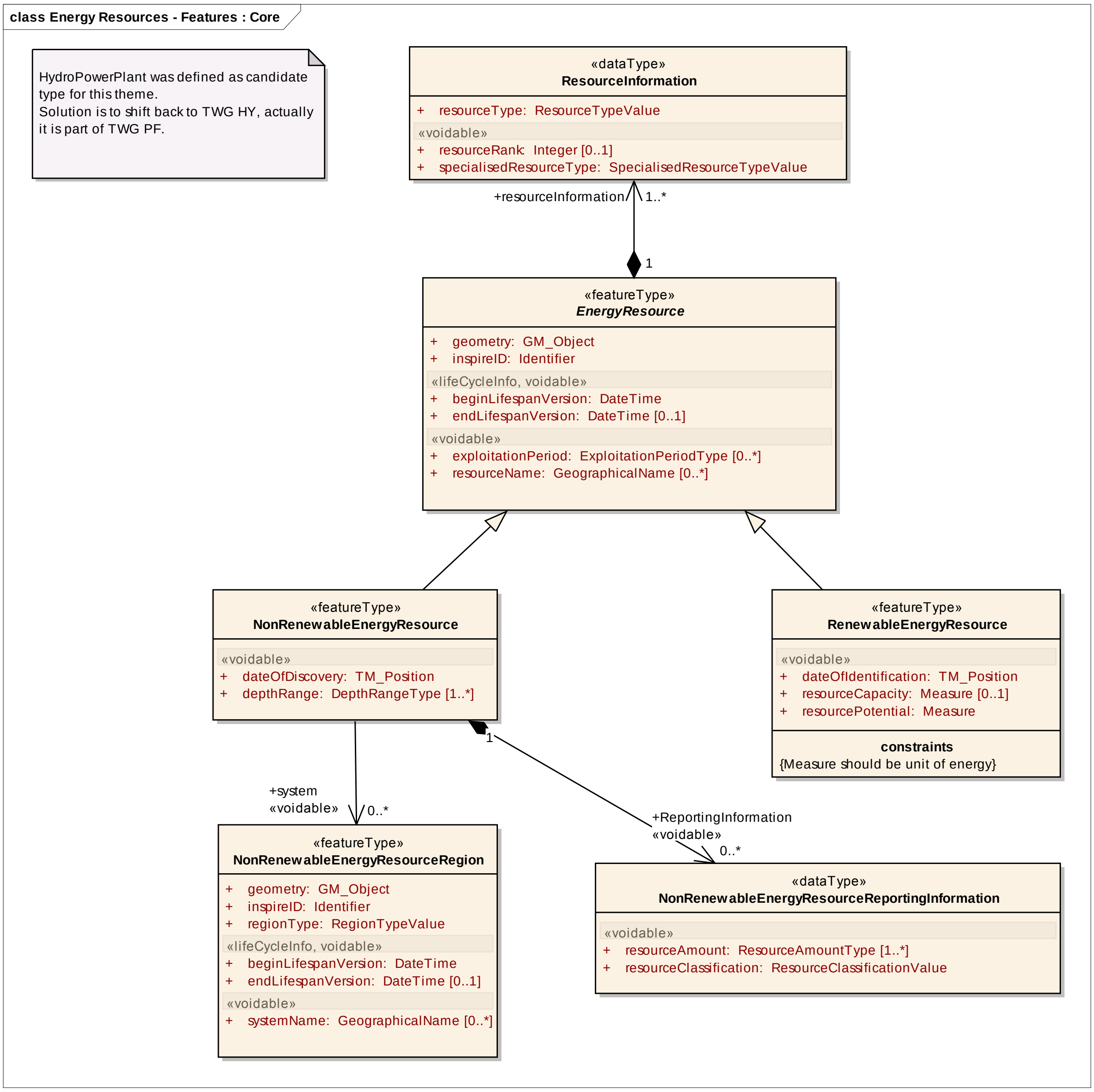


Figure 4 – UML class diagram: Core of the Energy Resources – Features schema

The central spatial object type in the '*Energy Resources –Features'* application schema is the abstract *EnergyResource* featuretype. This abstract featuretype acts as a superclass supporting two distinct concrete spatial object types: '*RenewableEnergyResource*' and '*NonRenewableEnergyResource*'. The superclass contains common attributes to identify and name the energy resource concerned, and it also comprises an additional attribute *ExploitationPeriod* to specify the time period of exploitation of the Energy Resource. A third spatial object type i.e. *NonRenewableEnergyResourceSystem* is a class that defines the small-scale geologic system in which a non-renewable Energy Resource originates. Besides the 4 featuretypes two datatypes *ResourceInformation* and *NonRenewableEnergyResourceReportingInformation* contain complex properties to include additional information on respectively the type of resource and the detailed classification and quantification of non-renewable Energy Resources. An overview of datatypes and codelists is given in Figure 5.

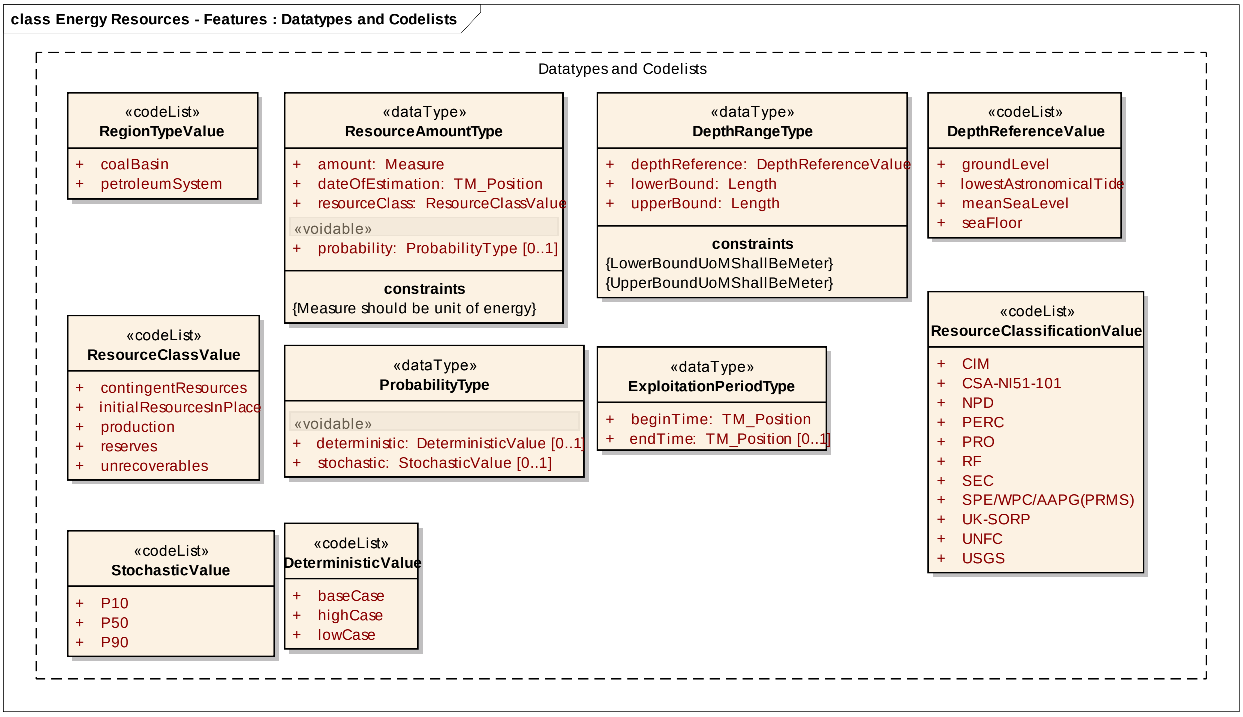


Figure 5 – UML class diagram: Datatypes and Codelists of the Energy Resources – Features schema

The two major datatypes mentioned above constitute the following information:

- *ResourceInformation*: a datatype indicating the type of resource and, if multiple types of resources are occurring, the rank of the resource. A codelist covering both renewable and non-renewable types of Energy Resources is provided through the *Energy Resources - Base* application schema.
  - resourceType: refers to the ResourceTypeValue codelist and specifies the general type of Energy Resource. This information must be provided.
  - specialisedResourceType: refers to the SpecialisedResourceTypeValue codelist and provides an additional classification value relevant to the specific Energy Resources domain (for example crude oil, coal, etc…)
  - resourceRank: the rank of the commodity is based on the importance of this commodity compared to other commodities that are part of the same spatial object.

- *NonRenewableEnergyResourceReportingInformation*: a datatype indicating a classification and an estimation of the amount of non-renewable energy sources. Through this datatype data providers can document general information on the classification scheme that was used to provide measures on the various categories of Energy Resources, with regard to geological, technical and economical conditions for exploitation.

IR Requirement 3	For each Energy Resource spatial object, information regarding the general type of Energy Resource shall be provided.

Recommendation 2	If applicable, it is strongly recommended to provide reporting information on the quantity of non-renewable Energy Resources by defining the classification scheme that was applied and provide measures for the amount of each category of Energy Resource.

With regard to the quantification of renewable Energy Resources, two attributes are included in the *RenewableEnergyResource* featuretype:

- resourceCapacity: Current generated energy produced from a renewable Energy Resource within the spatial extent provided (i.e. area of current production, this area can be any feature).
- resourcePotential: Theoretical average annual energy that can be extracted from a renewable Energy Resource within the spatial extent provided. (i.e. area of future interest, this area can be any feature)

Recommendation 3	If applicable, it is strongly recommended to provide reporting information on the quantity of renewable Energy Resources by defining the amount of the current produced renewable energy and/or the theoretical potential of renewable energy that can be extracted with the area of interest.

All Measures that are defined in this application schema should be a formal unit of energy. The standard unit of energy in the SI system is Joule. Other alternative and common units are volumes (barrels, m^3...), tonnes of oil equivalent (toe), Mega Watt hours (MWh), and Giga Joules (GJ).

5.4.1.3. Consistency between spatial data sets

The distinction between *Energy Resources* and *Area Management, Restriction and Regulation Zones* is not black-and-white. It is most likely that few data providers in fact use *Area Management, Restriction and Regulation Zones* to represent energy-related information instead of the boundaries of the natural resource. In this rare case the same spatial object is used to provide information on both themes.

IR Requirement 4	To ensure consistency of spatial data, the geometries of spatial objects coincident to a boundary of an Area Management, Restriction and Regulation Zone shall be consistent.

5.4.1.4. Identifier management

As is required by the GCM, all spatial objects must have a unique identifier. This must be persistent and will usually be supported by a defined lifecycle to ensure that users understand the conditions under which the identifier may be created, modified (in terms of its relationship with the spatial object) and deleted.

IR Requirement 5	All spatial object types published for INSPIRE in theme Energy Resources shall carry a unique identifier: the attribute inspireId. This attribute must have the characteristics defined in the Generic Conceptual Model.

5.4.1.5. Modelling of object references

The *Energy Resources – Feature* application schema does not require modelling of object references.

5.4.1.6. Geometry representation

IR Requirement 6	The value domain of spatial properties used in this specification shall be restricted to the Simple Feature spatial schema as defined by EN ISO 19125-1.

NOTE The specification restricts the spatial schema to 0-, 1-, 2-, and 2.5-dimensional geometries where all curve interpolations are linear.

NOTE The topological relations of two spatial objects based on their specific geometry and topology properties can in principle be investigated by invoking the operations of the types defined in ISO 19107 (or the methods specified in EN ISO 19125-1).

5.4.1.7. Temporality representation

The application schema(s) use(s) the derived attributes "beginLifespanObject" and "endLifespanObject" to record the lifespan of a spatial object.

The attributes "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

Recommendation 4 If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

Within the *Energy Resources – Features* application schema a series of attributes may contain measures quantifying the (potential) amount of energy available. If such values are provided, the measures should correspond to **annual average** values.

Recommendation 5 If applicable, it is strongly recommended to provide measure values corresponding to annual averages of (potential) energy.

5.4.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Energy Resources - Features
Scope	Energy Resources - Features
Version number	2.0
Version date	2011-06-15
Definition source	INSPIRE data specification Energy Resources - Features

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
DepthRangeType	Energy Resources - Features	«dataType»	5.4.2.2.1
DepthReferenceValue	Energy Resources -	«codeList»	5.4.2.3.1

Type	Package	Stereotypes	Section
	Features		
DeterministicValue	Energy Resources - Features	«codeList»	5.4.2.3.2
EnergyResource	Energy Resources - Features	«featureType»	5.4.2.1.1
ExploitationPeriodType	Energy Resources - Features	«dataType»	5.4.2.2.2
NonRenewableEnergyResource	Energy Resources - Features	«featureType»	5.4.2.1.2
NonRenewableEnergyResourceRegion	Energy Resources - Features	«featureType»	5.4.2.1.3
NonRenewableEnergyResourceReportingInformation	Energy Resources - Features	«dataType»	5.4.2.2.3
ProbabilityType	Energy Resources - Features	«dataType»	5.4.2.2.4
RegionTypeValue	Energy Resources - Features	«codeList»	5.4.2.3.3
RenewableEnergyResource	Energy Resources - Features	«featureType»	5.4.2.1.4
ResourceAmountType	Energy Resources - Features	«dataType»	5.4.2.2.5
ResourceClassValue	Energy Resources - Features	«codeList»	5.4.2.3.4
ResourceClassificationValue	Energy Resources - Features	«codeList»	5.4.2.3.5
ResourceInformation	Energy Resources - Features	«dataType»	5.4.2.2.6
StochasticValue	Energy Resources - Features	«codeList»	5.4.2.3.6

5.4.2.1. Spatial object types

5.4.2.1.1. EnergyResource

EnergyResource (abstract)	
Name:	Energy Resource
Definition:	A feature defining an inferred or observable spatial extent of a resource that can be, or has been, used as a source of energy.
Description:	SOURCE Adapted from [DER 2011].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: beginLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«lifeCycleInfo,voidable»
Attribute: endLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Multiplicity:	0..1

EnergyResource (abstract)

Stereotypes: «lifeCycleInfo,voidable»

Attribute: exploitationPeriod

Value type:	ExploitationPeriodType
Definition:	The exploitationPeriod defines the start and, if applicable, the end date of the application
Description:	NOTE For several reasons there might be more than 1 exploitation period
Multiplicity:	0..*
Stereotypes:	«voidable»

Attribute: geometry

Value type:	GM_Object
Definition:	Geometric representation of spatial extent covered by this energy resource.
Multiplicity:	1

Attribute: inspireID

Value type:	Identifier
Definition:	External object identifier of the spatial object.
Description:	NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon.
Multiplicity:	1

Attribute: resourceName

Value type:	GeographicalName
Definition:	The name of the energy resource
Description:	NOTE For non-renewable energy sources this name is the official name, as it's registered in the national register governed by geological survey or other national authority in charge.
Multiplicity:	0..*
Stereotypes:	«voidable»

Association role: resourceInformation

Value type:	ResourceInformation
Definition:	Information on the type of Energy resource as a part of the Energy Resource.
Multiplicity:	1..*

5.4.2.1.2. NonRenewableEnergyResource

NonRenewableEnergyResource

Name:	Non Renewable Energy Resource
Subtype of:	EnergyResource
Definition:	A feature defining an inferred or observable spatial extent of a resource that can be, or has been, used as a source of non-renewable energy.
Description:	NOTE It comprises reservoirs (gas, oil) and relevant deposits (peat, coal, uranium, thorium).
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

Attribute: dateOfDiscovery

Value type:	TM_Position
Definition:	The date the non-renewable energy source was discovered.
Multiplicity:	1

NonRenewableEnergyResource	
Stereotypes:	«voidable»
Attribute: depthRange	
Value type:	DepthRangeType
Definition:	The range between the deepest (lower bound) and most shallow (upper bound) aspect of the deposit body, where the depth is true vertical depth below the Earth's surface or average sea level.
Multiplicity:	1..*
Stereotypes:	«voidable»
Association role: ReportingInformation	
Value type:	NonRenewableEnergyResourceReportingInformation
Definition:	Information describing the classification and estimates on the amount of resources.
Multiplicity:	0..*
Stereotypes:	«voidable»
Association role: productionFacility	
Value type:	Facility
Multiplicity:	0..*
Stereotypes:	«voidable»
Association role: system	
Value type:	NonRenewableEnergyResourceRegion
Definition:	Relation to the basin-scale system within which deposits of energy resource accumulate.
Multiplicity:	0..*
Stereotypes:	«voidable»

5.4.2.1.3. NonRenewableEnergyResourceRegion

NonRenewableEnergyResourceRegion	
Name:	Non Renewable Energy Resource Region
Definition:	A feature defining Geographical area that includes/contains accumulations or deposits of non renewable resources which are genetically related
Description:	NOTE Occurrence and extent of such a region is predominantly determined by geological conditions, especially by the presence of basis (substance) from which energy resource is generated and, if needed, by the presence of appropriate accumulation/deposit structures in which energy resource(s) is/are trapped.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: beginLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«lifeCycleInfo,voidable»
Attribute: endLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Multiplicity:	0..1
Stereotypes:	«lifeCycleInfo,voidable»

NonRenewableEnergyResourceRegion

Attribute: geometry

Value type: GM_Object
Definition: Geometric representation of spatial extent covered by this energy resource system.
Multiplicity: 1

Attribute: inspireID

Value type: Identifier
Definition: External object identifier of the spatial object.
Description: NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon.
Multiplicity: 1

Attribute: regionType

Value type: RegionTypeValue
Definition: Type of the Energy Resource system
Multiplicity: 1

Attribute: systemName

Value type: GeographicalName
Definition: Name of the Energy Resource System.
Multiplicity: 0..*
Stereotypes: «voidable»

5.4.2.1.4. RenewableEnergyResource

RenewableEnergyResource

Name: Renewable Energy Resource
Subtype of: EnergyResource
Definition: A feature defining an inferred or observable spatial extent of a resource that can be, or has been used as a source of renewable energy.
Description: NOTE It comprises existing areas, but may also refer to areas of future interest.
Status: Proposed
Stereotypes: «featureType»
URI: null

Attribute: dateOfIdentification

Value type: TM_Position
Definition: The date the spatial extent of the renewable energy source was identified.
Multiplicity: 1
Stereotypes: «voidable»

Attribute: resourceCapacity

Value type: Measure
Definition: Current generated energy produced from a renewable energy resource within the spatial extent.
Description: NOTE Measure should be unit of energy. The standard unit of energy in the SI system is Joule. Most common units are volumes (barrels, m^3..), tonnes of oil equivalent (toe), Mega Watt hours (MWh), Giga Joules (GJ)
Multiplicity: 0..1
Stereotypes: «voidable»

Attribute: resourcePotential

Value type: Measure

RenewableEnergyResource

Definition:	Theoretical average annual energy that can be extracted from a renewable energy resource within the spatial extent.
Description:	NOTE Measure should be unit of energy. The standard unit of energy in the SI system is Joule. Most common units are volumes (barrels, m^3..), tonnes of oil equivalent (toe), Mega Watt hours (MWh), Giga Joules (GJ)
Multiplicity:	1
Stereotypes:	«voidable»

Constraint: Measure should be unit of energy

Natural language:	

5.4.2.2. Data types

5.4.2.2.1. DepthRangeType

DepthRangeType

Name:	Depth Range Type
Definition:	The range between the deepest (lower bound) and most shallow (upper bound) aspect of the deposit body, where the depth is true vertical depth below the Earth's surface or average sea level.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null

