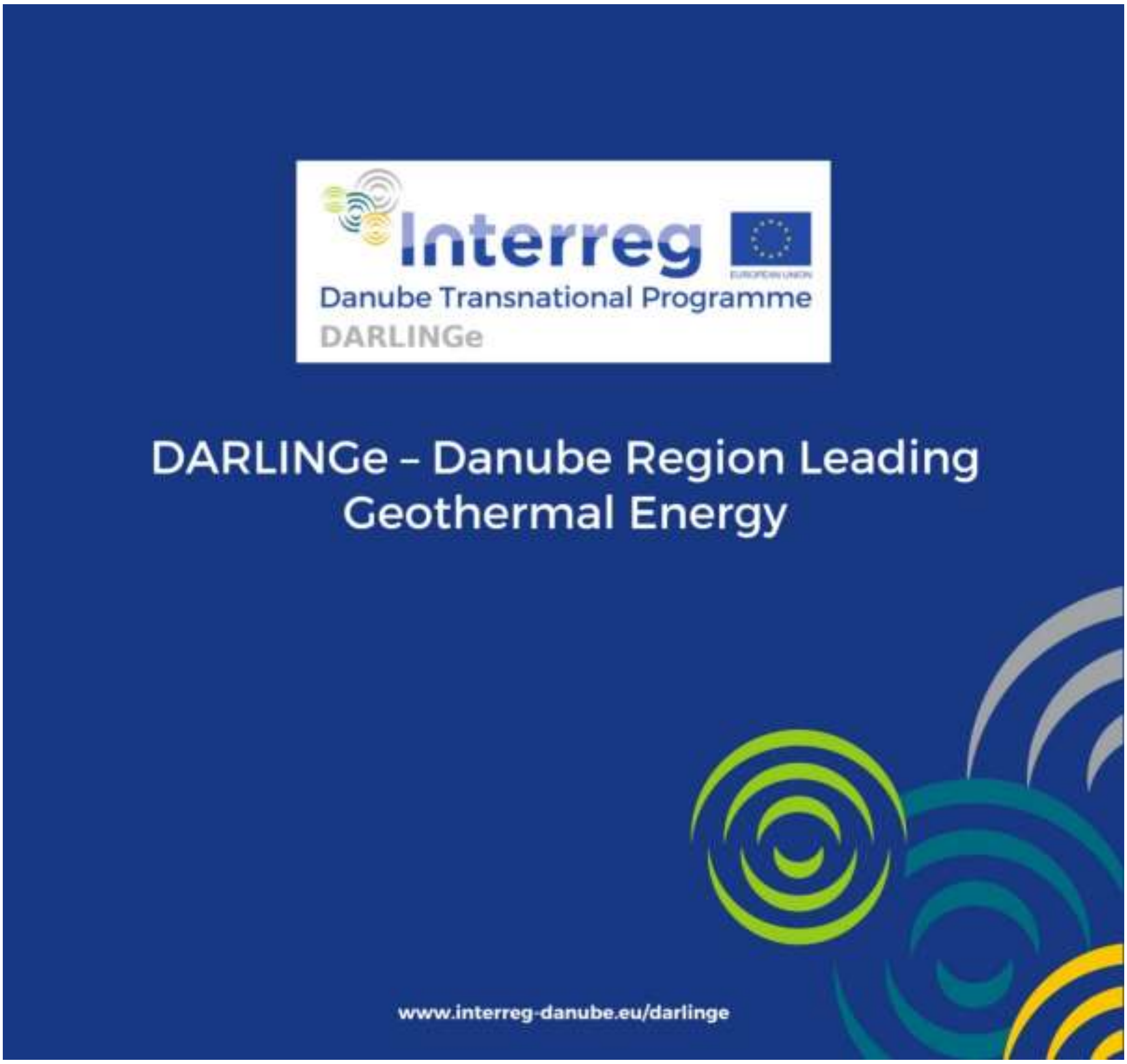

D.4.1.1. Report on the conceptual model of the DRGIP

December 2017

D.4.1.1. Report on the conceptual model of the DRGIP

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1. Introduction to the DARLINGe project

1.1. DARLINGe objectives, results and outputs

15 Project Partners representing geological surveys, universities, industry, regional energy and development agencies, ministries and municipalities, assisted by 7 Associated Strategic Partners from Hungary, Slovenia, Croatia, Serbia, Bosnia and Herzegovina and Romania are working together to improve energy security and efficiency in the Danube Region by promoting sustainable utilization of the existing, however still largely untapped deep geothermal resources in the heating sector, as a main objective. The project area covers the central and south-eastern part of the Danube Region, encompassing southern Hungary (southern Transdanubia and southern part of the Great Plain), north-eastern Slovenia (Pomurska and Podravska), northern Croatia (Slavonia), the northern parts of Bosnia and Herzegovina, northern Serbia (Vojvodina) and western Romania (Crisana and Banat), altogether about 95,000 km^2.

The specific objectives of the project are:

- to increase the use of geothermal energy and help the penetration of energy efficient cascade systems (where users are sequentially linked according to their decreasing heat demand) and matching them with heat-markets
- to establish a market-replicable tool-box consisting of 3 complementary modules for sustainable management of geothermal resources (an independent indicator-based benchmark evaluation of current uses, a decision tree to help developers, and a geological risk mitigation scheme to maximize the success rate of a first geothermal well reaching the expected yield and temperature),
- to advance stakeholder cooperation (establishment of a Transnational Stakeholder Forum) to foster geothermal developments and to create a strong geothermal value chain.

As a main result the intensity of cooperation among key players of the geothermal sector in the participating six countries will increase and contribute to energy security and energy efficiency by increasing the use of geothermal energy in the heating sector, which will make the Danube Region less dependent on imported fossil fuels, also respecting the environment.

Project outputs include:

- various workshops and training materials including site visits for stakeholders,
- Danube Region Geothermal Information Platform (interactive web-portal),
- Transnational Geothermal Strategy
- Danube Region Geothermal and Action Plans,
- tool-box to assist management of transboundary geothermal resources tested at 3 cross-border pilot areas.

1.2. Introduction of present report

This report shows the process of setting up a conceptual model of The Danube Region Geothermal Information Platform (hereinafter referred to as DRGIP), the joint and harmonised entry point for all spatially-referenced information collected and evaluated during the DARLINGe project.

The structure of this report is as follows:

In chapter 2 we summarize what the DRGIP is and why its development is important.

In chapter 3 we briefly introduce the theory behind the process of data modelling.

In chapter 4 we introduce the INSPIRE Directive.

In chapter 5 we introduce Mapping of DARLINGe conceptual model to INSPIRE Directive data specifications.

In chapter 6 we describe tables and code-lists included in the conceptual model of the database.

In chapter 7 we introduce Metadata and how they are important for the DARLINGe project.

Chapter 8 summarizes up all previous chapters and being presented as Conceptual model of the DRGIP.

2. Role and requirements of DRGIP

DRGIP (The Danube Region Geothermal Information Platform) is one core output of the DARLINGe project and represents the joint and harmonised entry point for all spatially-referenced information collected and evaluated during the project. It will be hosted at the GeoZS (PP4) server and will provide evaluated and processed data in a user-friendly innovative tool, demand-tailored to stakeholders needs. It jointly presents all spatial technical and non-technical information of WP5-7. Using it, faster and especially easier growth of the geothermal energy sector in the Danube Region is expected.

This output will hopefully act as an interface between experts from public authorities, private market (e.g. geothermal project developers, or energy suppliers) and the scientific community as well as the inhabitants of the project area. It intends to address both, stakeholders from pilot areas as well as other areas of Danube Region and beyond. It will contain all outcomes concerning harmonized workflows and standards (TWP2), the up scaled energy planning strategies (TWP4) and general communication tools like yellow pages.

The development of DRGIP will follow the rules, standards already used in previous projects such as OneGeology-Europe, EuroGeoResource, Minerals4EU etc.

The results of the DARLINGe project will also complement and support GeoERA. The ERA-NET GeoERA (Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe) has the overall goal of integrating the national geological surveys information and knowledge on subsurface energy, water and raw material resources, to support sustainable use of the subsurface in addressing Europe's grand challenges. The GeoERA transnational research projects will among other things address the development of interoperable, pan-European data and information services on the distribution of geo-energy including geothermal energy.

The DRGIP will contribute to an effective and lasting system designed for welcoming various datasets related to geothermal resources and facilitating data updates and maintenance, and for facilitating their visualization and their use.

ROAD MAP for the implementation of the DRGIP can be presented in 9 working steps:
1. Conceptual model – final version should be confirmed in Period 2;
2. Setting up DARLINGe Geodatabase v1.0 (empty database) – INSPIRE Data Specification – distribution to all PP;
3. First data input – Geodatabase DARLINGe v 1.1;
4. Last data input – Geodatabase DARLINGe v 1.2;
5. Creating services 1st time;
6. Implementation of the DRGIP v.1 ;
7. Testing DRGIP v.1 by PP:
   - Geodatabase DARLINGe v 1.3,
   - Creating services 2nd time,
   - Corrections of the DRGIP;
8. The final version DRGIP;
9. Creating service of the entire geodatabase / or physical distribution of the last geodatabase.

2.1. Requirements for the DRGIP

All project partners were asked to consider in advanced, what kind of functionalities they would want to be implemented in the DRGIP. They compare already existing web-based geothermal information systems, such as:
ThermoGIS (http://www.thermogis.nl/thermogis_en.html)
GeoTIS (https://www.geotis.de/)
EGIP (http://www.geothermaleranet.is/joint-activities/egip/)
Geo-DH (http://geodh.eu/)
Geoelec (http://www.geoelec.eu/test-geoelec-online-viewer/)
GeoMol (http://www.geomol.eu/home/index_html)
TRANSENERGY (http://transenergy-eu.geologie.ac.at/)
THERMOMAP (http://geoweb2.sbg.ac.at/thermomap/)
Partners were asked to answer following questions, while comparing different webmaps:

- What you want to be presented in DRGIP and what functionalities should be included?
- What requirements the DRGIP should fulfil and which queries you would like to have in?
- Is there any specific question to be addressed?

Five (5) project partners prepared their suggestions of possible functionalities, which DARLINGe project could offer within DRGIP. Following there are their suggestions presented in more detail.

2.1.1. Comments from MANNVIT – Geothermal Energy Consultants (Hungary)

Among the presented GIS examples the webmap of TransEnergy project seems to be the most efficient and user-friendly visualization technic to provide solution for DRGIP (Danube Region Geothermal Informational Platform). MANNVIT supports to develop the DRGIP according to the webmap of TransEnergy project.

Based on the discussions during the kick off meeting it is anticipated that much less input data will be available for DARLINGe as it was the case at TransEnergy project. On Figure 1 the items of TransEnergy webmap content are indicated, and some of them were highlighted as suggested items to be implemented in the frame of DRGIP. Below some explanations connected to the figure are listed:

- Taking into consideration the climate of the Pannonian basin the economic feasibility of a resource for electricity production is getting to be viable above 120 °C. It is suggested to use 120 °C instead of 100 °C. This way the parties interested for electricity production might get a more appropriate interpretation result.
- The successful harmonization of nomenclature of water-bearing Miocene layers among 6 participating countries seems stupendous feat. It might be enough to merge these layers into one labelled as “Miocene”.
- The reservoir located in sandstone layers of late Pannonian age has wide area coverage, and the division of expected highest reservoir temperature by 20 °C could be a useful support for end-users.

Beside the TransEnergy project there are several items of other projects, which might be useful to implement into DRGIP. These are listed below:

- From GeoElec webmap application the Theoretical and Technical Potential.
- From ThermoGIS World Edition -Aquifers application the Performance Indicator for greenhouse, spatial and cooling.
- From GeoTIS webmap application the characterization of installations by capacity and volume.
- From GeoDH project the cities with district heating systems and with geothermal district heating systems.

The database of GeoDH should be developed further eg. collecting data about the size of district heating system (MW and sold GJ/annum). The indication of town without existing district heating system is also recommended. It is worth to present settlements with population higher than 2000. In Table 1 the Hungarian settlements with geothermal systems are listed. Their distribution according to population is depicted on Figure 2. The list is presumably not complete, but most of the system is included. It is visible form the figure that numerous geothermal systems connected to settlements which's population is less than 20.000. It is anticipated that many future project will be connected to such a small town, even if they have no registered district heating system, or a system with observable size.