Attribute: depthReference

Value type:	DepthReferenceValue
Definition:	Reference level that was chosen to determine the vertical depth.
Multiplicity:	1

Attribute: lowerBound

Value type:	Length
Definition:	True vertical depth from the earths crust or mean sea level to the deepest vertex of the deposit body.
Multiplicity:	1

Attribute: upperBound

Value type:	Length
Definition:	True vertical depth from the earths crust or mean sea level to the shallowest vertex of the deposit body.
Multiplicity:	1

Constraint: LowerBoundUoMShallBeMeter

Natural language:	Value of lowerbound is expressed in meters
OCL:	inv: self.lowerbound.uom.uomSymbol='m'

Constraint: UpperBoundUoMShallBeMeter

Natural language:	Value of upperBound is expressed in meters
OCL:	inv: self.upperBound.uom.uomSymbol='m'

5.4.2.2.2. ExploitationPeriodType

ExploitationPeriodType

Name:	Exploitation Period Type
Definition:	Exploitation period of the energy resource.
Status:	Proposed

ExploitationPeriodType	
Stereotypes:	«dataType»
URI:	null
Attribute: beginTime	
Value type:	TM_Position
Definition:	The time when the exploitation started.
Description:	This is both for renewable and non-renewable energy sources. For non-renewable energy resources exploitation starts with certain mining activities. In the case of renewable energy resources, it starts with the extraction of energy using specific equipment.
Multiplicity:	1
Attribute: endTime	
Value type:	TM_Position
Definition:	The time when the exploitation has ended.
Description:	This is both for renewable and non-renewable energy sources. For non-renewable energy resources exploitation starts with certain mining activities. In the case of renewable energy resources, it starts with the extraction of energy using specific equipment.
Multiplicity:	0..1

5.4.2.2.3. NonRenewableEnergyResourceReportingInformation

NonRenewableEnergyResourceReportingInformation	
Name:	Non Renewable Energy Resource Reporting Information
Definition:	The amount of Energy Resources can be reported through different stages and projects. The reporting information complies with a common generic principle-based system in which quantities are classified on the basis of social-economic viability, feasibility, and geological knowledge on the fossil resources.
Description:	SOURCE Adapted from Adapted from [RCSEIES 2009].
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: resourceAmount	
Value type:	ResourceAmountType
Definition:	Amount of resources.
Description:	NOTE The amount of resources includes an amount (with or without probability statement) for each type of resources.
Multiplicity:	1..*
Stereotypes:	«voidable»
Attribute: resourceClassification	
Value type:	ResourceClassificationValue
Definition:	Classification system for calculating the measurement. Examples include SPE (PRMS), UNFC, SEC, etc...
Multiplicity:	1
Stereotypes:	«voidable»

5.4.2.2.4. ProbabilityType

ProbabilityType	
Name:	Probability Type
Definition:	Datatype reflecting the probability model which has been used to determine the amount of energy resources.
Description:	The probability represents a 'confidence' level on the stated amount of resources. The probability is based on either a deterministic or stochastic probability model.

ProbabilityType	
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: deterministic	
Value type:	DeterministicValue
Multiplicity:	0..1
Stereotypes:	«voidable»
Attribute: stochastic	
Value type:	StochasticValue
Multiplicity:	0..1
Stereotypes:	«voidable»

5.4.2.2.5. ResourceAmountType

ResourceAmountType	
Name:	Resource Amount Type
Definition:	Amount of resources.
Description:	NOTE The amount of resources includes an amount (with or without probability statement) for each type of resources.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: amount	
Value type:	Measure
Definition:	Quantification of resources.
Description:	NOTE Measure should be unit of energy. The standard unit of energy in the SI system is Joule. Most common units are volumes (barrels, m^3..), tonnes of oil equivalent (toe), Giga Joules (GJ).
Multiplicity:	1
Attribute: dateOfEstimation	
Value type:	TM_Position
Definition:	Date of classification and estimation of resources.
Multiplicity:	1
Attribute: probability	
Value type:	ProbabilityType
Definition:	Probability figures on the amount of category of resource.
Description:	The probability represents a 'confidence' level on the stated amount of resources. The confidence level can be clarified using either stochastic or deterministic values.
Multiplicity:	0..1
Stereotypes:	«voidable»
Attribute: resourceClass	
Value type:	ResourceClassValue
Definition:	Category or energy resource.

ResourceAmountType

Description: The resource categories proposed are common categories to most classification schemes, representing an aggregated quantity at the level of:

- the production,
- the total amount initially in place
- the reserves,
- the contingent resources and
- unrecoverable.

Multiplicity: 1

Constraint: Measure should be unit of energy

Natural language:

5.4.2.2.6. ResourceInformation

ResourceInformation

Name:	Resource Information
Definition:	Primary energy resource information detailing the type of resource and the rank of resource.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null

Attribute: resourceRank

Value type:	Integer
Definition:	The rank of the energy resource in the order of energy resources that are bounded by the same geometric object.
Description:	NOTE This is mainly applicable to non-renewable energy resources and is used to state where one resource type has more quantity than another.
Multiplicity:	0..1
Stereotypes:	«voidable»

Attribute: resourceType

Value type:	ResourceTypeValue
Definition:	Type of Energy Resource.
Description:	NOTE Only primary energy resource types are considered.
Multiplicity:	1

Attribute: specialisedResourceType

Value type:	SpecialisedResourceTypeValue
Definition:	Specialised type of Energy Resource.

ResourceInformation	
Description:	EXAMPLE 1: Coal resources can be specialised as either: • hardCoal • lowRankCoal
Multiplicity:	1
Stereotypes:	«voidable»

5.4.2.3. Code lists

5.4.2.3.1. DepthReferenceValue

DepthReferenceValue	
Name:	Depth Reference
Definition:	code list for the reference level that has been considered to capture its true vertical depth.
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/DepthReferenceValue
Value: groundLevel	
Definition:	The Earth's surface
Value: lowestAstronomicalTide	
Definition:	The lowest tide level that can be predicted to occur under average meteorological conditions and under any combination of astronomical conditions.
Description:	SOURCE [DFDD]
Value: meanSeaLevel	
Definition:	The average height of the sea at a tide station measured from a fixed predetermined reference level.
Description:	SOURCE [DFDD].
Value: seaFloor	
Definition:	The bottom of a sea or ocean.

5.4.2.3.2. DeterministicValue

DeterministicValue	
Name:	Deterministic
Definition:	Codelist with low case, high case, base case deterministic confidence levels
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/DeterministicValue
Value: baseCase	
Definition:	Very unlikely to be equal to the expected outcome. Best estimates are used for all parameters.
Value: highCase	
Definition:	High estimates are used for all parameters.
Value: lowCase	

DeterministicValue

Definition: Low estimates are used for all parameters.

5.4.2.3.3. RegionTypeValue

RegionTypeValue

Name: Region Type
Definition: All geological features that control the generation and preservation of non-renewable energy resources.
Status: Proposed
Stereotypes: «codeList»
Governance: May not be extended by Member States.
URI: http://inspire-registry.jrc.ec.europa.eu/registers/CLR/RegionTypeValue

Value: coalBasin

Definition: A sedimentary basin containing coal seams.
Description: SOURCE Adapted from [NPDG 2001].

Value: petroleumSystem

Definition: The petroleum system is a unifying concept that encompasses a pod of active source rock and all genetically related oil and gas accumulations.
Description: SOURCE Adapted from [PS 2003].

NOTE It includes all the geologic elements and processes that are essential if an oil and gas accumulation is to exist.

5.4.2.3.4. ResourceClassValue

ResourceClassValue

Name: Resource Class
Definition: List of resource categories.
Description: The list contains values that are common to most classification schemes.
Status: Proposed
Stereotypes: «codeList»
Governance: May not be extended by Member States.
URI: http://inspire-registry.jrc.ec.europa.eu/registers/CLR/ResourceClassValue

Value: contingentResources

Definition: Contingent resources are those quantities of energy resources estimated, as of a given date, to be potentially recoverable from known accumulations using established technology or technology under development

Value: initialResourcesInPlace

Definition: The total amount of a fossil resource accumulation

Value: production

Definition: The current production from a fossil resource accumulation

Value: reserves

Definition: Reserves are estimated remaining quantities of oil and gas and related substances anticipated to be economically producible, as of a given date, by application of development projects to known accumulations.

Value: unrecoverables

Definition: unrecoverable resources, whether discovered or not, are neither technically possible nor economic to produce.

5.4.2.3.5. ResourceClassificationValue

ResourceClassificationValue

ResourceClassificationValue

Name:	Resource Classification
Definition:	A list of most known and used classification schemes to classify and quantify energy resources.
Description:	SOURCE Adapted from [OGRC-2005]
Status:	Proposed
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	http://inspire-registry.jrc.ec.europa.eu/registers/CLR/ResourceClassificationValue

Value: CIM

Definition:	The CIM Definition Standards on Mineral Resources and Reserves (CIM Definition Standards) establish definitions and guidelines for the reporting of resources and reserves in Canada.

Value: CSA-NI51-101

Definition:	The disclosure rules for Canadian registered companies.
Description:	he disclosure rules for Canadian registered companies are contained in CSA's National Instrument (NI) 51-101 which references resource definitions and application guidelines contained in the Canadian Oil and Gas Evaluation Handbook Volume 1 authored by the Canadian chapter of the Society of Petroleum Evaluation Engineers.

Value: NPD

Definition:	The Norwegian Petroleum Directorate classification (NPD-2001)
Description:	The Norwegian Petroleum Directorate classification (NPD-2001) is based on the SPE/WPC/AAPG 2000 classification but expanded to utilize categories that differentiate projects based on their commerciality, that is, their maturity towards full producing status.

Value: PERC

Definition:	Pan-European Code for Reporting of Exploration Results, Mineral Resources and Reserves (PERC).
Description:	The PERC Code for Reporting of Exploration Results, Mineral Resources and Mineral Reserves sets out minimum standards, recommendations and guidelines for Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves in the United Kingdom, Ireland and Europe. The Code has been adopted by the Institute of Materials, Minerals and Mining (IoM3), the Geological Society of London (GSL), the European Federation of Geologists (EFG) and the Institute of Geologists of Ireland (IGI), and is therefore binding on their individual members.

Value: PRO

Definition:	Chinese classifcation system.
Description:	The current classification system was approved and issued in 2004 by the General Administration of Quality Supervision, Inspection and Quarantine of the Peoples Republic of China with implementation to be effective in 2005. Reserves and resource reporting is administered by the Petroleum Reserves Office of the Ministry of Land and Resources. Each Chinese company must report annually detailed volumes (by field, block, and reservoir) under this classification that are associated with new discoveries, extensions and changes in development plans on properties within the borders of China.

Value: RF

Definition:	Russian reserve guidelines
Description:	Russian reserve guidelines are in a state of transition from the system utilized within Soviet state companies to a new system more closely aligned with the needs of private industry.

ResourceClassificationValue

Value: SEC

Definition: US Security and Exchange Commission (1978)

Description: The SEC rules and guidelines address proved reserves only. The SEC prohibits additional disclosure of unproved reserves, i.e. probable and possible, as well as Contingent and Prospective Resources.

Value: SPE/WPC/AAPG(PRMS)

Definition: Petroleum Resources Management System

Description: In 2000, the Society of Petroleum Engineers (SPE) jointly with the World Petroleum Council (WPC) and the American Association of Petroleum Geologists (AAPG) published a Reserve and Resource Classification to address the requirement for an international standard. The underlying Reserves Definitions were unchanged from those published by the SPE/WPC in 1997. Additionally, in 2001 the SPE/WPC/AAPG jointly published “Guidelines for the Evaluation of Petroleum Reserves and Resources” as clarifications for the application of the 2001 and 1997 documents. Further clarification was provided in the Glossary of 2005, in particular by the definition of the term commercial, and thereby reserves.

Value: UK-SORP

Definition: UK Statement of Recommended practices (2001)

Description: SORP is primarily an accounting standards document. It does not discuss the full reserves and resource classification system (no possible reserves, no contingent or prospective resources) nor does it supply detailed guidance on the recommended evaluation practices.

Value: UNFC

Definition: United Nations Framework Classification (2004)

Description: The classification is based on three key attributes:

- Economic (E)
- Field Project Status/Feasibility (F)
- Geological (G)

Subdividing each attribute results in a 3-dimensional matrix composed of 36 potential categories, 19 of which are applied to petroleum. An alpha-numeric numbering system bridges the language barrier for international communication (by adopting the standard sequence “EFG”, it is further reduced to a pure numeric system).

Value: USGS

Definition: United States Geological Survey

Description: The USGS classification is based on two parameters whereby resources are classified by feasibility of economic recovery and degree of geologic certainty.

5.4.2.3.6. StochasticValue

StochasticValue

Name: Stochastic

Definition: Codelist with P10, P50, P90 stochastic confidence levels

Status: Proposed

StochasticValue	
Stereotypes:	«codeList»
Governance:	May not be extended by Member States.
URI:	
Value: P10	
Definition:	P is percentile. P10 represents the minimum for a given prospect.
Value: P50	
Definition:	P is percentile. P50 represents the most likely for a given prospect.
Value: P90	
Definition:	P is percentile. P90 represents the maximum for a given prospect.

5.4.2.4. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.4.2.4.1. DateTime

DateTime	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Date and Time [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.2. Facility

Facility	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Production and Industrial Facilities::Production and Industrial Facilities [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Something designed, built, installed to serve a specific function, comprehending the complete equipment or apparatus for a particular process or operation.
Description:	A facility groups together one or more installations on the same site that are operated by the same natural or legal person and potentially the land, buildings, and equipment used in carrying on an industrial, business, or other undertaking or service.

5.4.2.4.3. GM_Object

GM_Object (abstract)	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19107:2003 Spatial Schema:: Geometry::Geometry root [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.4. GeographicalName

GeographicalName	
Package:	INSPIRE Consolidated UML Model::Themes::Annex I::Geographical Names::Geographical Names [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Proper noun applied to a real world entity.

5.4.2.4.5. Identifier

Identifier

Identifier	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.4.2.4.6. Integer

Integer	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Numerics [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.7. Length

Length	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.8. Measure

Measure	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.4.2.4.9. ResourceTypeValue

ResourceTypeValue	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Energy Resources::Energy Resources - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Type of energy resource.

5.4.2.4.10. SpecialisedResourceTypeValue

SpecialisedResourceTypeValue (abstract)	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Energy Resources::Energy Resources - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Additional classification value that defines the specialised type of enery resource.

SpecialisedResourceTypeValue (abstract)	
Description:	For some energy resources more information can be provided to indicate the specialised type of resource EXAMPLE 1: Coal resources can be specialised as either: • hardCoal • lowRankCoal

5.4.2.4.11. TM_Position

TM_Position	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19108:2006 Temporal Schema::Temporal Reference System [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5 Application schema Energy Resources - Coverages

5.5.1 Description

5.5.1.1. Narrative description

Another viewpoint to spatially describe Energy Resources is to assess the variation of an Energy Resource property within a domain of interest. This viewpoint is particularly applied for the description of renewable Energy Resources and relies to a large extent on the availability of a natural resource only and thus not any legal or socio-economic criterion. In most cases the variation of a measured property will be continuous, for example wind speed or solar radiation, but in few cases the variation of a property may be discrete. An example of the latter is in case of hydroelectricity, the aggregation of potential energy over a catchment's area.

The application schema *Energy Resources - Coverages* has been developed according the Rules for application schemas defined in ISO 19109 and ISO 19123 that defines the Coverage representation from a conceptual point of view. The coverage representation should be applied in order to present the variation of energy-related properties through grid representations or to present the distribution of potential energy aggregated over analytical units.

The feature type *RenewableEnergyPotentialCoverage* is the key spatial object type in this application schema for modelling geospatial coverages representing renewable energy sources. Although certain properties of subsurface non-renewable energy sources may also vary over both space and time, it is recommended to model them as distinct features corresponding with real-world object such as coal fields, oil and gas accumulations, etc…

Open issue 5: It is still an open discussion whether the coverage viewpoint can also be used to represent non-renewable Energy Resources. The TWG does not intend to exclude beforehand the application of coverage implementations for non-renewable Energy Resources, however no use cases to illustrate the use of a coverage implementation for non-renewable Energy resources were made available until this moment. Are there any user requirements?

Detailed information on the potential amount of energy can be provided by subtyping the class *RenewableEnergyPotentialCoverage* into a theme or domain-specific coverage, each based on a specific domain (grid, multisurface,…) and a range set containing specific measures to describe and quantify the renewable energy potential. When providing data according to the proposed application schema, it is of paramount importance that the methodology used for modelling and generating the coverage is documented. This type of information is essential to interpret the provided information correctly.

The current application schema only intends to provide a generic solution for Coverage representations. Examples of how the generic class *RenewableEnergyPotentialCoverage* can be specialized in domain-specific coverages are given in Annex C. In order to achieve a greater interoperability among European data sets, Annex C also defines specific units of measures for each category of renewable energy.

Open issue 6: The UML diagram provided in Annex C contains examples of specific multisurface Coverage implementations. It should be noted that a proper and realistic implementation for multisurface coverages is not yet made available via the OGC standards. It has to be considered for version 3 of the data specifications, whether the *Energy Resources – Coverages* application schema needs further development and how domain and theme-specific range properties could be implemented and maintained.

5.5.1.2. UML Overview

Figure 6 shows how the complete 'Energy Resources –Coverages application schema is modelled and is further described in detail below.