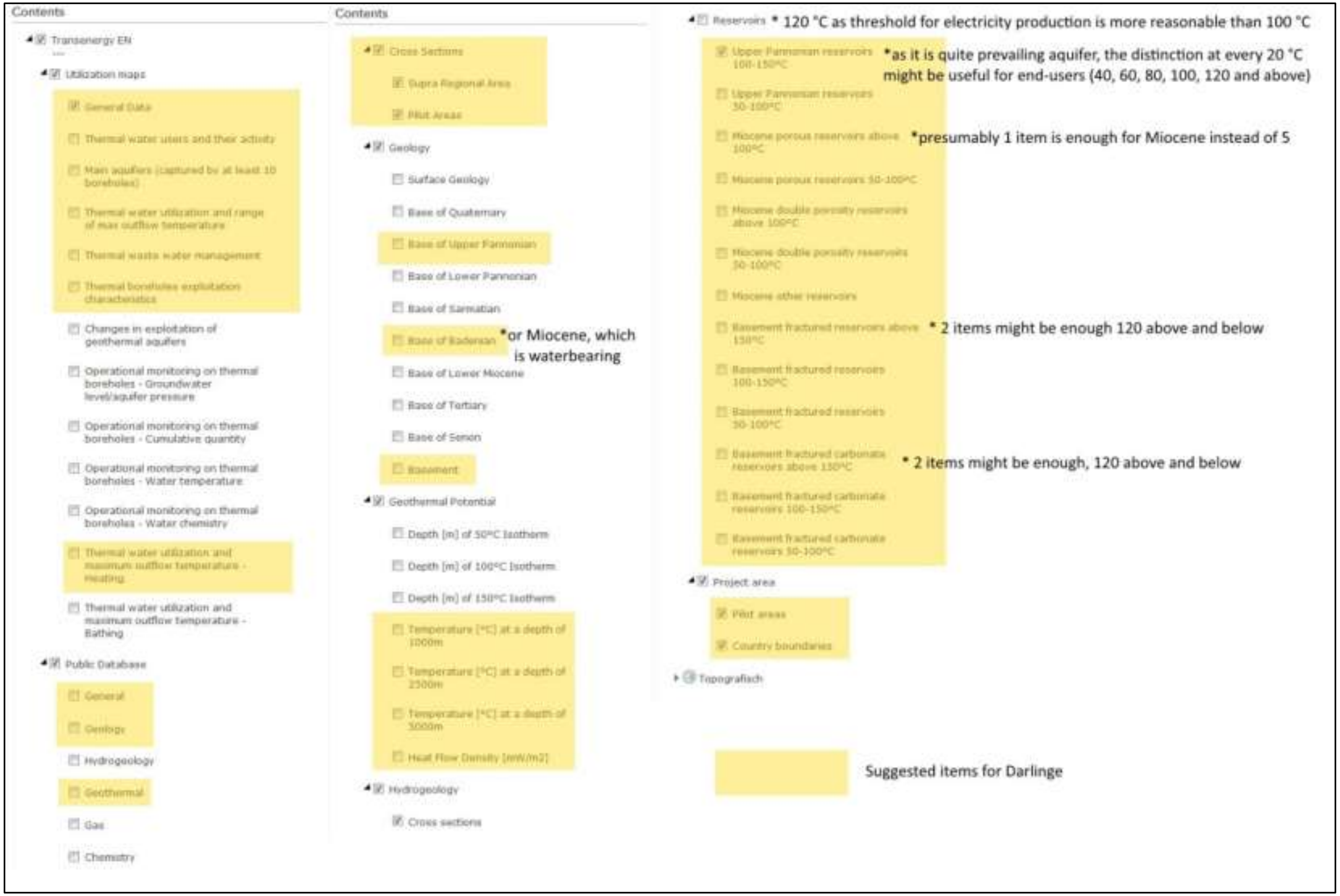

Figure 1: Suggested items from TransEnery webmap for DRGIP webmap

Table 1: Settlements of Hungary using geothermal energy for district heating

County	Settlement	Population
Pest megye	Újszilvás	2562
Csongrád megye	Kistelek	7033
Jász-Nagykun-Szolnok megye	Cserkeszőlő	2218
Fejér megye	Gárdony	10206
Csongrád megye	Mórahalom	5938
Vas megye	Vasvár	4266
Baranya megye	Szentlőrinc	6465
Somogy megye	Nagyatád	10623
Baranya megye	Bóly	3887
Baranya megye	Szigetvár	10656
Pest megye	Veresegyház	17025
Csongrád megye	Makó	22926
Jász-Nagykun-Szolnok megye	Törökszentmiklós	20626
Csongrád megye	Csongrád	16564
Tolna Megye	Tamási	8179
Csongrád megye	Szeged	162595
Csongrád megye	Hódmezővásárhely	44795
Békés megye	Szarvas	16275
Csongrád megye	Szentes	27898
Jász-Nagykun-Szolnok megye	Szolnok	72768
Borsod-Abaúj-Zemplén megye	Miskolc	159554
Győr-Moson-Sopron	Győr	129372

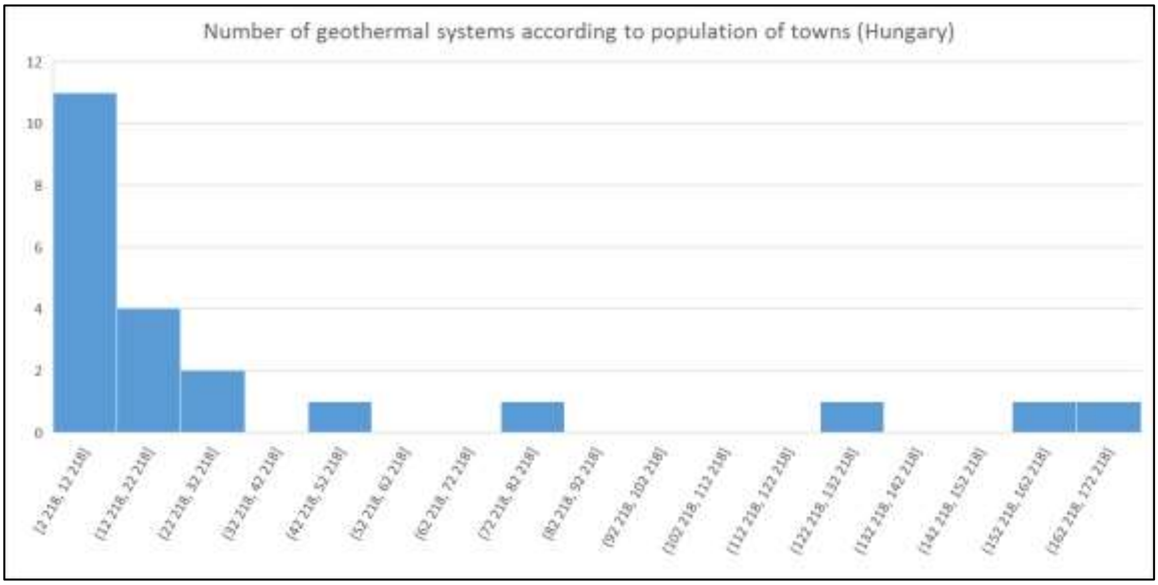

Figure 2: Number of geothermal systems in Hungary according to number of population

2.1.2 Comments from Federal Institute for Geology Sarajevo (FZZG), Bosnia and Hercegovina

FZZG have reviewed existing web-based geothermal information systems and for their point of view Geothermal Information System of Germany (GeoTIS) is simple and most useful. FZZG proposes that the DRGIP should be able to present:

1. Database of boreholes,
2. Maps of temperature at 500, 1000 and 2000 m depth,
3. Heat flow density map,
4. Geothermal gradient map,
5. Utilization map,
6. Map of potential areas for exploration and utilization of geothermal energy and
7. Cross-sections.

2.1.3. Comments from Belgrade University (FMG), Serbia

After review of the existing web-based systems (ThermoGIS, GeoTIS, EGIP, Geo-DH, Geoelec , GeoMol, TRANSENERGY) FMG finds that GeoTIS has the most compatible structure to DARLINGe project, with very well organized data, clear data overview and good data interpretation. For future DARLINGe project stakeholders and other potential geothermal energy consumers it is very important to show current state of geothermal usage: electricity generation, district heating, balneology, greenhouse... (GeoTis layer installations) as well as to show project results, thus outcomes (map view, table and/or graph view).

GeoTIS has very comprehensive database and in this very moment we do not know yet availability and quality of data for whole project area. Many of these layers will depend of spatial distribution of existing data, but it is good to have good web based model for modification.

In general FMG suggests keeping it simple and making portal very clear for future users. Thus maybe to establish three levels of data interpretation and data presentation should be established:

1. Map
    - basemap (background map): topography map, geological map, terrain model;
    - boundaries on map: state border line, project area, pilot area, potential aquifer delineation (sandstone and limestone), delineation of potential areas for electric generation (if there is one), for space heating, for balneology...;
    - symbols on map: wells, districts heating, space heating, balneology, greenhouses, cascade use...;
    - thematic data (highly depend on joint database quality): fault zones, geological cross sections, heat flow density, predicted temperatures by depth (data that will be useful for geoscientists)...
2. Table/graph
    - database of existing wells with main characteristics;
    - database of existing systems as districts heating, space heating...;
    - heat market analysis data.
3. Text

- project description in general;
- educational character: what is geothermal in general, how to exploit, field of usage;
- Guidelines for future investors: legislative on state level, roadmap for geothermal exploitation (for electricity production, district heating,...) based on state regulative...

Looking for the possibilities in print options, FMG suggests one or two pages as brochure, basic data for some potential area on national level with main characteristics, some flowcharts, etc.

2.1.4. Comments from Mining and Geological Survey of Hungary (MBFSZ), Hungary

MBFSZ suggested, that three (3) main types of info should be displayed:
- polygons/grids (various maps, contents should be defined later, e.g. geology, subsurface temperature distribution etc.). Not only „geoscientific maps" (e.g. like in Transenergy"), but interpreted (e.g. „technical potential- Geoelec" – in this case the calculation method has to be described, or simple „traffic light" maps);
- point source information with pop-up windows (e.g. for users)- good example on GeoTIS: separated on different layers according to different utilization groups (not different colours in the same layer like in Transenergy). Basic info in pop-up should appear;
- supplementary data/information (texts, graphs) like e.g. „energy statistics" in GeoTIS .

Zoom in function should consider the scale of the maps; however zoom on points (e.g. balneological site) should be possible.

When designing interactivity (e.g. plotting several maps on each other) visualizing of the different thematics is important (e.g. you cannot see contour lines or patches from each other). Maybe to define in advance the possible combinations to exclude those ones which have no meaning (e.g. to combine basement topography with surface geology).
Nice introduction page (also according to communication requirements, logo etc.), easy to navigate and find the map service immediately (e.g. GeoTIS, GeoDH), with a logical arrangement of infos (GeoTIS is a very good example) is very important.
Source and references for each map/thematic should be shown (e.g. Geothermal Atlas of Europe, from other projects, etc.) and "terms of use"/"disclaimer" at the beginning (copyright issues) clearly stated.

Other comments from MBFSZ are focusing on what already exists. In most these websites miss info from SRB, HR and BH (these countries are also missing from the Geothermal Atlas of Europe), i.e. it is foreseen that these countries need extra effort to produce maps, which already exist for SLO, HU and RO.

Recommended „extra" layers:
- NUTS-3 regions (GeoDH);
- heat demand: http://heatroadmap.eu/resourcesbycountry.php;
- cities with district heating infrastructure (some info in pop up window, number of habitants, etc. – GeoTIS;
- cities with geothermal DH: EGEC market report/country updates (some info in pop up window, e.g. installed capacity, annual production – GeoDH).

In general MBFSZ found GeoTIS as the most suitable example to follow in DARLINGe project.

2.1.5. Comments from Geological Survey of Slovenia (GeoZS), Slovenia

GeoZS found the GeoTIS the most efficient and user friendly viewer which should be modified for the needs of the DRGIP. Selecting and filtering different areas is user friendly and quickly. User can focus on the whole project area or only on pilot areas. Queries are simple and easy to use. The main menu bar is well organized and offers a lot of function (also restarting the map). Every view or query can be exported as PDF which is well organized.

Things that could be improved in DARLINGe project:

- Legend should be in separate window (e.g. floating legend)
- 3D viewer as from GEOMOL should be adopted.

The DRGIP should include all types of digital data: point (e.g. wells), line (e.g. cross-sections), polygon (e.g. lithology) and raster data(e.g. geometry of horizons).

2.1.6. Comments from Geological Institute of Romania (IGR), Romania

IGR considers that GeoTIS is a very good and complex portal. It has very many layers with information on geology, geophysics and use of geothermal energy. However, GeoTIS structure is too complex, with layers grouped in folders (logically, but not very common for the non-GIS users). In our opinion, the legends are also difficult to follow. On the other hand, for the stakeholders, TransEnergy webmap seems to be easier to use, offering from the beginning all the information as maps and images easy to download.