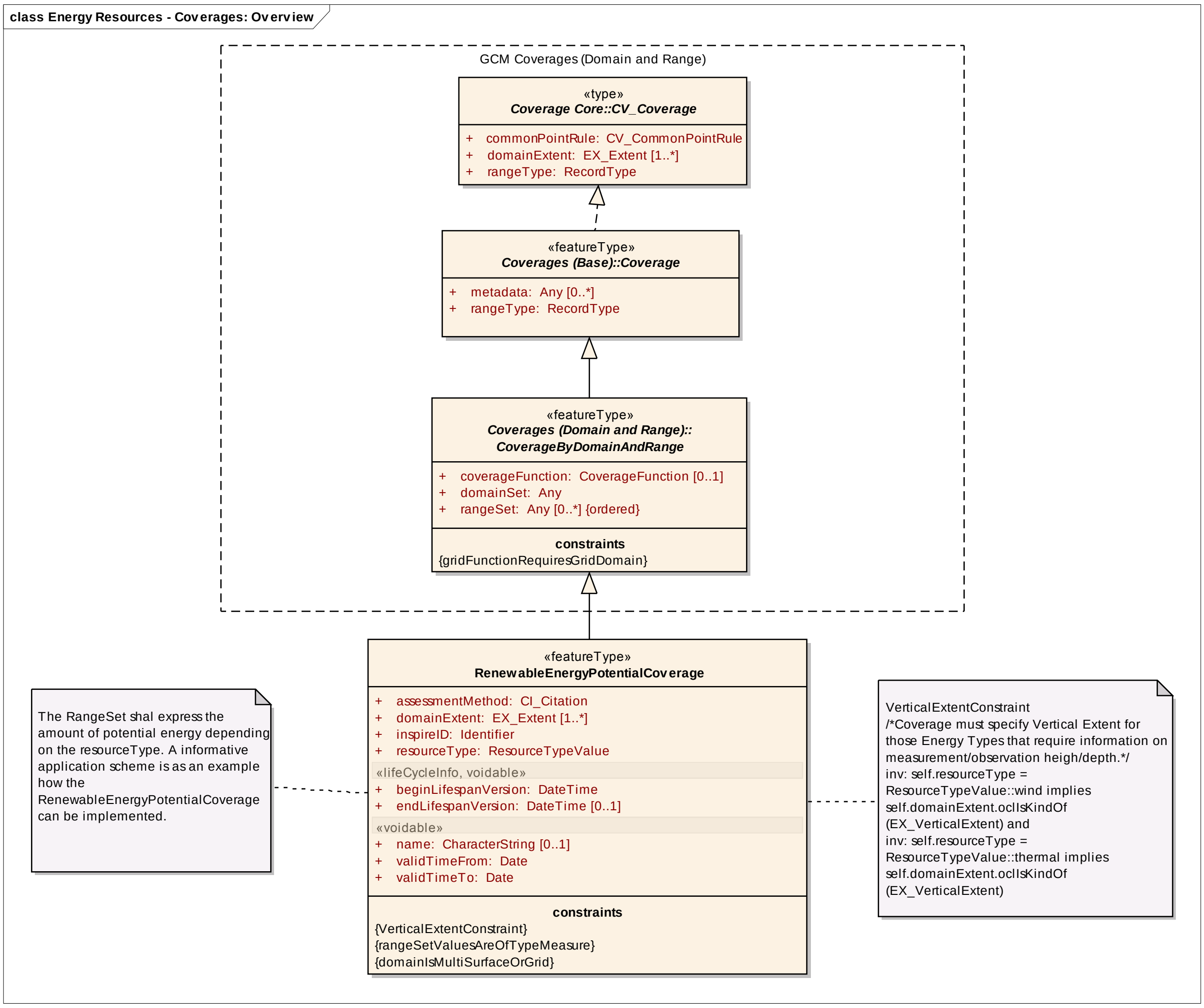


Figure 6 – UML class diagram: Overview of the Energy Resources - Coverages application schema

The central spatial object type for the *Energy Resources –Coverages* application schema is the abstract *RenewableEnergyPotentialCoverage* featuretype. This class is derived from the application schema 'Coverages (Domain and Range)' defined in and shared by the INSPIRE General Conceptual Model. In general this featuretype acts as a superclass supporting two types of Coverages:

- Discrete Coverages based on multiSurface domain: a multiSurface coverage is used to aggregate potential energy by any analytical unit. Each surface belonging to the coverage shall correspond with a value representing the aggregated amount of potential energy in that surface for a specific Energy Resource type.
- Grid Coverages based on a rectified or referenceable grid domain: a grid coverage is used to represent potential energy according grid cells. Each grid cell that is part of the domain shall correspond with a value representing the amount of potential energy modelled or calculated for a specific Energy Resource type.

Whereas the domain of the *RenewableEnergyPotentialCoverage* is restricted to multiSurface or Grid, the range set of the *RenewableEnergyPotentialCoverage* is composed of a finite number of values which are of type Measure. Examples are wind speed, geothermal gradient, Irradiation, etc.…

Examples of specialised discrete and grid coverages are provided in Annex C.

The modelled featuretype has only few specific attributes; nevertheless additional attribute information might be compulsory for a proper understanding of the quantified Energy Resource. First, it should always be documented which type of Energy Resource is represented by the Coverage. Then, in cases like estimating or modelling wind and geothermal energy it is as well important to know at which height respectively depth the wind speed and earth crust temperature have been measured and modelled into a coverage representation. This information can be provided by using the domainExtent attribute allowing for describing the temporal, vertical and geographic extent of the coverage.

IR Requirement 7	For each Energy Resource Coverage, information regarding the general type of Energy Resource shall be provided.

Recommendation 6	It is recommended to describe at least EX_GeographicExtent information through the DomainExtent attribute.

IR Requirement 8	EX_VerticalExtent information shall be provided through the domainExtent attribute for coverages having a vertical domain (for example potential of geothermal energy, of wind energy,…).

Finally it is important that the methodology used for modelling or assessing the coverage is documented using the CI_Citation datatype. In this way users of the data are properly informed and can interpret the provided data correctly.

Recommendation 7	It is strongly recommended to document the methodology used for modelling and generating the coverage using the assessmentMethod attribute.

All Measures that are defined in this application schema should be a formal unit of energy. The standard unit of energy in the SI system is Joule. Other alternative and common units are volumes (barrels, m^3...), tonnes of oil equivalent (toe), Mega Watt hours (MWh), and Giga Joules (GJ).

5.5.1.3. Consistency between spatial data sets

The *Energy Resources – Coverage* application schema does not require consistency rules.

5.5.1.4. Identifier management

As is required by the GCM, all spatial objects must have a unique identifier. This must be persistent and will usually be supported by a defined lifecycle to ensure that users understand the conditions under which the identifier may be created, modified (in terms of its relationship with the spatial object) and deleted.

IR Requirement 9	All spatial object types published for INSPIRE in theme Energy Resources shall carry a unique identifier: the attribute inspireId. This attribute must have the characteristics defined in the Generic Conceptual Model.

5.5.1.5. Modelling of object references

The *Energy Resources – Coverage* application schema does not require modelling of object references.

5.5.1.6. Geometry representation

The geometry representation for Energy Resources coverages is identified by the data structures defined for discrete (multisurface) and grid (rectified or referenceable) coverages in this specification.

5.5.1.7. Temporality representation

The application schema(s) use(s) the derived attributes "beginLifespanObject" and "endLifespanObject" to record the lifespan of a spatial object.

The attributes "beginLifespanVersion" specifies the date and time at which this version of the spatial object was inserted or changed in the spatial data set. The attribute "endLifespanVersion" specifies the date and time at which this version of the spatial object was superseded or retired in the spatial data set.

NOTE 1 The attributes specify the beginning of the lifespan of the version in the spatial data set itself, which is different from the temporal characteristics of the real-world phenomenon described by the spatial object. This lifespan information, if available, supports mainly two requirements: First, knowledge about the spatial data set content at a specific time; second, knowledge about changes to a data set in a specific time frame. The lifespan information should be as detailed as in the data set (i.e., if the lifespan information in the data set includes seconds, the seconds should be represented in data published in INSPIRE) and include time zone information.

NOTE 2 Changes to the attribute "endLifespanVersion" does not trigger a change in the attribute "beginLifespanVersion".

Recommendation 8	If life-cycle information is not maintained as part of the spatial data set, all spatial objects belonging to this data set should provide a void value with a reason of "unpopulated".

Within the application schema *Energy Resources – Coverages* a range of attributes are presented that represent continually varying real world phenomena like wind speed, solar irradiation etc.... The scope of these data specifications is not to have information on potential of Energy Resources for a specific point in time, but rather to have long term averages for a certain period. To represent this period information, two temporal attributes *ValidTimeFrom* and *ValidTimeto* were added to the *RenewableEnergyPotentialCoverage* featuretype. The ValidTime specifies the time window for which measurements have been captured to calculate the average energy potential corresponding to that period. The start time defines when the period began, whereas the end time specifies the end of the period.

IR Requirement 10	Temporality information on Energy Resource Coverages shall be provided using the 'ValidTimefrom' and 'ValidTimeTo' attributes.

Recommendation 9	It is strongly recommended to provide range values corresponding to annual averages of potential energy sources.

Recommendation 10	It is encouraged to provide range values corresponding to seasonal or monthly averages of potential energy sources when values may fluctuate considerably within a period of one year.

5.5.2 Feature catalogue

Table 3 - Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Energy Resources - Coverages
Scope	Energy Resources - Coverages
Version number	2.0
Version date	2011-06-15
Definition source	INSPIRE data specification Energy Resources - Coverages

Table 4 - Types defined in the feature catalogue

Type	Package	Stereotypes	Section
RenewableEnergyPotentialCoverage	Energy Resources - Coverages	«featureType»	5.5.2.1.1

5.5.2.1. Spatial object types

5.5.2.1.1. RenewableEnergyPotentialCoverage

RenewableEnergyPotentialCoverage	
Name:	Renewable Energy Potential Coverage
Subtype of:	CoverageByDomainAndRange
Definition:	Feature type that acts as a function to return an energy potential property value from its range for any direct position within its spatial, temporal or spatiotemporal domain.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Attribute: assessmentMethod	
Value type:	CI_Citation
Definition:	A citation to the method used to assess the energy resource potential.
Multiplicity:	1
Attribute: beginLifespanVersion	
Value type:	DateTime

RenewableEnergyPotentialCoverage	
Definition:	Date and time at which this version of the spatial object was inserted or changed in the spatial data set.
Multiplicity:	1
Stereotypes:	«lifeCycleInfo,voidable»
Attribute: domainExtent	
Name	Domain extent.
Value type:	EX_Extent
Definition:	The attribute domainExtent shall contain the extent of the spatiotemporal domain of the coverage. The data type EX_Extent, is defined in ISO 19103. Extents may be specified in both space and time.
Description:	SOURCE Adapted from [ISO 19123:2005].
Multiplicity:	1..*
Attribute: endLifespanVersion	
Value type:	DateTime
Definition:	Date and time at which this version of the spatial object was superseded or retired in the spatial data set.
Multiplicity:	0..1
Stereotypes:	«lifeCycleInfo,voidable»
Attribute: inspireID	
Value type:	Identifier
Definition:	External object identifier of the spatial object.
Description:	NOTE An external object identifier is a unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object. The identifier is an identifier of the spatial object, not an identifier of the real-world phenomenon.
Multiplicity:	1
Attribute: name	
Value type:	CharacterString
Definition:	Name of the Energy Resource coverage.
Description:	EXAMPLE The name of the catchment area for which a coverage has been extracted to represent Hydroelectric potential.
Multiplicity:	0..1
Stereotypes:	«voidable»
Attribute: resourceType	
Value type:	ResourceTypeValue
Definition:	Type of Energy Resource.
Description:	NOTE Most detailed classification must be provided.
Multiplicity:	1
Attribute: validTimeFrom	
Value type:	Date
Definition:	The ValidTime specifies the time window for which measurements have been captured to calculate the average energy potential corresponding to that period. The start time defines when the period began.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: validTimeTo	
Value type:	Date

RenewableEnergyPotentialCoverage	
Definition:	The ValidTime specifies the time window for which measurements have been captured to calculate the average energy potential corresponding to that period. The end time defines when the period stopped.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: VerticalExtentConstraint	
Natural language:	Coverage must specify Vertical Extent for those Energy Types that require information on measurement/observation heigh/depth.
OCL:	inv: self.resourceType = ResourceTypeValue::wind implies self.domainExtent.oclIsKindOf(EX_VerticalExtent) and inv: self.resourceType = ResourceTypeValue::thermal implies self.domainExtent.oclIsKindOf(EX_VerticalExtent)
Constraint: rangeSetValuesAreOfTypeMeasure	
Natural language:	rangeSet values are of type Measure
OCL:	inv: rangeSet.forAll(oclIsKindOf(Measure))
Constraint: domainIsMultiSurfaceOrGrid	
Natural language:	domain is a multi surface or grid (rectified or referenceable)
OCL:	inv: domainSet.oclIsKindOf(GM_MultiSurface) or domainSet.oclIsKindOf(CV_Grid)

5.5.2.2. Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

5.5.2.2.1. CI_Citation

CI_Citation	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115:2006 Metadata (Corrigendum)::Citation and responsible party information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.2. CharacterString

CharacterString	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Text [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.3. CoverageByDomainAndRange

CoverageByDomainAndRange (abstract)	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Models::Coverages (Domain and Range) [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	coverage which provide the domain and range as separate properties

5.5.2.2.4. Date

Date	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Date and Time [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.5. DateTime

DateTime	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Primitive::Date and Time [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.6. EX_Extent

EX_Extent	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19115:2006 Metadata (Corrigendum)::Extent information [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

5.5.2.2.7. Identifier

Identifier	
Package:	INSPIRE Consolidated UML Model::Generic Conceptual Model::Base Types [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	External unique object identifier published by the responsible body, which may be used by external applications to reference the spatial object.
Description:	NOTE1 External object identifiers are distinct from thematic object identifiers. NOTE 2 The voidable version identifier attribute is not part of the unique identifier of a spatial object and may be used to distinguish two versions of the same spatial object. NOTE 3 The unique identifier will not change during the life-time of a spatial object.

5.5.2.2.8. ResourceTypeValue

ResourceTypeValue	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Energy Resources::Energy Resources - Base [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Type of energy resource.

6 Reference systems

6.1 Coordinate reference systems

6.1.1 Datum

IR Requirement 11 For the coordinate reference systems used for making available the INSPIRE spatial data sets, the datum shall be the datum of the European Terrestrial Reference System 1989 (ETRS89) in areas within its geographical scope, and the datum of the International Terrestrial Reference System (ITRS) or other geodetic coordinate reference systems compliant with ITRS in areas that are outside the geographical scope of ETRS89. Compliant with the ITRS means that the system definition is based on the definition of the ITRS and there is a well established and described relationship between both systems, according to EN ISO 19111.

6.1.2 Coordinate reference systems

IR Requirement 12 INSPIRE spatial data sets shall be made available using one of the three-dimensional, two-dimensional or compound coordinate reference systems specified in the list below.

Other coordinate reference systems than those listed below may only be used for regions outside of continental Europe. The geodetic codes and parameters for these coordinate reference systems shall be documented, and an identifier shall be created, according to EN ISO 19111 and ISO 19127.

1. Three-dimensional Coordinate Reference Systems
   – Three-dimensional Cartesian coordinates
   – Three-dimensional geodetic coordinates (latitude, longitude and ellipsoidal height), using the parameters of the GRS80 ellipsoid

2. Two-dimensional Coordinate Reference Systems
   – Two-dimensional geodetic coordinates, using the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Lambert Azimuthal Equal Area projection and the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Lambert Conformal Conic projection and the parameters of the GRS80 ellipsoid
   – Plane coordinates using the Transverse Mercator projection and the parameters of the GRS80 ellipsoid

3. Compound Coordinate Reference Systems
   – For the horizontal component of the compound coordinate reference system, one of the two-dimensional coordinate reference systems specified above shall be used
   – For the vertical component on land, the European Vertical Reference System (EVRS) shall be used to express gravity-related heights within its geographical scope
   – Other vertical reference systems related to the Earth gravity field shall be used to express gravity-related heights in areas that are outside the geographical scope of EVRS. The geodetic codes and parameters for these vertical reference systems shall be documented and an identifier shall be created, according to EN ISO 19111 and ISO 19127
   – For the vertical component measuring the depth of the sea floor, where there is an appreciable tidal range, the Lowest Astronomical Tide shall be used as reference surface. In marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200 m, the depth of the sea floor shall be referenced to the Mean Sea Level
   – For the vertical component measuring depths above the sea floor in the free ocean, barometric pressure shall be used
   – For the vertical component in the free atmosphere, barometric pressure, converted to height using ISO 2533:1975 International Standard Atmosphere shall be used

6.1.3 Display

IR Requirement 13 For the display of the INSPIRE spatial data sets with the View Service specified in D003152/02 Draft Commission Regulation implementing Directive 2007/2/EC of the European Parliament and of the Council as regards Network Services, at least the two dimensional geodetic coordinate system shall be made available.

6.1.4 Identifiers for coordinate reference systems

IR Requirement 14 For referring to the non-compound coordinate reference systems listed in this Section, the identifiers listed below shall be used.

For referring to a compound coordinate reference system, an identifier composed of the identifier of the horizontal component, followed by a slash (/), followed by the identifier of the vertical component, shall be used.

- ETRS89-XYZ for Cartesian coordinates in ETRS89
- ETRS89-GRS80h for three-dimensional geodetic coordinates in ETRS89 on the GRS80 ellipsoid
- ETRS89-GRS80 for two-dimensional geodetic coordinates in ETRS89 on the GRS80
- EVRS for height in EVRS
- LAT for depth of the sea floor, where there is an appreciable tidal range
- MSL for depth of the sea floor, in marine areas without an appreciable tidal range, in open oceans and effectively in waters that are deeper than 200m
- ISA for pressure coordinate in the free atmosphere
- PFO for Pressure coordinate in the free ocean
- ETRS89-LAEA for ETRS89 coordinates projected into plane coordinates by the Lambert Azimuthal Equal Area projection
- ETRS89-LCC for ETRS89 coordinates projected into plane coordinates by the Lambert Conformal Conic projection
- ETRS89-TMzn for ETRS89 coordinates projected into plane coordinates by the Transverse Mercator projection

6.2 Temporal reference system

IR Requirement 15 The Gregorian Calendar shall be used for as a reference system for date values, and the Universal Time Coordinated (UTC) or the local time including the time zone as an offset from UTC shall be used as a reference system for time values.

6.3 Theme-specific requirements and recommendations on reference systems

There are no theme-specific requirements or recommendations on reference systems.

7 Data quality

This chapter includes a description of data quality elements and sub-elements as well as the associated data quality measures (section 7.1). The selected data quality measures should be used to evaluate quality of data sets for a specific data quality element / sub-element. The evaluation can be performed at the level of spatial object, spatial object type, dataset or dataset series.

The results of the evaluation are then reported at the spatial object type or dataset level in metadata utilising the same data quality elements and measures (see chapter 8).

NOTE The selection of appropriate data quality measures represents the first step towards the harmonisation of documenting data quality.

In addition, for some of the data quality elements described in section 7.1, minimum data quality requirements or recommendations may be defined. These are described in the section 1.2.

Recommendation 1 If data quality information is required at spatial object level then it should be modelled in the data model as an attribute of a relevant spatial object type.

7.1 Data quality elements and measures

No data quality elements for quantitative evaluation are defined for this theme.

Open issue 7: Data quality requirements based on real use cases

In case stakeholders participating on consultation & testing will identify via comments requirements for data quality and related measures based on real use cases these can be introduced for ver. 03 of this Data specification.

7.2 Minimum data quality requirements and recommendations

No minimum data quality requirements are defined.

8 Dataset-level metadata

Metadata can be reported for each individual spatial object (spatial object-level metadata) or once for a complete dataset or dataset series (dataset-level metadata). Spatial object-level metadata is fully described in the application schema (section **5**). If data quality elements are used at spatial object level, the documentation shall refer to the appropriate definition in section 7. This section only specifies dataset-level metadata elements.

For some dataset-level metadata elements, in particular on data quality and maintenance, a more specific scope can be specified. This allows the definition of metadata at sub-dataset level, e.g. separately for each spatial object type. When using ISO 19115/19139 to encode the metadata, the following rules should be followed:

- The scope element (of type DQ_Scope) of the DQ_DataQuality subtype should be used to encode the scope.
- Only the following values should be used for the level element of DQ_Scope: Series, Dataset, featureType.
- If the level is featureType the levelDescription/MDScopeDescription/features element (of type Set< GF_FeatureType>) shall be used to list the feature type names.

NOTEThe value featureType is used to denote spatial object type.

Mandatory or conditional metadata elements are specified in Section 8.1. Optional metadata elements are specified in Section 8. The tables describing the metadata elements contain the following information:

- The first column provides a reference to a more detailed description.
- The second column specifies the name of the metadata element.
- The third column specifies the multiplicity.
- The fourth column specifies the condition, under which the given element becomes mandatory (only for Table 2 and Table 3).

8.1 Common metadata elements

IR Requirement 16 The metadata describing a spatial data set or a spatial data set series related to the theme **Energy Resources** shall comprise the metadata elements required by Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata) for spatial datasets and spatial dataset series (Table 2) as well as the metadata elements specified in Table 3.