We propose to include in the DRGIP the maps of NUT3 regions and information about settlements in the project area and the type of used heating system, in order to assess the zones with geothermal potential which could be used for heating in localities which presently use mainly wood or fossil fuels.
In DARLINGe proposed DRGIP, not so many geophysical and geological data (e.g. seismic sections, lithological columns etc.) could be available in the short time span (2.5 years) for finalizing the project. Thus, the DRGIP structure should be simpler than in GeoTIS.

2.1.7. Summary of comparisons

Table below (Table 2) shows which already existing web-based geothermal information systems can form the basis for the development of the DRGIP, according to the opinion of the individual project partner.

Table 2: The relevance of the existing web-based geothermal information system according to the project partner opinions

	Transenergy	GeoDH	GeoTIS	GeoELEC	ThermoGIS	''Heat demand''	NUTS-3 regions
MANNVIT	++	+	+	+	+		
FZZG			++				
MFG			++				
GeoZS	+	+	++				
MFGI	+	+	++	+		+	+
IGR	++		+			+	+

It was concluded, that DARLINGe project will follow GeoTIS information system with the use of all the best solution from TRANSENERGY project.

3. Data modelling

Data modelling in software engineering is the process of creating a data model for an information system by applying formal data modelling techniques.

Data modelling is a process used to define and analyse data requirements needed to support the business processes within the scope of corresponding information systems in organizations. Therefore, the process of data modelling involves professional data modellers working closely with professionals of geothermal energy, business stakeholders, as well as potential users of the information system.

There are three different types of data models produced while progressing from requirements to the actual database to be used for the information system. [2] The data requirements are initially recorded as a conceptual data model which is essentially a set of technology independent specifications about the data and is used to discuss initial requirements with the business stakeholders. The conceptual model is then translated into a logical data model, which documents structures of the data that can be implemented in databases. Implementation of one conceptual data model may require multiple logical data models. The last step in data modelling is transforming the logical data model to a physical data model that organizes the data into tables, and accounts for access, performance and storage details. Data modelling defines not just data elements, but also their structures and the relationships between them.

Data modelling techniques and methodologies are used to model data in a standard, consistent, predictable manner in order to manage it as a resource.

3.1. Conceptual, logical and physical schemas

In 1975 ANSI (American National Standards Institute) described three kinds of data-model instance:

- Conceptual schema: describes the semantics of a domain (the scope of the model). For example, it may be a model of the interest area of an organization or of an industry. This consists of entity classes, representing kinds of things of significance in the domain, and relationships assertions about associations between pairs of entity classes. A conceptual schema specifies the kinds of facts or propositions that can be expressed using the model. In that sense, it defines the allowed expressions in an artificial "language" with a scope that is limited by the scope of the model. Simply described, a conceptual schema is the first step in organizing the data requirements.
- Logical schema: describes the structure of some domain of information. This consists of descriptions of (for example) tables, columns, object-oriented classes, and XML tags. The logical schema and conceptual schema are sometimes implemented as one and the same.
- Physical schema: describes the physical means used to store data. This is concerned with partitions, CPUs, table spaces, and the like.

Data modelling is also used as a technique for detailing business requirements for specific databases. It is sometimes called database modelling because a data model is eventually implemented in a database.

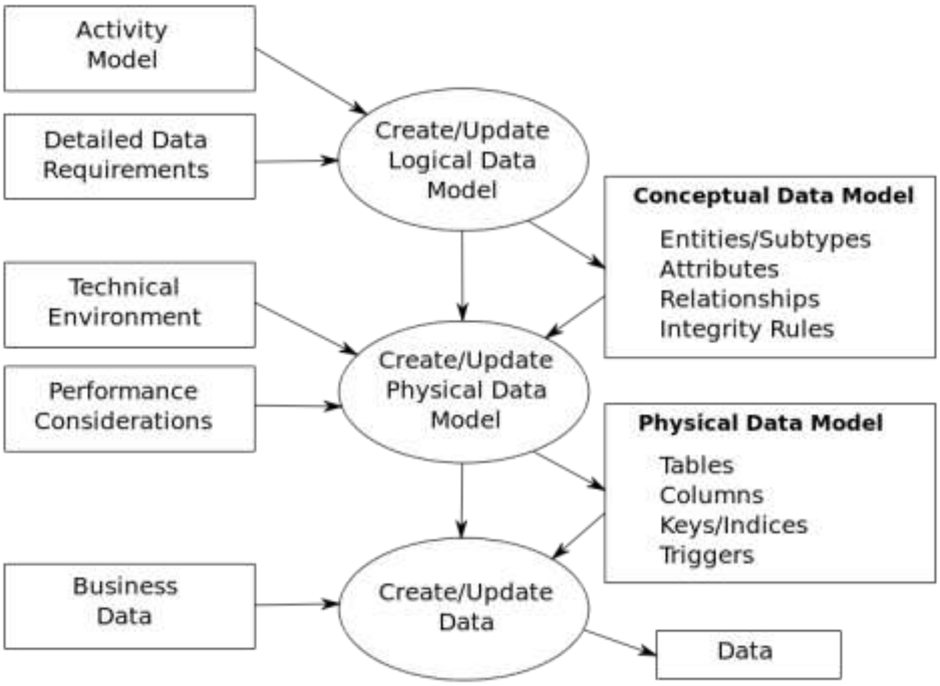

Figure 3: The data modelling process

The above figure (Figure 3) illustrates the way data models are developed and used today. A conceptual data model is developed based on the data requirements for the application that is being developed, perhaps in the context of an activity model. The data model will normally consist of entity types, attributes, relationships, integrity rules, and the definitions of those objects. This is then used as the start point for interface or database design.

3.2. Conceptual data model

A conceptual schema is a high-level description of a business's informational needs. It typically includes only the main concepts and the main relationships among them. Typically this is a first-cut model, with insufficient detail to build an actual database. This level describes the structure of the whole database for a group of users. The conceptual model is also known as the data model as data model can be used to describe the conceptual schema when a database system is implemented. It hides the internal details of physical storage and targets on describing entities, data type, relationships and constraints.

A conceptual schema or conceptual data model is a map of concepts and their relationships used for databases. This describes the semantics of an organization and represents a series of assertions about its nature. Specifically, it describes the things of significance to an organization (entity classes), about which it is inclined to collect information, and characteristics of (attributes) and associations between pairs of those things of significance (relationships).

The model does allow for what is called inheritance in object oriented terms. The set of instances of an entity class may be subdivided into entity classes in their own right.