Table 2 – Metadata for spatial datasets and spatial dataset series specified in Regulation 1205/2008/EC (implementing Directive 2007/2/EC of the European Parliament and of the Council as regards metadata)

Metadata Regulation Section	Metadata element	Multiplicity	Condition
1.1	Resource title	1	
1.2	Resource abstract	1	
1.3	Resource type	1	
1.4	Resource locator	0..*	Mandatory if a URL is available to obtain more information on the resource, and/or access related services.
1.5	Unique resource identifier	1..*	
1.7	Resource language	0..*	Mandatory if the resource includes textual information.
2.1	Topic category	1..*	
3	Keyword	1..*	
4.1	Geographic bounding box	1..*	
5	Temporal reference	1..*	
6.1	Lineage	1	
6.2	Spatial resolution	0..*	Mandatory for data sets and data set series if an equivalent scale or a resolution distance can be specified.
7	Conformity	1..*	
8.1	Conditions for access and use	1..*	

8.2	Limitations on public access	1..*	
9	Responsible organisation	1..*	
10.1	Metadata point of contact	1..*	
10.2	Metadata date	1	
10.3	Metadata language	1	

Table 3 – Mandatory and conditional common metadata elements

INSPIRE Data Specification Energy Resources **Section**	**Metadata element**	**Multiplicity**	**Condition**
8.1.1	Coordinate Reference System	1	
8.1.2	Temporal Reference System	0..*	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
8.1.3	Encoding	1..*	
8.1.4	Character Encoding	0..*	Mandatory, if an encoding is used that is not based on UTF-8.
8.1.5	Data Quality – Logical Consistency – Topological Consistency	0..*	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.

8.1.1 Coordinate Reference System

Metadata element name	**Coordinate Reference System**
Definition	Description of the coordinate reference system used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type(and ISO 19115 no.)	189. MD_CRS
Domain	Either the referenceSystemIdentifier (RS_Identifier) or the projection (RS_Identifier), ellipsoid (RS_Identifier) and datum (RS_Identifier) properties shall be provided. NOTE More specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	

Example	referenceSystemIdentifier: code: ETRS_89 codeSpace: INSPIRE RS registry
Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>ETRS89 </gco:CharacterString> </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
Comments	

8.1.2 Temporal Reference System

Metadata element name	**Temporal Reference System**
Definition	Description of the temporal reference systems used in the dataset.
ISO 19115 number and name	13. referenceSystemInfo
ISO/TS 19139 path	referenceSystemInfo
INSPIRE obligation / condition	Mandatory, if the spatial data set or one of its feature types contains temporal information that does not refer to the Gregorian Calendar or the Coordinated Universal Time.
INSPIRE multiplicity	0..*
Data type(and ISO 19115 no.)	186. MD_ReferenceSystem
Domain	No specific type is defined in ISO 19115 for temporal reference systems. Thus, the generic MD_ReferenceSystem element and its reference SystemIdentifier (RS_Identifier) property shall be provided. NOTEMore specific instructions, in particular on pre-defined values for filling the referenceSystemIdentifier attribute should be agreed among Member States during the implementation phase to support interoperability.
Implementing instructions	
Example	referenceSystemIdentifier: code: GregorianCalendar codeSpace: INSPIRE RS registry

Example XML encoding	<gmd:referenceSystemInfo> <gmd:MD_ReferenceSystem> <gmd:referenceSystemIdentifier> <gmd:RS_Identifier> <gmd:code> <gco:CharacterString>GregorianCalendar</gco:CharacterString> </gmd:code> <gmd:codeSpace> <gco:CharacterString>INSPIRE RS registry</gco:CharacterString> </gmd:codeSpace> </gmd:RS_Identifier> </gmd:referenceSystemIdentifier> </gmd:MD_ReferenceSystem> </gmd:referenceSystemInfo>
Comments	

8.1.3 Encoding

Metadata element name	**Encoding**
Definition	Description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel
ISO 19115 number and name	271. distributionFormat
ISO/TS 19139 path	distributionInfo/MD_Distribution/distributionFormat
INSPIRE obligation / condition	mandatory
INSPIRE multiplicity	1
Data type (and ISO 19115 no.)	284. MD_Format
Domain	See B.2.10.4. The property values (name, version, specification) specified in section 9 shall be used to document the default and alternative encodings.
Implementing instructions	
Example	name: **Energy Resources** GML application schema version: version **2.0**, GML, version 3.2.1 specification: D2.8.**II/III.20** Data Specification on **Energy Resources** – Draft Guidelines
Example XML encoding	<gmd:MD_Format> <gmd:name> <gco:CharacterString> **Energy Resources** GML application schema </gco:CharacterString> </gmd:name> <gmd:version> <gco:CharacterString>**2.0**, GML, version 3.2.1</gco:CharacterString> </gmd:version> <gmd:specification> <gco:CharacterString>D2.8.**II/III.20** Data Specification on **Energy Resources** – Draft Guidelines</gco:CharacterString> </gmd:specification> </gmd:MD_Format>
Comments	

8.1.4 Character Encoding

Metadata element name	**Character Encoding**
Definition	The character encoding used in the data set.
ISO 19115 number and name	
ISO/TS 19139 path	
INSPIRE obligation / condition	Mandatory, if an encoding is used that is not based on UTF-8.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	
Domain	
Implementing instructions	
Example	-
Example XML encoding	<gmd:characterSet> <gmd:MD_CharacterSetCode codeListValue="8859part2" codeList="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/ML_gmxCodelists.xml#CharacterSetCode">8859-2</gmd:MD_CharacterSetCode> </gmd:characterSet>
Comments	

8.1.5 Data Quality – Logical Consistency – Topological Consistency

Metadata element name	**Data Quality – Logical Consistency – Topological Consistency**
Definition	Correctness of the explicitly encoded topological characteristics of the dataset as described by the scope
ISO 19115 number and name	18. dataQualityInfo
ISO/TS 19139 path	dataQualityInfo
INSPIRE obligation / condition	Mandatory, if the data set includes types from the Generic Network Model and does not assure centreline topology (connectivity of centrelines) for the network.
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	115. DQ_TopologicalConsistency
Domain	Lines 100-107 from ISO 19115
Implementing instructions	This metadata should be filled, at least, with these elements: - valueUnit: UnitOfMeasure - value: Record
Example	
Example XML encoding	
Comments	See clauses on topological consistency in section 7 for detailed information. This metadata element is mandatory if connectivity is not assured for network centrelines in the dataset. In this case the *Connectivity tolerance* parameter – as described in section 7 – must be provided in order to ensure automatic and unambiguous creation of centreline topology in post-process.

8.2 Metadata elements for reporting data quality

Information concerning the metadata elements for reporting data quality for this version (ver.02) is only defined in chapter 8.4 Guidelines on using metadata elements defined in Regulation 1205/2008/EC.

Open issue 8: Metadata for data quality reporting

In case stakeholders participating on consultation & testing will identify via comments requirements for data quality and related measures based on real use cases (to be defined in chapter 7), relevant metadata elements for reporting data quality can be introduced for ver. 03 of this Data specification.

Recommendation 2 For reporting the results of the data quality evaluation quantitatively, the data quality elements and measures defined in chapter 7 should be used.

The scope for reporting may be different from the scope for evaluating data quality (see section 7). If data quality is reported at the data set or spatial object type level, the results are usually derived or aggregated.

Metadata element name	**See chapter 7**
Definition	See chapter 7
ISO 19115 number and name	80. report
ISO/TS 19139 path	dataQualityInfo/*/report
INSPIRE obligation / condition	optional
INSPIRE multiplicity	0..*
Data type (and ISO 19115 no.)	Corresponding DQ_xxx element from ISO 19115, e.g. 109. DQ_CompletenessCommission
Domain	Lines 100-107 from ISO 19115 100. nameOfMeasure : CharacterString [0..*] 101. measureIdentification : MD_Identifier [0..1] 102. measureDescription : CharacterString [0..1] 103. evaluationMethodType : DQ_EvaluationMethodTypeCode [0..1] 104. evaluationMethodDescription : CharacterString [0..1] 105. evaluationProcedure : CI_Citation [0..1] 106. dateTime : DateTime [0..*] 107. result : DQ_Result [1..2]
Implementing instructions	**Recommendation 3** For each DQ result included in the metadata, at least the following properties should be provided: 100. nameOfMeasure NOTE This should be the name as defined in Chapter 7. 103. evaluationMethodType 104. evaluationMethodDescription NOTE If the reported data quality results are derived or aggregated (i.e. the scope levels for evaluation and reporting are different), the derivation or aggregation should also be specified using this property. 106. dateTime NOTE This should be data or range of dates on which the data quality measure was applied. 107. result NOTE This should be of type DQ_QuantitativeResult
Example	
Example XML encoding	

Comments	See Chapter 7 for detailed information on the individual data quality elements and measures to be used.

Open issue 9: In the ongoing revision of ISO 19115 and development of new ISO 19157 standard (Geographic Information – Data quality), a new element is introduced (DQ_DescriptiveResult). This element enables to describe and report qualitative results of the data quality evaluation and could be used instead of DQ_QuantitativeResult. Once the new (version of the) standards are approved, these guidelines will be revisited and be updated if necessary.

Open issue 10: For reporting compliance with minimum data quality requirements and recommendations specified in section 7, the INSPIRE conformity metadata element should be used.

However, since this issue is part of the larger discussion on the Abstract Test Suite and the definition of conformance classes for the data specification, detailed instructions on how to provide metadata on compliance with minimum data quality requirements and recommendations will only be provided for v3.0.

8.3 Theme-specific metadata elements

No mandatory theme-specific metadata elements are defined for this theme.

Recommendation 4 The metadata describing a spatial data set or a spatial data set series related to the theme **Energy Resources** should comprise the theme-specific metadata elements specified in Table 4.

Table 4 – Optional theme-specific metadata elements for the theme Energy Resources

INSPIRE Data Specification Energy Resources **Section**	**Metadata element**	**Multiplicity**
Error! Reference source not found.Error! Reference source not found.8.3.1	Maintenance Information	0..1

8.3.1 Maintenance information

Metadata element name	**Maintenance information**
Definition	Information about the scope and frequency of updating
ISO 19115 number and name	30. resourceMaintenance
ISO/TS 19139 path	identificationInfo/MD_Identification/resourceMaintenance
INSPIRE obligation / condition	Optional

INSPIRE multiplicity	0..1
Data type (and ISO 19115 no.)	142. MD_MaintenanceInformation
Domain	This is a complex type (lines 143-148 from ISO 19115). At least the following elements should be used (the multiplicity according to ISO 19115 is shown in parentheses): − maintenanceAndUpdateFrequency [1]: frequency with which changes and additions are made to the resource after the initial resource is completed / domain value: MD_MaintenanceFrequencyCode: − updateScope [0..*]: scope of data to which maintenance is applied / domain value: MD_ScopeCode − maintenanceNote [0..*]: information regarding specific requirements for maintaining the resource / domain value: free text
Implementing instructions	
Example	ResourceMaintenance: maintenanceAndUpdateFrequency: asNeeded updateScope: dataset maintenanceNote:
Example XML encoding	<gmd:resourceMaintenance> <gmd:MD_MaintenanceInformation> <gmd:maintenanceAndUpdateFrequency> <gmd:MD_MaintenanceFrequencyCode code-List="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/gmxCodelists.xml#MD_MaintenanceFrequencyCode" codeList-Value="weekly">asNeeded</gmd:MD_MaintenanceFrequencyCode> </gmd:maintenanceAndUpdateFrequency> <gmd:updateScope> <gmd:MD_ScopeCode codeList-Value="dataset" code-List="http://standards.iso.org/ittf/PubliclyAvailableStandards/ISO_19139_Schemas/resources/Codelist/gmxCodelists.xml#MD_ScopeCode">dataset</gmd:MD_ScopeCode> </gmd:updateScope> <gmd:maintenanceNote> <gco:CharacterString> </gco:CharacterString> </gmd:maintenanceNote> </gmd:MD_MaintenanceInformation> </gmd:resourceMaintenance>
Comments	

8.4 Guidelines on using metadata elements defined in Regulation 1205/2008/EC

8.4.1 Conformity

The *Conformity* metadata element defined in Regulation 1205/2008/EC allows to report the conformance with the Implementing Rule for interoperability of spatial data sets and services or another specification. The degree of conformity of the dataset can be *Conformant* (if the dataset is fully conformant with the cited specification), *Not Conformant* (if the dataset does not conform to the cited specification) or *Not evaluated* (if the conformance has not been evaluated).

Recommendation 5 The Conformity metadata element should be used to report conceptual consistency with this INSPIRE data specification. The value of Conformant should be used for the Degree element only if the dataset passes all the requirements described in the abstract test suite presented in Annex A. The Specification element should be given as follows:
- title: "INSPIRE Data Specification on <Theme Name> – Draft Guidelines"
- date:
    - dateType: publication
    - date: 2011-06-15

Open issue 11: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

This may also lead to an update of the recommendations on how to fill the conformity metadata element.

8.4.2 Lineage

Recommendation 6 Following the ISO 19113 Quality principles, if a data provider has a procedure for quality validation of their spatial data sets then the data quality elements listed in the Chapters 7 and 8 should be used. If not, the *Lineage* metadata element (defined in Regulation 1205/2008/EC) should be used to describe the overall quality of a spatial data set.

According to Regulation 1205/2008/EC, lineage "is a statement on process history and/or overall quality of the spatial data set. Where appropriate it may include a statement whether the data set has been validated or quality assured, whether it is the official version (if multiple versions exist), and whether it has legal validity. The value domain of this metadata element is free text".

The Metadata Technical Guidelines based on EN ISO 19115 and EN ISO 19119 specify that the statement sub-element of LI_Lineage (EN ISO 19115) should be used to implement the lineage metadata element.

Recommendation 7 To describe the transformation steps and related source data, it is recommended to use the following sub-elements of LI_Lineage:
- For the description of the transformation process of the local to the common INSPIRE data structures, the LI_ProcessStep sub-element should be used.
- For the description of the source data the LI_Source sub-element should be used.

NOTE 1 This recommendation is based on the conclusions of the INSPIRE Data Quality Working Group to avoid overloading of the overall lineage statement element with information on the transformation steps and related source data.

Open issue 12: The suggested use of the LI_Lineage sub-elements needs to be discussed as part of the maintenance of the INSPIRE metadata Technical Guidelines.

8.4.3 Temporal reference

According to Regulation 1205/2008/EC, at least one of the following temporal reference metadata elements shall be provided: temporal extent, date of publication, date of last revision, date of creation. If feasible, the date of the last revision of a spatial data set should be reported using the *Date of last revision* metadata element.

9 Delivery

9.1 Delivery medium

DS Requirement 2 Data conformant to this INSPIRE data specification shall be made available through an INSPIRE network service.

DS Requirement 3 All information that is required by a calling application to be able to retrieve the data through the used network service shall be made available in accordance with the requirements defined in the Implementing Rules on Network Services.

EXAMPLE 1 Through the Get Spatial Objects function, a download service can either download a pre-defined data set or pre-defined part of a data set (non-direct access download service), or give direct access to the spatial objects contained in the data set, and download selections of spatial objects based upon a query (direct access download service). To execute such a request, some of the following information might be required:

- the list of spatial object types and/or predefined data sets that are offered by the download service (to be provided through the Get Download Service Metadata operation),
- and the query capabilities section advertising the types of predicates that may be used to form a query expression (to be provided through the Get Download Service Metadata operation, where applicable),
- a description of spatial object types offered by a download service instance (to be proviced through the Describe Spatial Object Types operation).

EXAMPLE 2 Through the Transform function, a transformation service carries out data content transformations from native data forms to the INSPIRE-compliant form and vice versa. If this operation is directly called by an application to transform source data (e.g. obtained through a download service) that is not yet conformant with this data specification, the following parameters are required:
Input data (mandatory). The data set to be transformed.

- Source model (mandatory, if cannot be determined from the input data). The model in which the input data is provided.
- Target model (mandatory). The model in which the results are expected.
- Model mapping (mandatory, unless a default exists). Detailed description of how the transformation is to be carried out.

9.2 Encodings

9.2.1 Default Encoding(s)

DS Requirement 4 Data conformant to the application schema(s) defined in section 5.2 shall be encoded using the encoding(s) specified in this section.

9.2.1.1. Default encoding for application schema Energy Resources - Base

Name: Energy Resources - Base GML Application Schema
Version: version 2.0, GML, version 3.2.1
Specification: D2.8.**II/III.20** Data Specification on **Energy Resources** – Draft Guidelines
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

9.2.1.2. Default encoding for application schema Energy Resources - Features

Name: Energy Resources - Features GML Application Schema
Version: version 2.0, GML, version 3.2.1
Specification: D2.8.**II/III.20** Data Specification on **Energy Resources** – Draft Guidelines
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

9.2.1.3. Default encoding for application schema Energy Resources - Coverages

Name: Energy Resources - Coverages GML Application Schema
Version: version 2.0, GML, version 3.2.1
Specification: D2.8.**II/III.20** Data Specification on **Energy Resources** – Draft Guidelines
Character set: UTF-8

The GML Application Schema is distributed in a zip-file separately from the data specification document.

Note that GML allows the encoding of the value side of the coverage (i.e. the range set) either internally to the GML Coverage or in external files by using references. Either option is permitted. For the external file formats used it is suggested that GeoTiff, Tiff or JPEG2000 (without lossy compression) could be applied.

Open issue 13: From the provided reference material it could not be deduced which encoding format for coverages would be the most appropriate in the Energy Resources community. Are there any preferences?

Note also that currently the conceptually multiSurface coverage type is not yet supported by current implementations. While waiting on the results of the ongoing work done in the OGC working group on Coverages and WCS services, it was decided not to create a separate implementation UML model, however for testing purposes multiSurface Coverages can be implemented for the moment being based on the *Energy Resources – Feature* application schema.

9.2.2 Alternative Encoding(s)

Recommendation 8 It is recommended that also the encodings specified in this section be provided for the relevant application schemas.

9.2.2.1. Alternative encoding for application schemas of Energy Resources

Currently, no alternative encodings are specified for the Energy Resources application schemas

10 Data Capture

There is no specific guidance required with respect to data capture.

11 Portrayal

This clause defines the rules for layers and styles to be used for portrayal of the spatial object types defined for this theme.

In section 11.1, the *types* of layers are defined that are to be used for the portrayal of the spatial object types defined in this specification. A view service may offer several layers of the same type, one for each dataset that it offers on a specific topic.

Section 11.2 specifies the styles that shall be supported by INSPIRE view services for each of these layer types.

In section 11.3, further styles can be specified that represent examples of styles typically used in a thematic domain. It is recommended that also these styles should be supported by INSPIRE view services, where applicable.

Where XML fragments are used in these sections, the following namespace prefixes apply:

- sld="http://www.opengis.net/sld" (WMS/SLD 1.1)
- se="http://www.opengis.net/se" (SE 1.1)
- ogc="http://www.opengis.net/ogc" (FE 1.1)

IR Requirement 17 If an INSPIRE view services supports the portrayal of data related to the theme **Energy Resources**, it shall provide layers of the types specified in this section.

DS Requirement 5 If an INSPIRE view network service supports the portrayal of spatial data sets corresponding to the spatial data theme **Energy Resources**, it shall support the styles specified in section 11.2.

If no user-defined style is specified in a portrayal request for a specific layer to an INSPIRE view service, the default style specified in section 11.2 for that layer shall be used.

Recommendation 9 In addition to the styles defined in section 11.2, it is recommended that, where applicable, INSPIRE view services also support the styles defined in section 11.3.

11.1 Layers to be provided by INSPIRE view services

Layer Name	Layer Title	Spatial object type(s)	Keywords
ER.NonRenewableEnergyResource	Non Renewable Energy Resource	NonRenewableEnergy Resource	Non-renewable, Energy, Resource

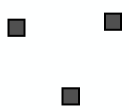
ER.RenewableEnergyResource	Renewable Energy Resource	RenewableEnergyResource	Renewable, Energy, Resource,
ER.NonRenewableEnergyResourceRegion	Non Renewable Energy Resource Region	NonRenewableEnergyResourceRegion	Non-renewable, Energy, Resource, Region
ER.RenewableEnergyPotentialCoverage	Renewable Energy Potential Coverage	RenewableEnergyPotentialCoverage	Renewable, Energy, Resource, Coverage

11.1.1 Layers organisation

None.

11.2 Styles to be supported by INSPIRE view services

11.2.1 Styles for the layer ER.NonRenewableEnergyResource

Style Name	**ER.NonRenewableEnergyResource**
Default Style	yes
Style Title	Non Renewable Energy Resource
Style Abstract	This layer type is for representation of Non Renewable Energy Resource data as points, curves and surfaces
Symbology	The symbol depends on the geometry type. **For point geometry:** Fill colour: 50% GREY RGB 80,80,80 Outline colour: SOLID BLACK Abstract: The geometry is rendered as a square with a size of 6 pixels, with a 50% grey (#808080) fill and a black outline. Example:  SLD:

```
  <sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResource</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a square with a size of 6
pixels, with a 50% grey (#808080) fill and a black outline.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResource</se:FeatureTypeName>
        <se:Rule>
          <se:PointSymbolizer>
```

```
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Graphic/>
          </se:PointSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

<u>For curve geometry:</u>

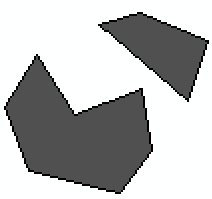
Colour: SOLID BLACK
Width: 1px
Abstract: The geometry is rendered as a solid black line with a stroke width of 1 pixel..
Example:

<u>SLD:</u>

```
  <sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResource</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a solid black line with a 
stroke width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResource</se:FeatureTypeName>
        <se:Rule>
          <se:LineSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Stroke/>
          </se:LineSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

<u>For surface geometry:</u>

Fill Colour: 50% GREY RGB 80,80,80
Outline colour: SOLID BLACK
Width: 1px
Abstract: The geometry is rendered using a 50% grey (#808080) fill and a solid black outline with a stroke width of 1 pixel.
Example:



<u>SLD:</u>

```
<sld:NamedLayer>
```

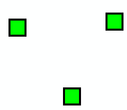
```
    <se:Name>ER.NonRenewableEnergyResource</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Default Style</se:Title>
          <se:Abstract>The geometry is rendered using a 50% grey (#808080) fill
and a solid black outline with a stroke width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResource</se:FeatureTypeName>
        <se:Rule>
          <se:PolygonSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Fill/>
            <se:Stroke/>
          </se:PolygonSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

Minimum & maximum scales	No scale limits.

11.2.2 Styles for the layer ER.RenewableEnergyResource

Style Name	**ER.RenewableEnergyResource**
Default Style	yes
Style Title	Renewable Energy Resource
Style Abstract	This layer type is for representation of Renewable Energy Resource data as points, curves and surfaces.
Symbology	**<u>For point geometry:</u>**

Fill colour: LIGHT GREEN RGB 00,255,00
Outline colour: SOLID BLACK
Abstract: The geometry is rendered as a square with a size of 6 pixels, with a green (#008000) fill and a black outline.
Example:



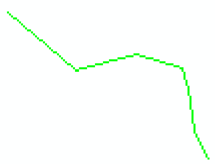
<u>SLD:</u>

```
<sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceProject</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Project Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a square with a size of 6
pixels, with a green (#008000) fill and a black outline.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceProject</se:FeatureTypeName>
```

```
        <se:Rule>
          <se:PointSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Graphic/>
          </se:PointSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

For curve geometry:

Colour: LIGHT GREEN RGB 00,255,00
Width: 1px
Abstract: The geometry is rendered as a green line with a stroke width of 1 pixel..
Example:

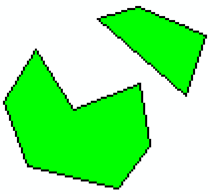


SLD:

```
 <sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceProject</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Project Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a green line with a stroke
width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceProject</se:FeatureTypeName>
        <se:Rule>
          <se:LineSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Stroke/>
          </se:LineSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

For surface geometry:

Fill Colour: LIGHT GREEN RGB 00,255,00
Outline colour: SOLID BLACK
Width: 1px
Abstract: The geometry is rendered using a green (#008000) fill and a solid black outline with a stroke width of 1 pixel.
Example:



<table>
<tr><td></td><td>
<u>SLD:</u>

```
<sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceProject</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Project Default Style</se:Title>
          <se:Abstract>The geometry is rendered using a green (#008000) fill and a
solid black outline with a stroke width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceProject</se:FeatureTypeName>
        <se:Rule>
          <se:PolygonSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Fill/>
            <se:Stroke/>
          </se:PolygonSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```
</td></tr>
<tr><td>Minimum & maximum scales</td><td>No scale limits.</td></tr>
</table>

11.2.3 Styles for the layer ER.NonRenewableEnergyResourceRegion

<table>
<tr><th>Style Name</th><th>ER.NonRenewableEnergyResourceRegion</th></tr>
<tr><td>Default Style</td><td>yes</td></tr>
<tr><td>Style Title</td><td>Non Renewable Energy Resource Region</td></tr>
<tr><td>Style Abstract</td><td>This layer type is for representation of Non Renewable Energy Resource data as points, curves and surfaces.</td></tr>
<tr><td>Symbology</td><td>
<u>For point geometry:</u>

<u>SLD:</u>

```
<sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceSystem</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource System Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a square with a size of 6
pixels, with a 50% grey (#808080) fill and a black outline.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceSystem</se:FeatureTypeName>
        <se:Rule>
          <se:PointSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Graphic/>
          </se:PointSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```
</td></tr>
</table>

<table>
<tr><td></td><td>

<u>For curve geometry:</u>

<u>SLD:</u>

```
 <sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceSystem</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource System Default Style</se:Title>
          <se:Abstract>The geometry is rendered as a solid black line with a
stroke width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceSystem</se:FeatureTypeName>
        <se:Rule>
          <se:LineSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Stroke/>
          </se:LineSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

<u>For surface geometry:</u>

<u>SLD:</u>

```
<sld:NamedLayer>
    <se:Name>ER.NonRenewableEnergyResourceProject</se:Name>
    <sld:UserStyle>
      <se:Name>INSPIRE_Default</se:Name>
      <sld:IsDefault>1</sld:IsDefault>
      <se:FeatureTypeStyle version="1.1.0">
        <se:Description>
          <se:Title>Non-Renewable Energy Resource Project Default Style</se:Title>
          <se:Abstract>The geometry is rendered using a green (#008000) fill and a
solid black outline with a stroke width of 1 pixel.</se:Abstract>
        </se:Description>
        <se:FeatureTypeName>NonRenewableEnergyResourceProject</se:FeatureTypeName>
        <se:Rule>
          <se:PolygonSymbolizer>
            <se:Geometry>
              <ogc:PropertyName>ER.geometry</ogc:PropertyName>
            </se:Geometry>
            <se:Fill/>
            <se:Stroke/>
          </se:PolygonSymbolizer>
        </se:Rule>
      </se:FeatureTypeStyle>
    </sld:UserStyle>
  </sld:NamedLayer>
```

</td></tr>
<tr><td>Minimum & maximum scales</td><td>No scale limits.</td></tr>
</table>

11.2.4 Styles for the layer ER.RenewableEnergyPotentialCoverage

Style Name	**ER.RenewableEnergyPotentialCoverage**
Default Style	yes
Style Title	Renewable Energy Potential Coverage

Style Abstract	This layer type is for representation of Renewable Energy Potential Coverage data as colored raster symbolize (values are Measures, expressed in units of Energy)

Symbology

Example:

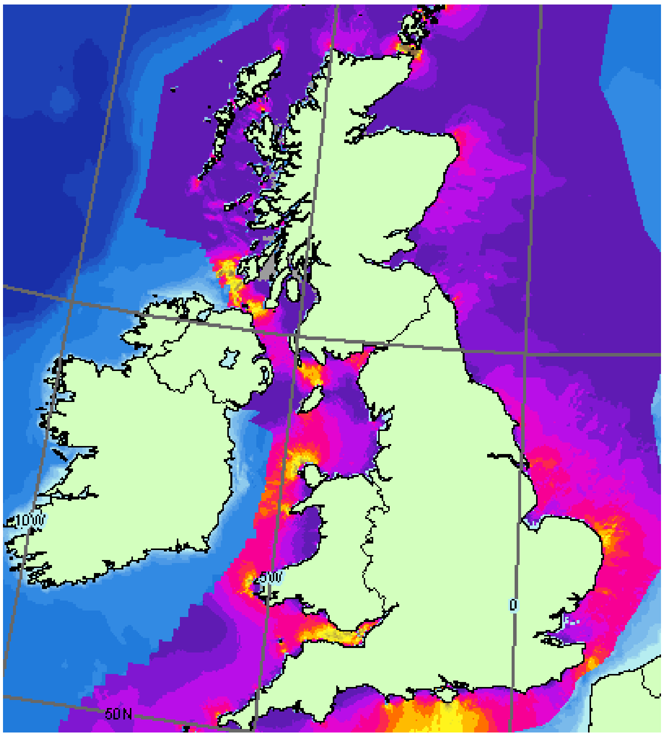


Figure 7 - ©Atlas of UK Marine Renewable Energy Resources

<u>SLD Example for potential coverage:</u>

```
<sld:NamedLayer>
<se:Name> ER.TidalPotentialSurfaceCoverage </se:Name>
<sld:UserStyle>
<se:Name> ER.TidalPotentialSurfaceCoverage.tidalPower </se:Name>
<sld:IsDefault>1</sld:IsDefault>
<se:Raster Symbolizer version="1.1.0">
<se:Description>
<se:Title> Tidal power potential Surface Coverage  </se:Title>
<se:Abstract> Grid Coverage is symbolized by a colored raster symbolizer (Values
in kW/m2)
</se:Abstract>
</se:Description>
<se:Opacity>1.0</se:Opacity>
<se:OverlapBehavior>AVERAGE</se:OverlapBehavior>
<se:ColorMap>
<se:Categorize fallbackValue="#FFFFFF">
<se:LookupValue>Rasterdata</se:LookupValue>
<se:Value>#9B9C9D</se:Value>
<se:Threshold>0.01</se:Threshold>
<se:Value>#583495</se:Value>
<se:Threshold>0.05</se:Threshold>
<se:Value>#6D429A</se:Value>
<se:Threshold>0.1</se:Threshold>
<se:Value>#8E489C</se:Value>
<se:Threshold>0.25</se:Threshold>
<se:Value>#B44299</se:Value>
<se:Threshold>0.5</se:Threshold>
<se:Value>#EC148C</se:Value>
<se:Threshold>1</se:Threshold>
<se:Value>#EC2D50</se:Value>
<se:Threshold>1.5</se:Threshold>
<se:Value>#F46F21</se:Value>
<se:Threshold>2</se:Threshold>
<se:Value>#F7B71B</se:Value>
<se:Threshold>3</se:Threshold>
<se:Value>#F2EC3B</se:Value>
```

	`<se:Threshold>4</se:Threshold>`
	`<se:Value>#E5E03C</se:Value>`
	`<se:Threshold>5</se:Threshold>`
	`<se:Value>#D2C53F</se:Value>`
	`<se:Threshold>6</se:Threshold>`
	`<se:Value>#BDAB3E</se:Value>`
	`<se:Threshold>8</se:Threshold>`
	`<se:Value>#AD9140</se:Value>`
	`<se:Threshold>10</se:Threshold>`
	`<se:Value>#997940</se:Value>`
	`<se:Threshold>20</se:Threshold>`
	`<se:Value>#866240</se:Value>`
	`<se:Threshold>40</se:Threshold>`
	`</se:Categorize>`
	`</se:ColorMap>`
	`</se:RasterSymbolizer>`
	`</sld:UserStyle>`
	`</sld:NamedLayer>`

Minimum & maximum scales	No scale limits.

Open issue 14: Common portrayal for the layers to be provided by INSPIRE view services

In case stakeholders participating on consultation & testing will identify via comments requirements for another common portrayal for layers, well established within the community with relevant justification can be introduced for ver. 03 of this Data specification.

11.3 Other recommended styles

No other styles were identified.

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Annex A
(normative)

Abstract Test Suite

Any dataset conforming to this INSPIRE data specification shall meet all requirements specified in this document.

Open issue 15: Conformance testing is still an open issue under discussion.

Instructions on conformance testing and a common abstract test suite (including detailed instructions on how to test specific requirements) will be added at a later stage.

Annex B
(informative)
Use cases

Energy resources related information is mainly collected or produced to be used within the energy domain as well as for the usage in other domains (contingency planning, impact assessment, landscape planning, identification of EU critical infrastructure, etc.). Following use cases were used as examples of real life use of Energy Resources related data.

B.1 *Energy crisis management*

B.1.1 Overview and involved actors

Activities aimed to prevent and manage potential energy crises, with an enhanced Early Warning Mechanism.
Main actors:

- EU member states + countries with energy resources connection to EU
- DG Energy
- Citizens

B.1.2 Narrative description

An energy crisis is any great bottleneck (or price rise) in the supply of energy resources to an economy. In popular literature though, it often refers to one of the energy sources used at a certain time and place. Energy runs machinery in factories, lights our cities and powers our vehicles. There has been an enormous increase in the demand for energy as a result of industrial development and population growth. Supply of energy is, therefore, far less than the actual demand.

B.1.3 Detailed description

Use Case Description	
Name	Energy crisis management
Priority	High
Description	*In case some countries will reduce or stop providing energy from their own resources, this mechanism will ensure, the negative impact on the countries depending on those resources will be reduced on minimal level.*
Pre-condition	Knowledge on location of existing energy resources
Flow of Events – User 1	
Step 1.	In case country providing energy from energy resources located within their jurisdiction will see there are reasons to eliminate or interrupt supply of energy, they will inform the EC about the situation.
Step 2.	EC will analyse received information and based on available spatial data scenarios for alternative energy supply are prepared.
Step 3.	If the situation is not solved within the time countries can use their backups, the most appropriate implementable scenario have to be deployed.
Post-condition	Energy supply is secured via origin supplier or the new one based on deployed scenario

Use Case Description	
Data source: Location of Energy Resource	
Description	Identification of places with the technically, technologically and commercially (with profit) exploitable accumulation (occurrence) of whatever phenomenon from which energy is/might be produced or extracted.
Data provider	National energy agencies collecting deposit related data
Geographic scope	EU
Thematic scope	Energy resources
Scale, resolution	Depending on source data
Delivery	Of/on line
Documentation	*http://europa.eu/rapid/pressReleasesAction.do?reference=IP/09/1718* *http://en.wikipedia.org/wiki/Energy_crisis#Crisis_management* *http://www.informaworld.com/smpp/section?content=a919781602&fulltext=713240928#references* *http://www.springerlink.com/content/v2r1k301t426072h/fulltext.pdf*

B.1.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

- Energy resource
  - Resource Type
  - Resource Amount including quanitification and probability
- Energy resource region
  - Resource Type
  - Reserves in situ

B.1.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Production and industrial facilities
- Utility and governmental services

B.2 *Identification of appropriate underground structures for gas storages.*

Open issue 16: Carbon Dioxide (CO_2) Capture and Storage (CCS) — also known as CO_2 sequestration — is a process whereby CO_2 is captured from gases produced by fossil fuel combustion, compressed, transported and injected into geologic formations or structures for permanent storage. As such CCS cannot be considered as an Energy Resource, however it often reuses depleted Energy Resource accumulations to store CO_2. It is still an open question if spatial objects from the Energy Resources should be referenced to delineate the spatial boundaries of C02 storage structures.

B.2.1 Detailed description

Use Case Description	
Name	Identification of appropriate underground structures for gas storages.
Priority	High

Use Case Description	
Description	Recently some of the EU member states have encountered a phenomenon “gas crisis” when gas supplies at the Slovak-Ukrainian border were cut off. Due to the fact some of them recognized that their underground gas storage capacity, considering wintertime conditions logically coupled with bigger consumption, was too low. It is not always possible to manage reverse flows in the transit or transmission pan-European system and provide enough gas through pipelines where needed. In such cases sufficient gas storage capacity would be convenient backup which might temporarily, how long it depends on storage capacity and concrete strategy, save situation.
Pre-condition	Knowledge on location of gas fields, especially those which sizes comply with intended storage capacity and which status of utilization indicates, that they have already been depleted.
Flow of Events – User 1	
Step 1.	Member state is severely affected during wintertime insufficient gas supplies due to an unpredicted cut off.
Step 2.	The EC will analyse underground storage capacity of all affected countries and where it’s needed will propose a member state to start looking for convenient geological structures, considering the fact that gas depleted storage type is the most common, where might be enough gas stored – where might be a new underground storage projected/built.
Step 3.	Users/organizations/institutes put in charge work actively with relevant INSPIRE’s data.
Post-condition	Gas storage capacities, after carrying out new underground gas storage projects, comply with demands in regions, member states or in the EU.
Data source: Energy resource	
Description	Identification of places with the technically, technologically and commercially (with profit) exploitable accumulation (occurrence) of whatever phenomenon from which energy is/might be produced or extracted. Some of those structures can be after depletion transformed into storages (gas storages, CO2 storages). Geographical position, possibly also spatial extend and attribute as development status (code of utilization) should be at least available, in order data can be used in efficient way.
Data provider	National geological institutes/surveys, possibly energy agencies collect data related to energy resources deposits
Geographic scope	EU
Thematic scope	Energy resources
Scale, resolution	Depending on source data
Delivery	off/on line (see examples below)

Use Case Description

Documentation

The International Map of Natural Gas Fields in Europe 1 : 2.500.000, consisting of nine map sheets, shows the distribution of natural gas fields and pipeline systems in Europe and adjacent areas covering a total of 64 countries. Important structural units such as sedimentary basins, major faults, orogenic belts and crystalline massifs are also represented on the map, because the distribution of natural gas fields is strongly connected with the geological underground.

At the 23rd meeting of the Committee on Gas of the Economic Commission for Europe in 1977, it was decided to revise both the International Map of Natural Gas Fields in Europe (1972) and the Explanatory Notes of the Map (1976).