A data structure diagram (DSD) is a data model or diagram used to describe conceptual data models by providing graphical notations which document entities and their relationships, and the constraints that bind them. We used this diagram also for representing conceptual model of DARLINGe project.

3.3. Logical data model

A logical data model or logical schema is a data model of a specific problem domain expressed independently of a particular database management product or storage technology (physical data model) but in terms of data structures such as relational tables and columns, object-oriented classes, or XML tags. This is as opposed to a conceptual data model, which describes the semantics of an organization without reference to technology.

Logical data models represent the abstract structure of a domain of information. They are often diagrammatic in nature and are most typically used in business processes that seek to capture things of importance to an organization and how they relate to one another. Once validated and approved, the logical data model can become the basis of a physical data model and form the design of a database.

Logical data models should be based on the structures identified in a preceding conceptual data model, since this describes the semantics of the information context, which the logical model should also reflect. Even so, since the logical data model anticipates implementation on a specific computing system, the content of the logical data model is adjusted to achieve certain efficiencies.

The term 'Logical Data Model' is sometimes used as a synonym of 'domain model' or as an alternative to the domain model. While the two concepts are closely related, and have overlapping goals, a domain model is more focused on capturing the concepts in the problem domain rather than the structure of the data associated with that domain.

When ANSI first laid out the idea of a logical schema in 1975, the choices were hierarchical and network. The relational model – where data is described in terms of tables and columns – had just been recognized as a data organization theory but no software existed to support that approach. Since that time, an object-oriented approach to data modelling – where data is described in terms of classes, attributes, and associations – has also been introduced.

The relational model (RM) for database management is an approach to managing data using a structure and language consistent with first-order predicate logic, first described in 1969 by Edgar F. Codd, where all data is represented in terms of tuples, grouped into relations. A database organized in terms of the relational model is a relational database.

The purpose of the relational model is to provide a declarative method for specifying data and queries: users directly state what information the database contains and what information they want from it, and let the database management system software take care of describing data structures for storing the data and retrieval procedures for answering queries.
Most relational databases use the SQL data definition and query language; these systems implement what can be regarded as an engineering approximation to the relational model. A table in an SQL database schema corresponds to a predicate variable; the contents of a table to a relation; key constraints, other constraints, and SQL queries correspond to predicates. However, SQL databases deviate from the relational model in many details, and Codd fiercely argued against deviations that compromise the original principles.

3.4. Physical data model

A physical data model (or database design) is a representation of a data design as implemented, or intended to be implemented, in a database management system. In the lifecycle of a project it typically derives from a logical data model, though it may be reverse-engineered from a given database implementation. A complete physical data model will include all the database artefacts required to create relationships between tables or to achieve performance goals, such as indexes, constraint definitions, linking tables, partitioned tables or clusters. Analysts can usually use a physical data model to calculate storage estimates; it may include specific storage allocation details for a given database system.

Physical schema is a term used in data management to describe how data is to be represented and stored (files, indices, et al.) in secondary storage using a particular database management system (DBMS) (e.g., Oracle RDBMS, Sybase SQL Server, etc.).

In the process of database modelling considering DARLINGe project, we are currently in the stage of conceptual modelling, which is the subject of this report and will be represented in next chapters.

4. INSPIRE Directive – general information

General information of the following chapter are summarized from the INSPIRE KNOWLEDGE BASE internet page (https://inspire.ec.europa.eu/).

INSPIRE is "an EU initiative to establish an infrastructure for spatial information in Europe that is geared to help to make spatial or geographical information more accessible and interoperable for a wide range of purposes supporting sustainable development".

The INSPIRE Directive aims to create a European Union spatial data infrastructure for the purposes of EU environmental policies and policies or activities which may have an impact on the environment. This European Spatial Data Infrastructure will enable the sharing of environmental spatial information among public sector organizations, facilitate public access to spatial information across Europe and assist in policy-making across boundaries.

Environmental problems do not stop at the borders. Solving them often requires cooperation between countries, which is more successful when it is easy to share data across borders and organizations. There are benefits associated with the effective and efficient collection and sharing of data linked to a particular location (spatial data).

The Directive came into force on 15 May 2007 and will be implemented in various stages, with full implementation required by 2021.

INSPIRE constitutes a future framework for NSDI's within EU Member States. For this reason, INSPIRE guidelines can be considered mandatory for all future activities of NSDI. INSPIRE is a framework Directive. More detailed technical instructions are defined by implementation rules and technical guidelines. INSPIRE is based on existing spatial data infrastructures of the Member States and demands no new gathering of data, but it does demand harmonization of existing data.

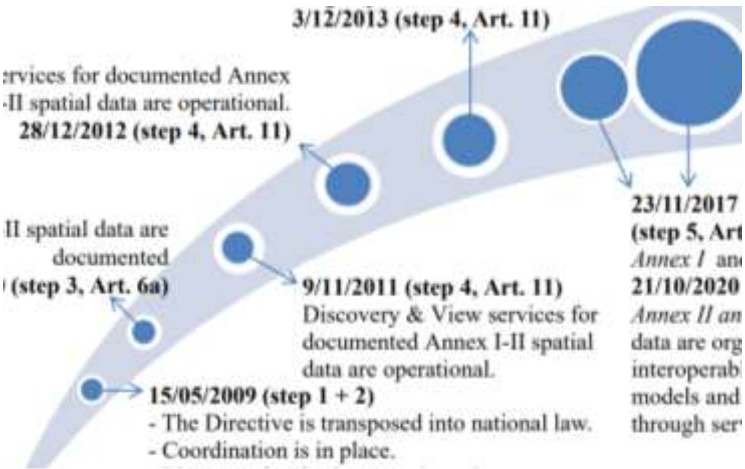

Figure 4: INSPIRE implementation roadmap - major milestones

Main components of the INSPIRE Directive are:

- metadata,
- interoperability of spatial data and services,
- services (discovery, viewing, downloading, transformation and invoke),
- joint use of spatial data and services,
- coordination and supervision and reporting measures.

INSPIRE is based on a number of common principles:

Data should be collected only once and kept where it can be maintained most effectively.

It should be possible to combine seamless spatial information from different sources across Europe and share it with many users and applications.

It should be possible for information collected at one level/scale to be shared with all levels/scales; detailed for thorough investigations, general for strategic purposes.

Geographic information needed for good governance at all levels should be readily and transparently available.

Easy to find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used.