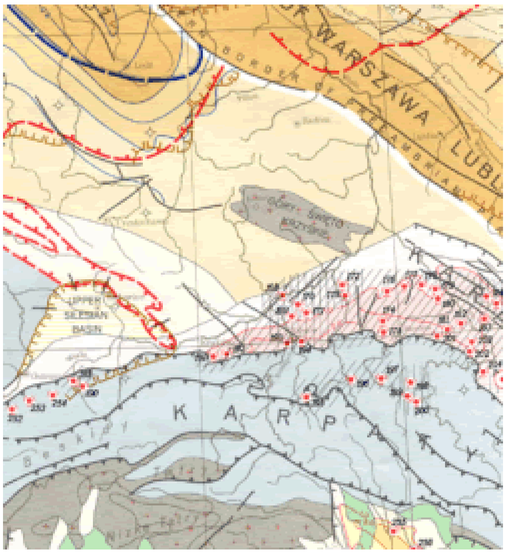

Figure B1 - International Map of Natural Gas Fields in Europe 1 : 2.500.000, detail view.
Source: BGR

The updated version of the map was published in 1984 by the Economic Commission for Europe (ECE) and the Federal Institute for Geosciences and Natural Resources (BGR).

Examples of national servers with such information:

Denmark
http://www.ens.dk/EN-US/OILANDGAS/DATA/Sider/Forside.aspx
Netherlands
http://www.nlog.nl/en/pubs/maps/other_maps/other_maps.html
Norway
http://www.npd.no/engelsk/cwi/pbl/en/factmap/download/shapes_welcome.htm
United Kingdom
https://www.og.decc.gov.uk/information/index.htm

B.2.2 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

- Energy resource
  - Resource type - Gas Field
  - Extent of resource depletion
- Energy resource region
  - Resource type - Petroleum System

B.3 *Development of petroleum assessment units*

B.3.1 Overview and involved actors

This use case is focused on description of development of petroleum assessment units, which can be used also in general for other energy resources representing mappable areas of whatever phenomenon from which energy might be produced or extracted. In order to decide whether the source is technically, technologically and commercially exploitable a detailed survey has to be carried out.

Main actors:

- U.S. Geological Survey
- National geology mapping agencies

B.3.2 Narrative description

This use case describes the process of assesment unit's identification done during the U.S. Geological Survey World Petroleum Assessment 2000. Each assessment unit is defined as a mappable volume of rock within a total petroleum system that encompasses fields (discovered and undiscovered) that share similar geologic traits and socio-economic factors. The fields inside an assessment are a sufficiently homogenous population that a single methodology of resource assessment is applicable. Assessment units are described by U.S. Geological Survey research scientists on the basis of available geologic knowledge, exploration and production histories, and extensive literature searches. Assessment units are identified with a numeric code derived from the numeric code of the World Geologic Provinces defined by the U.S. Geological Survey World Petroleum Assessment 2000. Most assessment units are contained within a single geologic province, but there are numerous cases where units span more than one province.

B.3.3 Detailed description

Use Case Description	
Name	Development of petroleum assessment units
Priority	High
Description	Development of Assessment units, which can be used also in general for other energy resources representing mappable areas of whatever phenomenon from which energy might be produced or extracted. In order to decide whether the source is technically, technologically and commercially exploitable a detailed survey has to be carried out.
Pre-condition	Total Petroleum Systems, essential mappable geologic elements (source, reservoir, seal and overburden rocks, geologic province and energy region
Flow of Events – User 1	
Step 1.	Collection of relevant available oil and gas data by the relevant organisation
Step 2.	Description of geology – creating the maps by the relevant organisation
Step 3.	Allocation fields and wells to assessment units by the relevant organisation
Step 4.	Application of growth algorithms to field sizes by the relevant organisation
Step 5.	Generation exploration/discovery-history plots and statistics by the relevant organisation
Step 6.	Assessment: Assessment meeting (Complete seventh approximation assessment data-input form)
Step 7.	Resources: Calculation undiscovered oil, gas, NGL resources
Step 8.	Delivery of "Summary Assessment Data of World Assessment Units" dataset
Post-condition	Possibility to use assessment units when planning further area investigations and deposits planning

Use Case Description	
Data source: Summary Assessment Data of World Assessment Units	
Description	This shapefile includes arcs and regions that describe U.S. Geological Survey defined petroleum resource Assessment Units of the World.
Data provider	U.S. Geological Survey
Geographic scope	World
Thematic scope	Energy resources
Scale, resolution	7500000
Delivery	To be checked
Documentation	*http://pubs.usgs.gov/dds/dds-060/wrldmp3.html#TOP*

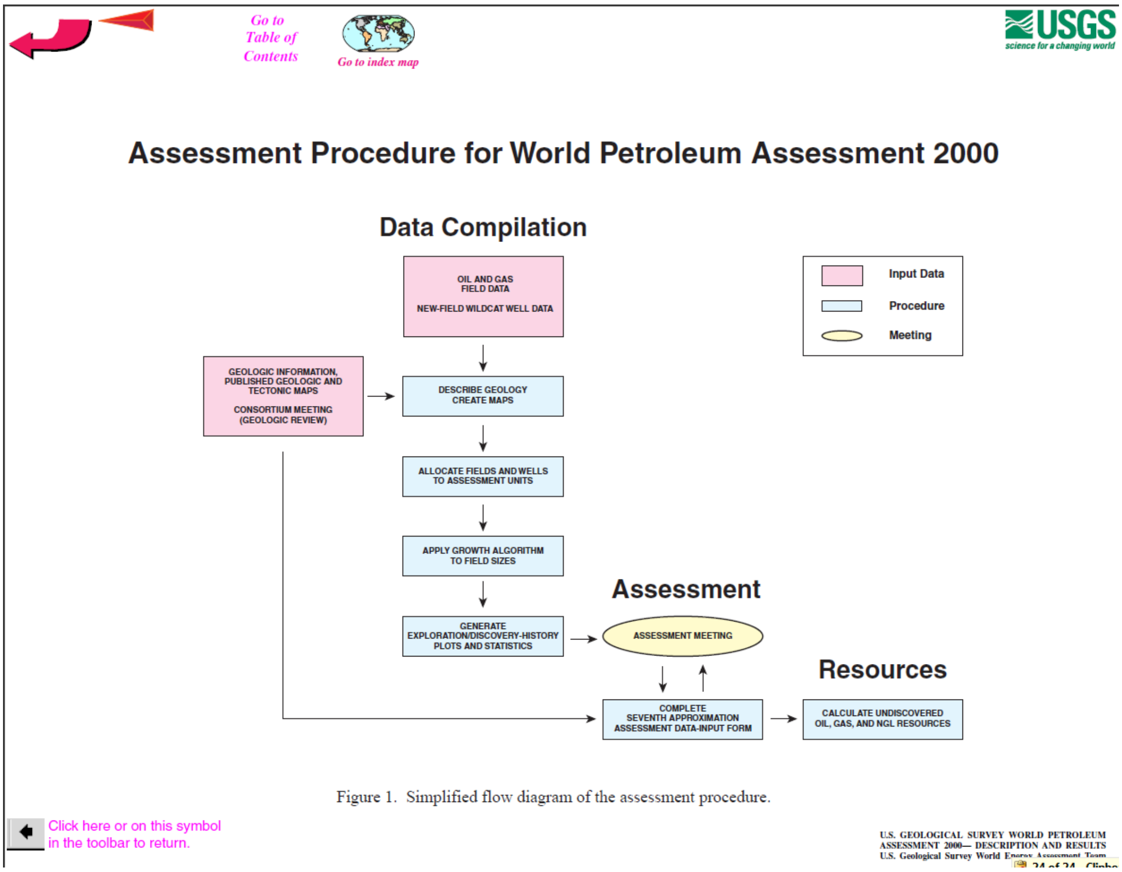

Figure B2 – Assessment Procedure for WPA 2000

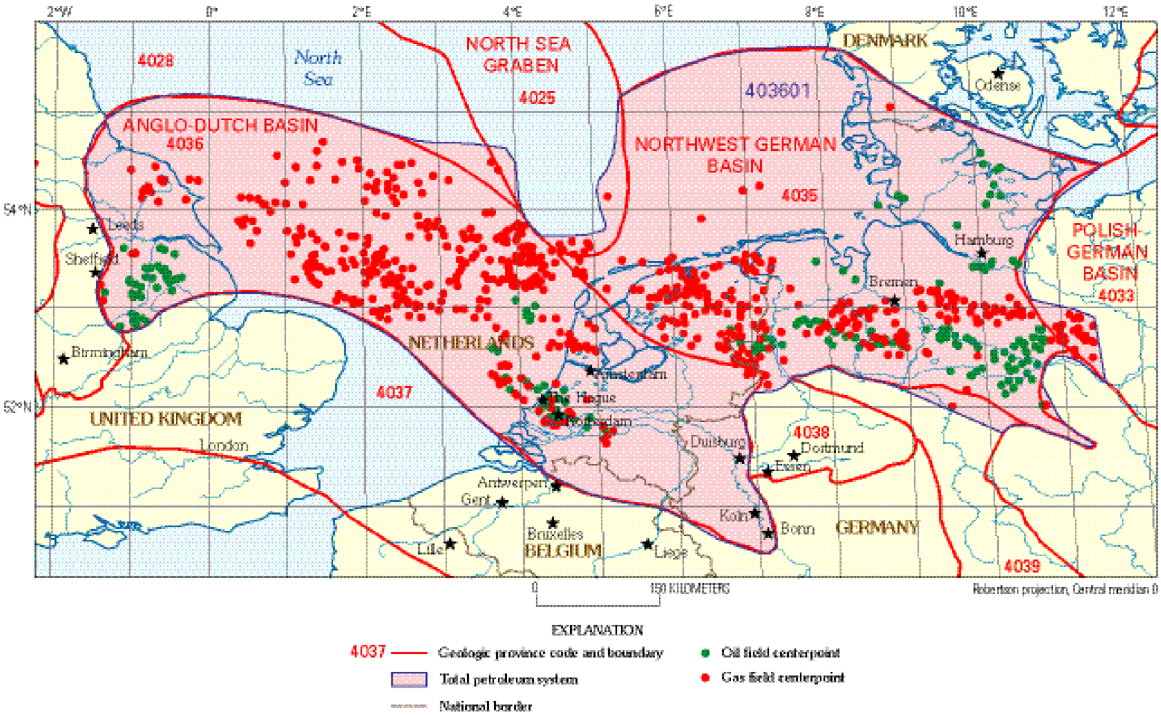

Figure B3 – Example of a Petroleum Assessment Unit

B.3.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Energy Resources Region
    Region Type

Energy Resource
    Resource Type
    Reporting Information on classification and estimates on the amount of resources

B.3.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:

- Geology
- Mineral resources

B.4 *County Development Plan (Wind energy resources data usage), Ireland*

B.4.1 Overview and involved actors

This use case shows flow of the spatial data (from Wind energy resources point of view) used for the purpose of County Development Plan (CDP) In Ireland.
Main actors:

- Sustainable Energy Authority of Ireland?"
- County council
- Citizens

B.4.2 Narrative description

Main purpose of CPD is to set out an overall strategy for the proper planning and sustainable development on the County level. CPD is in line with National Spatial Strategy as well as Irish Spatial Data Infrastructure development strategies. Each county has developed their own CDP which covers all aspects of development and land use within that county e.g. commercial, residential and of course wind-

farm development. CPD is diretly driven by the legislative requirement defined in the Planning and Development Act, 2000.

CDP assessment has to be updated at least every six years.

B.4.3 Detailed description

Use Case Description	
Name	County Development Plan (Wind energy resources data usage) adoped by County Council
Priority	Minor
Description	Relevant authorities in Ireland collect the wind energy resources spatial data, which are used to perform the analysis for the Environment and Heritage part of the CDP, especially in area of Landscape and Visual Amenity evaluation. Available data are adjusted for the purpose of CDP and provided to County Council. County Council (or another authorituy) performs analysis of data data and prepare CDP including landscape designation maps containing the results of analysis and synthesis done according the specific methodology based on dedicated legislation. The CDP covers also other aspects such as the identification and location of archaeological monuments, protected views/prospects, protected habitat such as Special Protection Areas (SPAs) and Special Area of Conservation (SACs), protected landscapes (Areas of Outstanding Natural Beauty – AONB) etc, but focus on this use case is to the energy resources scope.
Pre-condition	Availability of spatial data to be used for the purpose of CDP
Flow of Events – User 1	
Step 1.	Relevant authorities responsible for wind energy resources inventories and data provision identify, where necessary collect and collate existing data.
Step 2.	Collected data are adjusted to the desirable structure by (same authority like in step 1, or by the different authority).
Step 3.	Adjusted data are analysed by (same authority like in step 1, or by the different authority) according the methodology based on relevant legislation.
Step 4.	Results of analysis are provided to County Council for preparation of Draft Development Plan.
Step 5.	Evaluation of comments received by Public displays (1st+2nd) .
Step 6.	Adoption by County Council of the Development Plan and Manager's report
Step 7.	CPD publication
Post-condition	The County Council data sets are available **on-line** (in future complying with INSPIRE standards) comprising data sets of all stages of the processing, basic data, grid data and range data.
Data source: Member State Data Set	
Description	Relevant authorities responsible for wind energy resources manages database with a collection of all relevant wind energy data. This database is available internally and published to some extent in information systems.
Data provider	*The Sustainable Energy Authority of Ireland? *http://maps.seai.ie/wind/*
Geographic scope	Ireland
Thematic scope	Energy resources
Scale, resolution	The highest resolution that the member state can provide.

Use Case Description	
Delivery	Formats of encoding? (XML, SHP, other?). These data are published in specific information systems on the internet by state administrative services including view services. In future, data should be delivered INSPIRE GML application schema conform, either directly or through OGC web services.
Documentation	*http://www.irishspatialstrategy.ie/* *http://www.irishspatialstrategy.ie/isdi/* *http://www.irishstatutebook.ie/2000/en/act/pub/0030/index.html* *http://www.leitrimcoco.ie/eng/Services_A-Z/Planning_and_Building_Control/Publications/County_Development_Plan.pdf*

B.4.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:

Wind energy assessment units with:
- Wind speed x (to be defined) meters height above surface [m/s]
- Wind power [W/m2]

B.4.5 Relationship with other INSPIRE Themes

This use case has some relationships with the following INSPIRE data themes:
- Protected sites: identification and location of archaeological monuments

Note: This use case is related to the use case defined in TWG AC-MF "**Use Case on finding best locations for new wind farms**". Despite the connection, scope of both use cases is different. The finality of the use case provided by TWG ER is to optimize spatial planning and spatial development in which wind farms are one of the features to be considered, whereas the use case developed by TWG AC/MF is really to find the best location for wind farms by primarily using meteorological information and secondary looking to the environment (availability of infrastructure, protected areas, etc….). Nevertheless the use case defined by AC-MF has high relevance for this data specification, therefore it is highly recommended to read also AC-MF use case.

B.5 *Potential for photovoltaic power generation in EU countries*

B.5.1 Overview and involved actors

Performance of photovoltaic (PV) power plants depends strongly on solar radiation and temperature which are variable across regions. A study has been conducted by European Commission Joint Research Centre (EU JRC) to quantify potential for solar electricity production in member states as one of key pieces of information needed for setting up policy incentives for promoting photovoltaic installations.

Main actors:
- EU JRC, EU member states + regions
- Research and education
- Citizens

B.5.2 Narrative description

Solar renewable energy needs political support mechanisms that aim to promote dissemination of solar energy technology and development of new markets. One of the most used measure to support renewable energies in Europe are preferential feed-in-tariffs which are calculated from information about production potential for each of technologies and payback time of the investment. To set up proper feed-in-tariff for photovoltaics, an information about annual PV production potential is needed. To provide this information a GIS-based study has been conducted, which resulted in maps and statistical information on PV production potential in countries and regions.

B.5.3 Detailed description

Use Case Description	
Name	Potential for photovoltaic power generation in EU countries
Priority	High
Description	*For setting up proper financial support incentives for solar photovoltaics, information about production potential of photovoltaic power systems is needed for each region or country.*
Pre-condition	Knowledge on existing solar energy resources
Flow of Events – User 1	
Step 1.	To quantify potential electricity production from a PV system a grid data layers (maps) on annual average global horizontal and in-plane irradiation are needed. These data layers are used for calculation of annual PV electricity production maps across the EU.
Step 2.	The PV production maps are overlaid with a land cover map, namely with the category 1 (at the hierarchical level 1 this class represents urbanised land) to focus the analysis on areas where installations of PV systems are the most likely (places where people live, or close to them).
Step 3.	The map of PV potential in urban areas is statistically summarised at the level of a country and at the level of large administrative region (corresponding to the NUTS level 1 or 2) to provide an aggregated information for decision making. Such maps are statistically analysed to provide info about average PV potential but also about statistical distribution values.

Use Case Description

Post-condition

The resulting map and derived statistical information is used in policy making for setting up the incentives for solar photovoltaics.

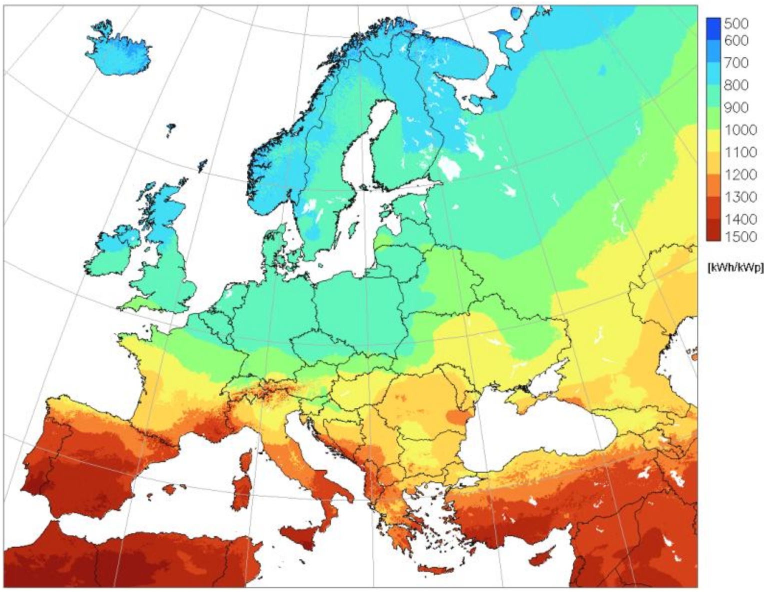

Figure B4 - Illustrative example: Input data source - annual sum of global in-plane irradiation for optimally inclined surface

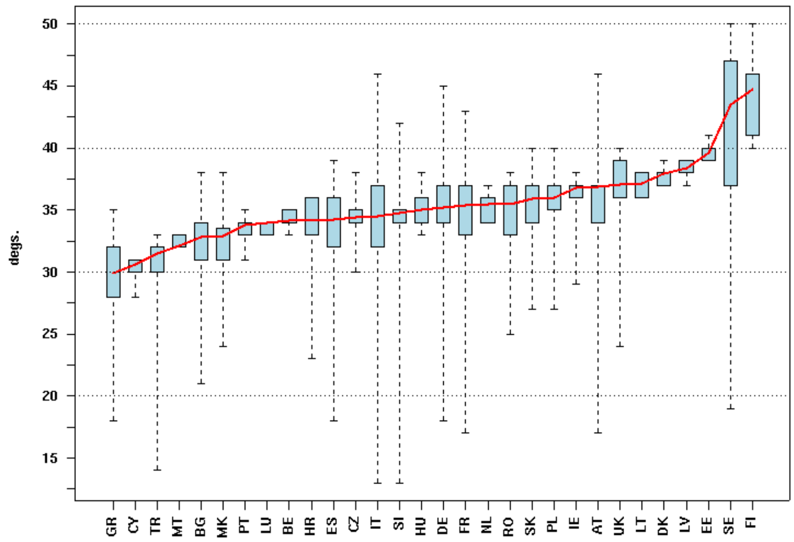

Figure B5 - Illustrative example of the output: Yearly sum of the electricity generated by a typical 1 kWp PV system in EU 27 Member States and 3 Candidate Countries (kWh/kWp) with modules mounted at the optimum angle.