One of the main tasks of the INSPIRE program is to enable the interoperability and, where practicable, harmonization of spatial data sets and services within Europe. Interoperability has to go beyond any particular community, but take the various cross-community information needs into account.

Examples of interoperability components addressed by INSPIRE are: rules for application schemas, coordinate referencing and units model, identifier management, multi-lingual text and cultural adaptability, object referencing modelling, multiple representations (levels of detail) and consistency, and more. All these components do apply to (nearly) all themes identified within INSPIRE. The conceptual modelling framework of INSPIRE is based in the ISO 19100 series of International Standards.

INSPIRE is based on the infrastructures for spatial information established and operated by the Member States of the European Union. The Directive addresses 34 spatial data themes needed for environmental applications in 3 annexes:

ANNEX: 1

- Addresses
- Administrative Units
- Cadastral Parcels
- Coordinate Reference Systems
- Geographical Grid Systems
- Geographical Names
- Hydrography
- Protected Sites
- Transport Networks

ANNEX: 2

- Elevation
- Geology
- Land Cover
- Orthoimagery

ANNEX: 3

- Agricultural and Aquaculture Facilities
- Area Management/Restriction/Regulation Zones and Reporting Units
- Atmospheric Conditions and Meteorological Geographical Features
- Bio-geographical Regions
- Buildings
- Energy Resources
- Environmental Monitoring Facilities
- Habitats and Biotopes
- Human Health and Safety
- Land Use
- Mineral Resources
- Natural Risk Zones
- Oceanographic geographical features
- Population Distribution
- Production and Industrial Facilities
- Sea Regions
- Soil
- Species Distribution
- Statistical Units
- Utility and Government Services

To ensure that the spatial data infrastructures of the member states are compatible and usable in a community and transboundary context, the INSPIRE Directive requires that additional legislation or common Implementing Rules (IR) are adopted for a number of specific areas (metadata, interoperability of spatial data sets and services, network services, data and service sharing and monitoring and reporting). These are published either as Commission Regulations] or as Decisions.

The Commission is assisted in the process of adopting such rules by a regulatory committee, INSPIRE Committee, composed of representatives of the member states and chaired by a representative of the Commission (this is known as the Comitology procedure).

In order to assist with the integration of national infrastructures into INSPIRE, Member States need to provide access to their infrastructures through the EU Geoportal (INSPIRE Geoportal), managed by the European Commission, as well as through other access points which Member States decide to manage.

For more information on the INSPIRE Directive, go to http://INSPIRE.jrc.ec.europa.eu/ .

For more information on the INSPIRE Geoportal, go to http://www.INSPIRE-geoportal.eu/ .

5. Mapping of DARLINGe conceptual model to INSPIRE Directive data specifications

To ensure that the spatial data infrastructures of the Member States (in our case Hungary, Croatia, Slovenia and Romania) are compatible and usable in a transboundary context, we implemented some common rules of INSPIRE Directive in our conceptual model.

Even though INSPIRE Directive is broad and generic in contrast with the project DARLINGe, which is focused and specific, it was decided to use INSPIRE at four parts (whenever applicable):

- Conceptual model of the database (basis for web application);
- Discovery (CSW), View (WMS) and Download services (WFS) services (for certain data only – public data);

Content of DARLINGe project corresponds to the following annexes of INSPIRE Directive:

- ANNEX II: Geology (D2.8.II.4 Data Specification on Geology);
- ANNEX III: Energy resources (D2.8.III.20 Data Specification on Energy Resources);
- ANNEX II and III: Observations & Measurements and Sensor Web Enablement (D2.9 Guidelines for the use of Observations & Measurements and Sensor Web Enablement-related standards in Annex II and III data specification development);
- ANNEX III: Production and Industrial Facilities (D2.8.III.8 INSPIRE Data Specification on Production and Industrial Facilities –Technical Guidelines);
- EN ISO 19115 (INSPIRE Metadata Implementing Rules: Technical Guidelines based on EN ISO 19115 and EN ISO 19119).

Following figure (Figure 5) represents the connections between INSPIRE Directive and conceptual model of the DARLINGe database.