The solid line represents the country's average value. The extremes of thedash lines show the minimum and maximum values in each country. The box plot depicts the 90% of occurrence of values in urban residential areas

Use Case Description	
Data source: Global horizontal and in-plane irradiation, CORINE Land Cover, GISCO NUTS	
Description	From renewable energy sources, a data file representing annual potential of global horizontal irradiation and global in-plane irradiation are needed at a medium spatial resolution. In addition the following data are needed: CORINE Land Cover map and GISCO NUTS (administrative regions).
Data provider	JRC, EEA, GISCO
Geographic scope	EU
Thematic scope	Energy resources and other thematic groups
Scale, resolution	regional (cca 1:500 000)
Delivery	Off–line
Documentation	http://dx.doi.org/10.1016/j.solener.2006.12.007

B.5.4 Requirements from the use case

Analyzing the use case, there is a need to provide the following objects and attributes:
globalHorizontalIrradiation

B.5.5 Relationship with other INSPIRE Themes

This use case has relationships with the following INSPIRE data themes:
- Land Cover (CORINE Land Cover 2000 (grid data layer))
- Administrative Units (GISCO administrative units)

Annex C
(informative)
Specialisation of Energy Resources Coverages

C.1 *Description*

C.1.1 Narrative Description and UML overview

Energy Resources can be described through a Coverage representation that represents the variation of an Energy Resource property within a domain of interest. This viewpoint is particularly applied for the description of renewable Energy Resources. Due to the ongoing work in the OGC working on Coverages and Web Coverage Services (WCS), the implementation and proper encoding of Coverages within the INSPIRE framework cannot be finalized yet. This Annex tries to clarify a conceptually point of view how the generic *RenewableEnergyPotentialCoverage* can be further specialised into domain-specific coverages (For example potential wind energy maps). The reason for further subtyping the generic *RenewableEnergyPotentialCoverage* is threefold:

- Allowing for defining the Coverage domain: Examples are multiSurface, Grids, etc…
- Allowing for defining Range Values via domain-specific datatypes: What are the domain-specific values to be represented: wind power density, direct normal solar irradiaton, potential Biomass etc…
- Propose common units of energy measures: In order to achieve a greater interoperability among European data sets, the definition of common units of measures would be benefical for each category of renewable energy.

It should be noticed that the specialisation of Coverages is not a theme-independent process. Some natural phenomena such as wind properties, temperature properties, and wave properties are modelled in other Annex II and III themes, as the observations of these natural phenomena are within the scope of these themes. Therefore the subtyping of a generic coverage in the Energy Resource theme is also to a certain extent depending on the ongoing data specifications development in these themes, as illustrated in the package diagram in Figure.

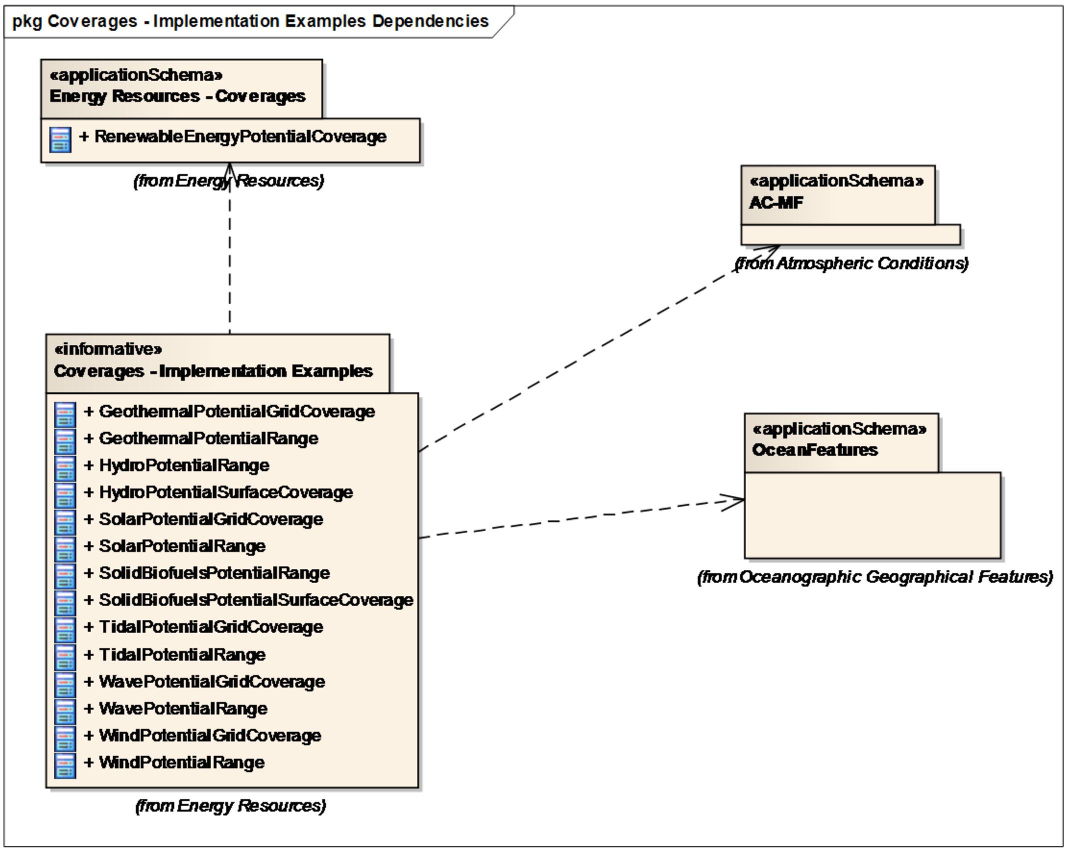

Figure C1 - Package diagram of Energy Resources Coverages

Figure below shows how the complete *Coverages-Implementations* application schema is modelled whereas Figure provides an overview of domain-specific datatypes and codelists which can be applied to specify real range values of the coverage.
The conceptual UML model only provides an initial series of Coverage specialisations in certain domains and presumably can be extended with specialisations in other domains as well.

As can be observed from the UML model the modelled featuretypes do not have specific attributes; for all coverages modelled in the application schema additional OCL constraints are set to ensure the rangeset of the coverages is determined by a datatype corresponding to the type of renewable energy source. Each datatype contains one or more attributes that can be used as measure to represent the quantification of potential energy.

Recommendation 10 For further subtyping the generic Coverage into domain-specific coverages, it is recommended to describe the Energy Resource potential using the following Measures:
Tidal energy: averageTidalPower
Wave energy: averageMeanWavePower
Hydroelectric energy: potentialHydroPower
Wind energy: averageMeanWindPowerDensity
Bio-energy: potentialBioEnergy
Geothermal energy: geothermalGradient
Solar energy: directNormalIrradiation, globalHorizontalIrradiation

The recommended measures may be complemented with other measures listed as voidable attributes in each of the data types.

In order to have a better understanding of the proposed datatypes and attributes, a feature catalogue was extracted from the conceptual UML models and added in the next section.

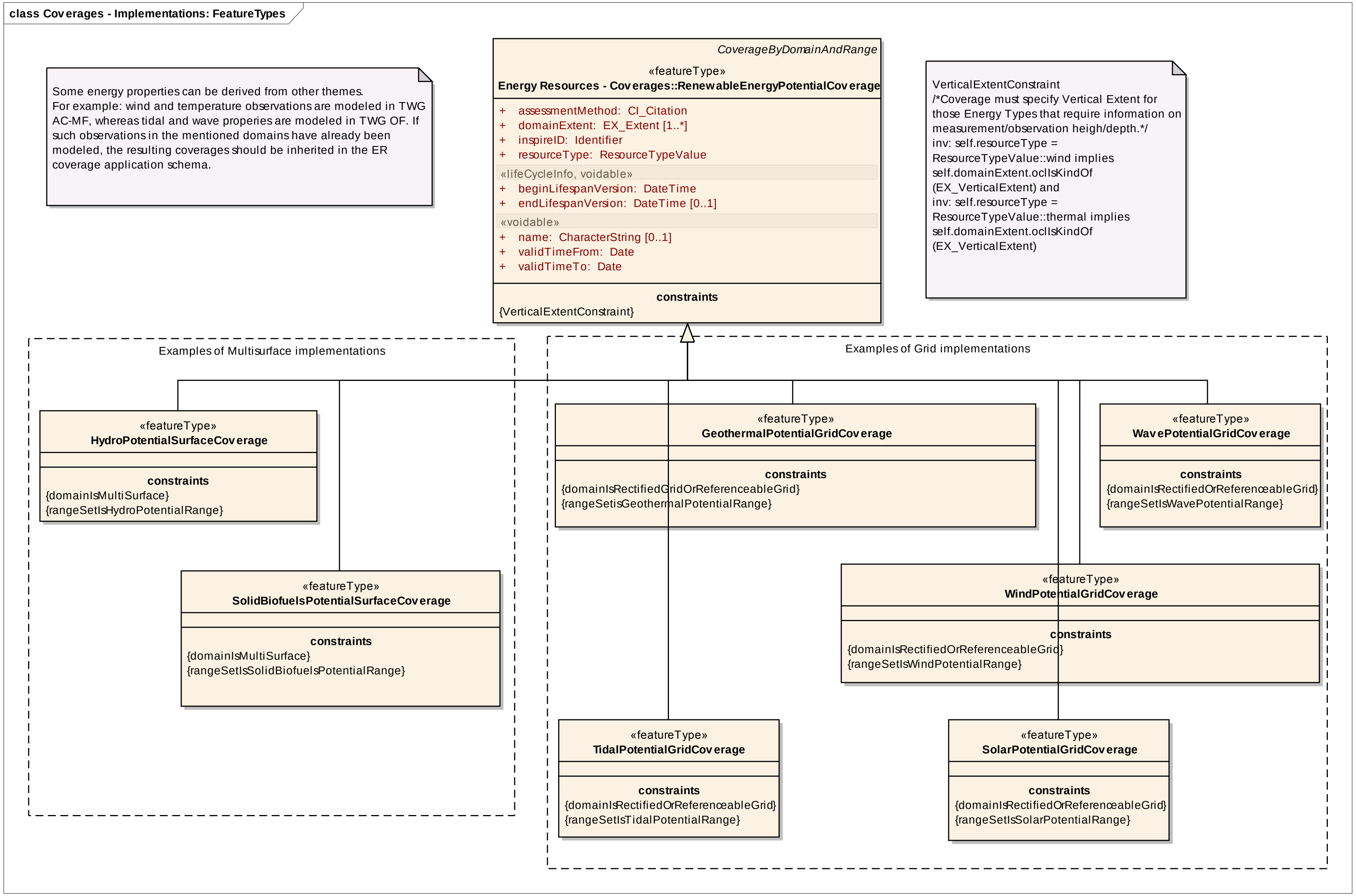

Figure C2 - UML overview of conceptual Coverage Implementation: featuretypes

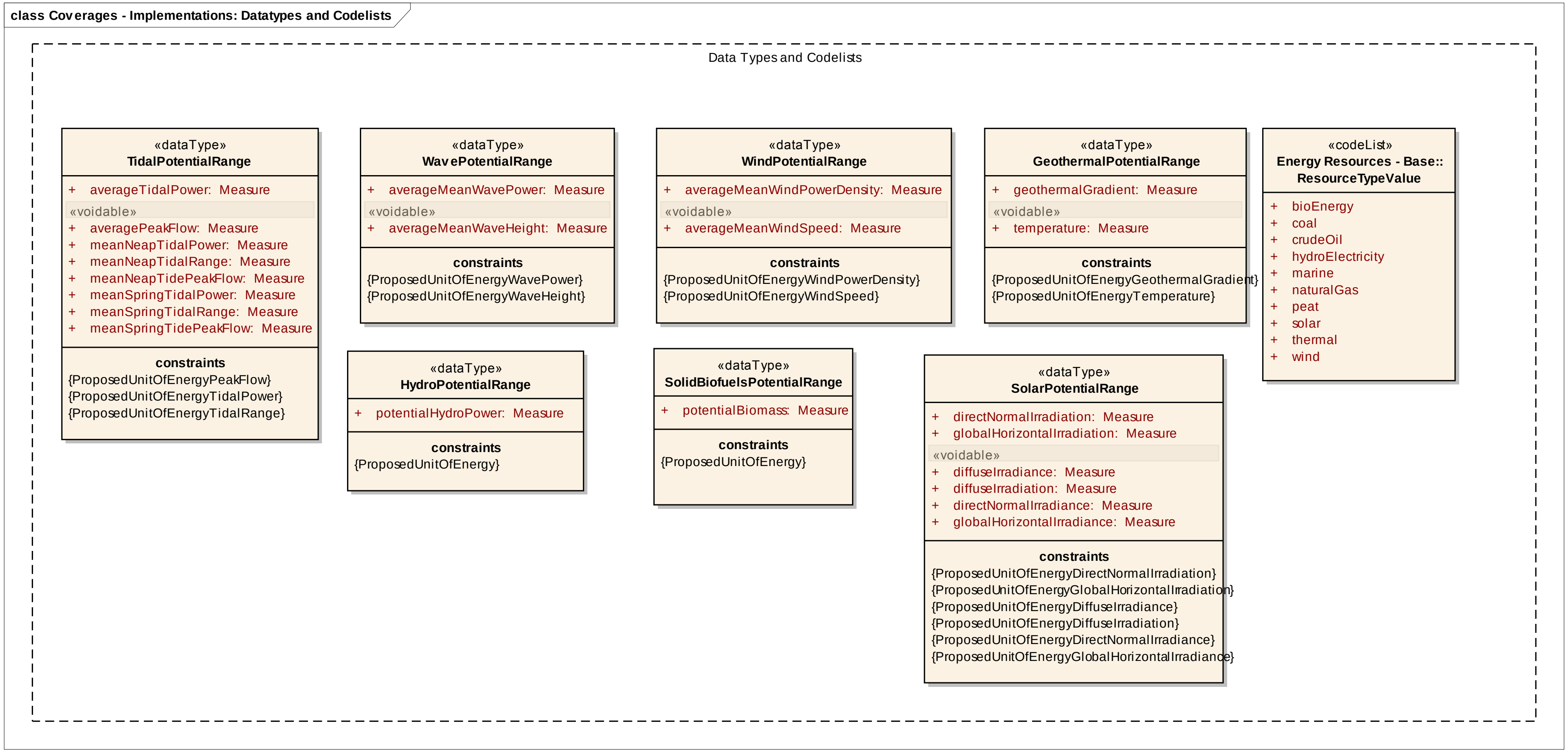

Figure C3 - UML overview of conceptual Coverage Implementation: datatypes and codelists

C.1.2 Feature Catalogue

Feature catalogue metadata

Feature catalogue name	INSPIRE feature catalogue Coverages - Implementation Examples
Scope	Coverages - Implementation Examples
Version number	2.0
Version date	2011-06-15
Definition source	INSPIRE data specification Coverages - Implementation Examples

Types defined in the feature catalogue

Type	Package	Stereotypes	Section
GeothermalPotentialGridCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.1
GeothermalPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.1
HydroPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.2
HydroPotentialSurfaceCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.2
SolarPotentialGridCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.3
SolarPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.3
SolidBiofuelsPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.4
SolidBiofuelsPotentialSurfaceCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.4
TidalPotentialGridCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.5
TidalPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.5
WavePotentialGridCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.6
WavePotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.6
WindPotentialGridCoverage	Coverages - Implementation Examples	«featureType»	C.1.2.1.7
WindPotentialRange	Coverages - Implementation Examples	«dataType»	C.1.2.2.7

C1.2.1 Spatial object types

C.1.2.1.1 GeothermalPotentialGridCoverage

GeothermalPotentialGridCoverage	
Name:	Geothermal Potential Grid Coverage
Subtype of:	RenewableEnergyPotentialCoverage
Definition:	Continuous Coverage representing potential geothermal power of which the domain is specified as a rectified grid and where the geothermal power property value is known for each of its grid points.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005]. NOTE MeasurementDepth only needs to be completed when besides temperatureGradient also an absolute temperature for a certain depth is

GeothermalPotentialGridCoverage	
	provided.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: domainIsRectifiedGridOrReferenceableGrid	
Natural language:	domain is a rectified or referenceable grid
OCL:	inv: domainSet.oclIsKindOf(CV_RectifiedGrid) or domainSet.oclIsKindOf(CV_ReferenceableGrid)
Constraint: rangeSetisGeothermalPotentialRange	
Natural language:	range set is described by GeothermalPotentialRange
OCL:	inv: rangeSet.oclIsKindOf(GeothermalPotentialRange)

C.1.2.1.2 HydroPotentialSurfaceCoverage

HydroPotentialSurfaceCoverage	
Name:	Hydro Potential Surface Coverage
Subtype of:	RenewableEnergyPotentialCoverage
Definition:	Discrete Coverage representing hydroelectric power of which the domain can be specified by any analytical unit (for example catchment areas) and where the hydroelectric power property value is equal for every point within the analytical unit.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005]. NOTE Often catchment boundaries are used in order to aggregate the sum for potential hydropower production within each catchment. Actual values derives from national inventories or through more theoretical approaches.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: domainIsMultiSurface	
Natural language:	domain is a multisurface
OCL:	inv: domainSet.oclIsKindOf(GM_MultiSurface)
Constraint: rangeSetIsHydroPotentialRange	
Natural language:	range set is described by HydroPotentialRange
OCL:	inv: rangeSet.oclIsKindOf(HydroPotentialRange)

C.1.2.1.3 SolarPotentialGridCoverage

SolarPotentialGridCoverage	
Name:	Solar Potential Grid Coverage
Subtype of:	RenewableEnergyPotentialCoverage
Definition:	Continuous Coverage representing potential solar power of which the domain is specified as a rectified grid and where the solar power property value is known for each of its grid points.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null

SolarPotentialGridCoverage

Constraint: domainIsRectifiedOrReferenceableGrid

Natural language: domain is a rectified or referenceable grid

OCL: inv: domainSet.oclIsKindOf(CV_RectifiedGrid) or domainSet.oclIsKindOf(CV_ReferenceableGrid)

Constraint: rangeSetIsSolarPotentialRange

Natural language: range set is described by SolarPotentialRange

OCL: inv: rangeSet.oclIsKindOf(SolarPotentialRange)

C.1.2.1.4 SolidBiofuelsPotentialSurfaceCoverage

SolidBiofuelsPotentialSurfaceCoverage

Name: Solid Biofuels Potential Surface Coverage

Subtype of: RenewableEnergyPotentialCoverage

Definition: Discrete Coverage representing solid biofuels of which the domain can be specified by any mappable region appropriate for biomass production, with an intention to use all those substancies for solid biofuel production, and where the bioenergy property value is equal for every point within the analytical unit.

Description: SOURCE Adapted from "Coverage" [ISO 19123:2005]

NOTE Key elements in making biomass for energy commercially and economically feasible involve spatial correlation of resource information with other geospatial data to identify potential for a resource supply, and to optimize position and size of a processing plant in a relation to the logistics of resource collection and management.

Status: Proposed

Stereotypes: «featureType»

URI: null

Constraint: domainIsMultiSurface

Natural language: domain is a multisurface

OCL: inv: domainSet.oclIsKindOf(GM_MultiSurface)

Constraint: rangeSetIsSolidBiofuelsPotentialRange

Natural language: range set is described by SolidBiofuelsPotentialRange

OCL: inv: rangeSet.oclIsKindOf(SolidBiofuelsPotentialRange)

C.1.2.1.5 TidalPotentialGridCoverage

TidalPotentialGridCoverage

Name: Tidal Potential Grid Coverage

Subtype of: RenewableEnergyPotentialCoverage

Definition: Continuous Coverage representing potential tidal power of which the domain is specified as a rectified grid and where the tidal power property value is known for each of its grid points.

Description: SOURCE Adapted from "Coverage" [ISO 19123:2005].

NOTE Potential is described by parameters tidal range, peak flow and tidal power which are dynamically changing during tidal cycle period.

Status: Proposed

Stereotypes: «featureType»

URI: null

TidalPotentialGridCoverage	
Constraint: domainIsRectifiedOrReferenceableGrid	
Natural language:	domain is a rectified or referenceable grid
OCL:	inv: domainSet.oclIsKindOf(CV_RectifiedGrid) or domainSet.oclIsKindOf(CV_ReferenceableGrid)
Constraint: rangeSetIsTidalPotentialRange	
Natural language:	range set is described by TidalPotentialRange
OCL:	inv: rangeSet.oclIsKindOf(TidalPotentialRange)

C.1.2.1.6 WavePotentialGridCoverage

WavePotentialGridCoverage	
Name:	Wave Potential Grid Coverage
Subtype of:	RenewableEnergyPotentialCoverage
Definition:	Continuous Coverage representing potential wave power of which the domain is specified as a rectified grid and where the wave power property value is known for each of its grid points.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005].
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: domainIsRectifiedOrReferenceableGrid	
Natural language:	domain is a rectified or referenceable grid
OCL:	inv: domainSet.oclIsKindOf(CV_RectifiedGrid) or domainSet.oclIsKindOf(CV_ReferenceableGrid)
Constraint: rangeSetIsWavePotentialRange	
Natural language:	range set is described by WavePotentialRange
OCL:	inv: rangeSet.oclIsKindOf(WavePotentialRange)

C.1.2.1.7 WindPotentialGridCoverage

WindPotentialGridCoverage	
Name:	Wind Potential Grid Coverage
Subtype of:	RenewableEnergyPotentialCoverage
Definition:	Continuous Coverage representing potential wind power of which the domain is specified as a rectified grid and where the wind power property value is known for each of its grid points.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005]. NOTE Wind power potential can be represented as an actual value in terms of available energy. Values for wind speed can be submitted as voidable.
Status:	Proposed
Stereotypes:	«featureType»
URI:	null
Constraint: domainIsRectifiedOrReferenceableGrid	
Natural language:	domain is a rectified or referenceable grid
OCL:	inv: domainSet.oclIsKindOf(CV_RectifiedGrid) or domainSet.oclIsKindOf(CV_ReferenceableGrid)

WindPotentialGridCoverage	
Constraint: rangeSetIsWindPotentialRange	
Natural language:	range set is described by WindPotentialRange
OCL:	inv: rangeSet.oclIsKindOf(WindPotentialRange)

C.1.2.2 Data types

C.1.2.2.1 GeothermalPotentialRange

GeothermalPotentialRange	
Name:	Geothermal Potential Range
Definition:	Data type which specifies the set of values which constitute the range of a geothermal potential grid coverage.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: geothermalGradient	
Value type:	Measure
Definition:	Geothermal gradient is the rate of increasing temperature with respect to increasing depth in the Earth's interior
Multiplicity:	1
Attribute: temperature	
Value type:	Measure
Definition:	Temperature.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: ProposedUnitOfEnergyGeothermalGradient	
Natural language:	Value of geothermal power shall be given in °C/km
OCL:	inv: self.geothermalGradient.uom.uomSymbol='°C/km'
Constraint: ProposedUnitOfEnergyTemperature	
Natural language:	Value of temperature shall be given in °C
OCL:	inv: self.temperature.uom.uomSymbol='°C'

C.1.2.2.2 HydroPotentialRange

HydroPotentialRange	
Name:	Hydro Potential Range
Definition:	Data type which specifies the set of values which constitute the range of a hydro potential multisurface coverage.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: potentialHydroPower	
Value type:	Measure
Definition:	Yearly potential hydro power production.
Description:	NOTE For planning purposes annual averaged values are the most valuable form.
Multiplicity:	1

HydroPotentialRange	
Constraint: ProposedUnitOfEnergy	
Natural language:	Value of potential Hydropower production shall be given in GWh
OCL:	inv: self.potentialHydroPower.uom.uomSymbol='GWh'

C.1.2.2.3 SolarPotentialRange

SolarPotentialRange	
Name:	Solar Potential Range
Definition:	Data type which specifies the set of values which constitute the range of a solar potential grid coverage.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null
Attribute: diffuseIrradiance	
Value type:	Measure
Definition:	Part of *solar power* (instantaneous rate of radiant energy), falling on a surface on the Earth per unit time, which is scattered by air molecules or atmospheric particles such as aerosols or clouds [W.m^{-2}].
Description:	NOTE 1 If not specified otherwise, diffuse irradiance falling on a *horizontal* surface is implicitly considered. In modelling solar power, diffuse *in-plane* irradiance can be calculated from diffuse horizontal irradiance (e.g. when considering a tilted surface of photovoltaic modules), and in such a case these two parameters have to be explicitly differentiated. Data on diffuse irradiance are often used together with direct irradiance (on a horizontal or tilted surface) in simulation software for design optimisation and performance assessment of solar energy installations. This parameter features site and time specific time series which are used mainly in a private business sector.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: diffuseIrradiation	
Value type:	Measure
Definition:	Amount of *solar energy* (integrated over a time), falling on a surface on the Earth, which is scattered by air molecules or atmospheric particles such as aerosols or clouds [Wh.m^{-2}].
Description:	NOTE 1 If not specified otherwise, diffuse irradiation on a *horizontal* surface is implicitly considered. In solar energy, diffuse *in-plane* irradiation can be calculated from diffuse horizontal irradiation (e.g. when considering a tilted surface of photovoltaic modules), and in such a case these two parameters have to be explicitly differentiated. Total amount of energy is typically summarised per hour, day, month or year. This parameter is sometimes used as a complementary parameter for an assessment of long-term performance of solar energy installations. Within the INSPIRE context practical use of this parameter is rather limited.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: directNormalIrradiance	
Value type:	Measure
Definition:	Part of *solar power* (instantaneous rate of radiant energy), falling on a surface perpendicular to the Sun's rays per unit time, which is not scattered or reflected by air molecules or atmospheric particles [Wh.m^{-2}].
Description:	NOTE 1 This is part of shortwave solar radiation that reaches the Earth surface

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	directly. In solar energy, an acronym *DNI* is often used for Direct Normal Irradiance, this can also be referred to as beam irradiance. Together with Global Horizontal Irradiance these are the most often used parameters in solar energy. Typically, this parameter is used in a simulation software for optimisation of design and performance assessment of two groups of solar energy facilities: Concentrated Solar Power (CSP, sometimes known also as solar electrical thermal power stations) and for Concentrated Photovoltaics (CPV). Sometimes direct irradiance on a *horizontal* surface is considered, and this case has to be explicitly differentiated from direct normal irradiance. This parameter features site and time specific time series that are used mainly in a private business sector.
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: directNormalIrradiation

Value type:	Measure
Definition:	Amount of *solar energy* (integrated over a time), falling on a surface perpendicular to sunrays, which is not scattered or reflected by air molecules or atmospheric particles [Wh.m^{-2}].
Description:	SOURCE Adapted from [PS 1996] and [PSRIS 1986]. NOTE 1 This is part of solar radiation that reaches the Earth surface directly. In solar energy, the acronym *DNI* is used for Direct Normal Irradiation (in the same way as Direct Normal Irradiance). Sometimes a term *beam irradiation* is used. Together with Global Horizontal Irradiation, these are the most often used parameters in solar energy. Typically, DNI is used for a long-term performance assessment of two groups of solar energy facilities: Concentrated Solar Power (CSP, sometimes known also as solar electrical thermal power stations) and for Concentrated Photovoltaics (CPV). NOTE 2 Total amount of energy is typically summarised per hour, day, month or year and this aggregation is used mainly by private business. Sometimes direct irradiation on a *horizontal* surface is considered, and this case has to be explicitly differentiated from direct normal irradiation. NOTE 3 Within the INSPIRE context, the most valuable aggregated form of data for a public use and official authorities are long-term annual (or monthly) averaged values of DNI. These can be used for studies of potential use of CSP and CPV technologies within a country or region.
Multiplicity:	1

Attribute: globalHorizontalIrradiance

Value type:	Measure
Definition:	*Solar power* (instantaneous rate of total radiant energy) attenuated by all constituents of the atmosphere and falling on a horizontal surface on the Earth per unit time. Global horizontal irradiance integrates direct, diffuse and reflected components of solar power [W.m^{-2}].
Description:	NOTE 1 In solar energy, an acronym *GHI* is used for Global Horizontal Irradiance. GHI is the most often used parameter in simulation software for assessing performance of solar energy systems. In simulation software, for tilted or sun-tracking surfaces in photovoltaics or solar heating/cooling, often global *in-plane* irradiance is computed from GHI. Therefore term *global in-plane irradiance* has to be differentiated from *global horizontal irradiance.* This parameter features site and time specific time series which are used mainly in a private business sector.
Multiplicity:	1
Stereotypes:	«voidable»

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Attribute: globalHorizontalIrradiation

Value type: Measure

Definition: Amount of *solar energy* (integrated over a time) attenuated by all constituents of the atmosphere and falling on a horizontal surface on the Earth. Global horizontal irradiation integrates direct, diffuse and reflected components of solar energy [Wh.m^{-2}].

Description: SOURCE Adapted from [PS 1996] and [PSRIS 1986].

NOTE 1 In solar energy, the acronym *GHI* is used for Global Horizontal Irradiation (in the same way as Global Horizontal Irradiance). In solar energy, GHI is the most often used for assessing long-term performance of solar energy systems.

NOTE 2 For tilted or sun-tracking surfaces (in photovoltaics or solar heating/cooling), often global *in-plane* irradiation is computed from GHI. Therefore term *global in-plane irradiation* has to be differentiated from *global horizontal irradiation.* Total amount of energy is typically summarised per hour, day, month or year and this aggregation is used mainly by private business.

NOTE 3 Within the INSPIRE context, the most valuable aggregated form of data for a public use and official authorities are long-term annual (or monthly) averaged values of GHI. These can be used for studies of potential use of photovoltaic and solar heating/cooling technologies within a country or region.

Multiplicity: 1

Constraint: ProposedUnitOfEnergyDiffuseIrradiance

Natural language: Value of diffuseIrradiance shall be given in W/m2

OCL: inv: self.diffuseIrradiance.uom.uomSymbol='W/m2'

Constraint: ProposedUnitOfEnergyDiffuseIrradiation

Natural language: Value of diffuseIrradiation shall be given in Wh/m2

OCL: inv: self.diffuseIrradiation.uom.uomSymbol='Wh/m2'

Constraint: ProposedUnitOfEnergyDirectNormalIrradiance

Natural language: Value of directNormalIrradiance shall be given in Wh/m2

OCL: inv: self.directNormalIrradiance.uom.uomSymbol='Wh/m2'

Constraint: ProposedUnitOfEnergyDirectNormalIrradiation

Natural language: Value of directNormalIrradiation shall be given in Wh/m2

OCL: inv: self.directNormalIrradiation.uom.uomSymbol='Wh/m2'

Constraint: ProposedUnitOfEnergyGlobalHorizontalIrradiance

Natural language: Value of globalHorizontalIrradiance shall be given in W/m2

OCL: inv: self.globalHorizontalIrradiance.uom.uomSymbol='W/m2'

Constraint: ProposedUnitOfEnergyGlobalHorizontalIrradiation

Natural language: Value of globalHorizontalIrradiation shall be given in Wh/m2

OCL: inv: self.globalHorizontalIrradiation.uom.uomSymbol='Wh/m2'

C.1.2.2.4 SolidBiofuelsPotentialRange

SolidBiofuelsPotentialRange

Name:	Solid Biofuels Potential Range
Definition:	Data type which specifies the set of values which constitute the range of a bioenergy potential multisurface coverage.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null

Attribute: potentialBiomass

Value type:	Measure
Definition:	The amount of tons of biomass produced by hectarea.
Multiplicity:	1

Constraint: ProposedUnitOfEnergy

Natural language:	Value of potential BioEnergy shall be given in tonnes per hectare per year
OCL:	inv: self.potentialHydroPower.uom.uomSymbol='t/ha/yr'

C.1.2.2.5 TidalPotentialRange

TidalPotentialRange

Name:	Tidal Potential Range
Definition:	Data type which specifies the set of values which constitute the range of a tidal potential grid coverage.
Status:	Proposed
Stereotypes:	«dataType»
URI:	null

Attribute: averagePeakFlow

Value type:	Measure
Definition:	Peak velocity of tidal stream for whole tidal cycle.
Description:	
Multiplicity:	1
Stereotypes:	«voidable»

Attribute: averageTidalPower

Value type:	Measure
Definition:	Average tidal power obtainable over a complete year.
Description:	NOTE 1 Tidal power is mechanical power, which may be converted to electrical power, generated by the rise and fall of ocean tides. The possibilities of utilizing tidal power have been studied for many generations, but the only feasible schemes devised so far are based on the use of one or more tidal basins, separated from the sea by dams (known as barrages), and of hydraulic turbines through which water passes on its way between the basins and the sea. NOTE 2 Average tidal power take into account the complete tidal curve (i.e. not just the peak current values).
Multiplicity:	1

Attribute: meanNeapTidalPower

Value type:	Measure
Definition:	Average neap power taking into account the peak only of the neap tidal curve.
Description:	NOTE 1 Tidal power is mechanical power, which may be converted to electrical power, generated by the rise and fall of ocean tides. The possibilities of utilizing tidal power have been studied for many generations, but the only feasible

TidalPotentialRange	
	schemes devised so far are based on the use of one or more tidal basins, separated from the sea by dams (known as barrages), and of hydraulic turbines through which water passes on its way between the basins and the sea.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: meanNeapTidalRange	
Value type:	Measure
Definition:	Vertical distance between high and low tide during neap tidal curve.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: meanNeapTidePeakFlow	
Value type:	Measure
Definition:	Peak velocity of neap tidal stream.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: meanSpringTidalPower	
Value type:	Measure
Definition:	Average spring power taking account the peak only of the spring tidal curve.
Description:	NOTE Tidal power is mechanical power, which may be converted to electrical power, generated by the rise and fall of ocean tides. The possibilities of utilizing tidal power have been studied for many generations, but the only feasible schemes devised so far are based on the use of one or more tidal basins, separated from the sea by dams (known as barrages), and of hydraulic turbines through which water passes on its way between the basins and the sea.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: meanSpringTidalRange	
Value type:	Measure
Definition:	Vertical distance between high and low tide during spring tidal curve.
Multiplicity:	1
Stereotypes:	«voidable»
Attribute: meanSpringTidePeakFlow	
Value type:	Measure
Definition:	Peak velocity of spring tidal stream.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: ProposedUnitOfEnergyPeakFlow	
Natural language:	Value of peakflow shall be given in m/s
OCL:	inv: self.AveragePeakFlow.uom.uomSymbol='m/s' and self.MeanSpringTidePeakFlow.uom.uomSymbol='m/s' and self.MeanNeapTidePeakFlow.uom.uomSymbol='m/s'
Constraint: ProposedUnitOfEnergyTidalPower	
Natural language:	Value of tidal power shall be given in kW/m2
OCL:	inv: self.AverageTidalPower.uom.uomSymbol='kW/m2' and self.MeanNeapTidalPower.uom.uomSymbol='kW/m2' and

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self.MeanSpringTidalPower.uom.uomSymbol='kW/m2'

Constraint: ProposedUnitOfEnergyTidalRange

Natural language: Value of tidal range shall be given in m

OCL: inv: self.MeanNeapTidalRange.uom.uomSymbol='m' and self.MeanSpringTidalRange.uom.uomSymbol='m'

C.1.2.2.6 WavePotentialRange

WavePotentialRange

Name: Wave Potential Range

Definition: Data type which specifies the set of values which constitute the range of a wave potential grid coverage.

Status: Proposed

Stereotypes: «dataType»

URI: null

Attribute: averageMeanWaveHeight

Value type: Measure

Definition: Average vertical distance between a wave crest and the previous wave trough.

Description: SOURCE Adapted from [OE glossary 2007].

Multiplicity: 1

Stereotypes: «voidable»

Attribute: averageMeanWavePower

Value type: Measure

Definition: Average annual mechanical power from waves, normally expressed in the kilowatts per meter of wave crest length.

Description: SOURCE Adapted from [OE glossary 2007].

Multiplicity: 1

Constraint: ProposedUnitOfEnergyWaveHeight

Natural language: Value of Wave Height shall be given in m

OCL: inv: self.AverageMeanWaveHeight.uom.uomSymbol='m'

Constraint: ProposedUnitOfEnergyWavePower

Natural language: Value of Wave power shall be given in kW/m of wave crest

OCL: inv: self.AverageMeanWavePower.uom.uomSymbol='kW/m'

C.1.2.2.7 WindPotentialRange

WindPotentialRange

Name: Wind Potential Range

Definition: Data type which specifies the set of values which constitute the range of a wind potential grid coverage.

Description: NOTE Wind speed is basic information in order to calculate the actual wind power potential

Status: Proposed

Stereotypes: «dataType»

URI: null

Attribute: averageMeanWindPowerDensity

Value type: Measure

WindPotentialRange	
Definition:	The availability of energy at a location for conversion by a wind turbine.
Multiplicity:	1
Attribute: averageMeanWindSpeed	
Value type:	Measure
Definition:	Annual Mean wind speed at a location.
Description:	NOTE The arithmetic wind speed over a specified time period and height above the ground.
Multiplicity:	1
Stereotypes:	«voidable»
Constraint: ProposedUnitOfEnergyWindPowerDensity	
Natural language:	Value of wind power density shall be given in W/m2
OCL:	inv: self.AverageMeanWindPowerDensity.uom.uomSymbol='W/m2'
Constraint: ProposedUnitOfEnergyWindSpeed	
Natural language:	Value of windspeed shall be given in m/s
OCL:	inv: self.AverageMeanWindSpeed.uom.uomSymbol='m/s'

C.1.2.3 Imported types (informative)

This section lists definitions for feature types, data types and enumerations and code lists that are defined in other application schemas. The section is purely informative and should help the reader understand the feature catalogue presented in the previous sections. For the normative documentation of these types, see the given references.

C.1.2.3.1 Measure

Measure	
Package:	INSPIRE Consolidated UML Model::Foundation Schemas::ISO TC211::ISO 19103:2005 Schema Language::Basic Types::Derived::Units of Measure [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]

C.1.2.3.2 RenewableEnergyPotentialCoverage

RenewableEnergyPotentialCoverage	
Package:	INSPIRE Consolidated UML Model::Themes::Annex III::Energy Resources::Energy Resources - Coverages [Include reference to the document that includes the package, e.g. INSPIRE data specification, ISO standard or the GCM]
Definition:	Feature type that acts as a function to return an energy potential property value from its range for any direct position within its spatial, temporal or spatiotemporal domain.
Description:	SOURCE Adapted from "Coverage" [ISO 19123:2005].