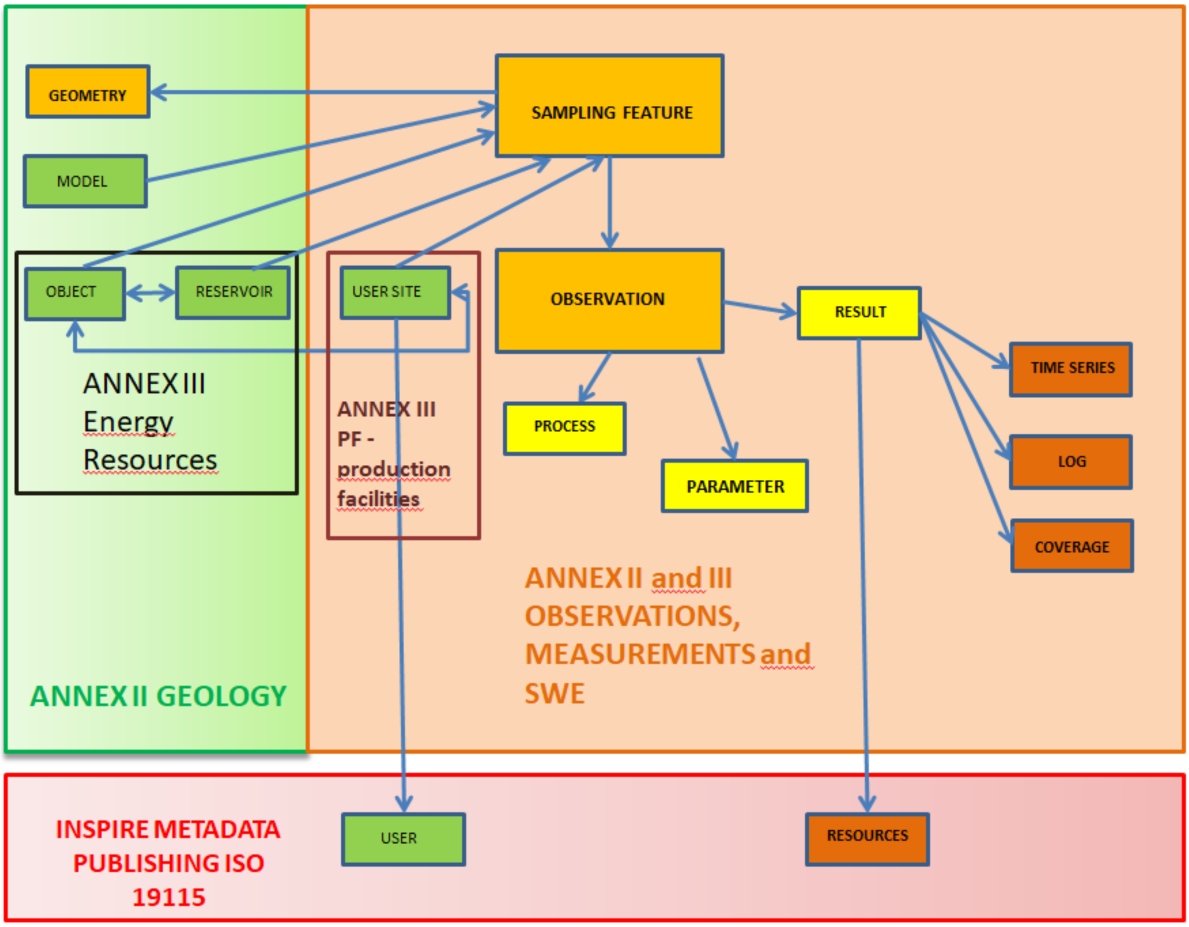

Figure 5: DARLINGe and INSPIRE

For the DARLINGe project INSPIRE view and download (WMS and simple feature WFS) services will be provided from the database for some key layers based on stored data and geometry (more details are described in chapter 7 – Metadata catalogue). Key layers, specific to DARLINGe project will be Reservoir with connection to Aquifer System, User Site with connection to the Production Facility, information connected to Well, etc.

Following, mapping of DARLINGe conceptual model to INSPIRE Directive data specifications is described. Examples of presented code lists are not INSPIRE code-lists, but DARLINGe project-oriented code-lists. They can be modified and extended considering the future data.

5.1. Sampling Feature entity

As shown on Figure 5, the main connections between INSPIRE Directive and conceptual model of the DARLINGe database go through entity **Sampling Feature** (INSPIRE D2.9 Guidelines for the use of Observations & Measurements), which is an abstract class to model spatial objects that are associated with observations.

Sampling feature should have 2 attributes:

- SamplingFeatureType (from code list)
- geometry:

- point() for boreholes, wells, sites(?)
- linestring() for profiles,
- polygon() for countourMap, rasterMap and reservoirs.

This geometry contains the location or outline of the related feature and is used for discovery and view services.

The example of code list for SamplingFeatureType is shown below, but it can be extended considering the future data.

Table 3: Code list for SamplingFeatureType

Sampling_feature_type
curveModel
HG object
reservoire
surfaceModel
usersite

Specific sampling features are **a) <u>Models</u> <u>b) Measurements,</u> <u>c) Hydrogeological objects,</u> <u>d) Reservoirs and</u> <u>e) Usersites.</u>**

a) Model (ANNEX II: Geology)

Model should have Subtype from code list. The example of code list for model Subtype is shown below, it can be extended considering the future data:

Table 4: Model Subtype

Model_Subtype
geologicalProfile
hydrogeologicalProfile
temperatureMap
porosityMap
compositLog
geothermal
reservoir

b) Measurement (ANNEX II: Geology)

As we don't have data of such measurements, linked to sampling feature (they are more or less connected to geophysical measurements of earthquakes etc.), we currently didn't include it in the database model. We can extend the data model later.

c) HidrogeologicalObject (ANNEX II: Geology and ANNEX III: Energy Resources)

Currently there are three types of HG objects in the database (active well spring and borehole. This is not INSPIRE compliant structure, but our current decision on existing data. We will adopt change the conceptual model according to final results (gathered data) in the project.
Code lists for HG objects are INSPIRE compliant (ANNEX II):

Table 5: Object purpose codelist

OBJECT_PURPOSE_CODELIST		
Purpose_ID	**Purpose**	**Purpose_description**
1	production	it is used for water production
2	reinjection	it is used for reinjection
3	production and reinjection	it is used for both
4	monitoring	it is used only for monitoring, no production or reinjection occurred in the last 10 years (except for sampling water for monitoring)

Table 6: Object activity codelist

OBJECT_ACTIVITY_CODELIST		
Activity_ID	**Activity**	**Activity_description**
1	continuously	well is used all over the year with minor stops
2	occasional	well is used only for short unsystematic periods (e.g. emergency…)
3	periodically	well is used in a repeated sequence, e.g. every summer or every winter time
4	inactive	no water is produced or reinjected
5	no information	no information available

ANNEX III ER for object is also included in the model (e.g. vertical extent etc.)

d) Reservoir (ANNEX II: Geology and ANNEX III: Energy Resources)

Code list for Reservoirs are INSPIRE compliant (ANNEX II):

Table 7: Aqui type porosity codelist

AQUI_TYPE_POROSITY_CODELIST	
Type_aqui_por _ID	**Type_aqui_por_description**
1	porous
2	fractured
3	karstic
4	compound
5	karstic and fractured
6	porous and fractured
7	other

Table 8: Hydraulic connections codelist

HYDRAULIC_CONNECTIONS_CODELIST	
Connections_hydr_ID	**Connect_hidr_description**
1	Part of regional gravitational flow system
2	Partly connected to regional gravitational flow system
3	Partly stagnant, locally connected to regional gravitational flow system
4	Mainly stagnant, partly connected to regional gravitational flow system
5	Stagnant water

ANNEX III ER for reservoirs is also included in the model (e.g. vertical extent etc.)

e) Usersite (ANNEX III: Production facilities)

Usersite represents the geographical location of the facility or a piece of land where the facility was, is, or is intended to be located. Activities under the control of an organization may be carried out on it.

e1) User (INSPIRE Metadata Guidelines based on ISO 19115)

User is described as Metadata point of contact, e.g.:

+ organisationName: The name of the Metadata point of contact
+ contactInfo: Contact
+ address: There may be more than one address, so more than one e-mail
+ electronicEmail: At least one e-mail address of the Metadata point of contact

5.2. Observation entity

SamplingFeature is linked to Observation (INSPIRE D2.9 Guidelines for the use of Observations & Measurements in Annex II and III data specification development)

Observations should have:

- name (from dictionary)/should be GenericName

  The example of code list for ObservationName is shown below, but it can be extended considering the future data:

  Table 9: Observation name

ObservationName
interpretation
boreholeLogProcessing
wellMonitoring
waterLevelMonitoring
filterCheck
contouring
rasterProcessing

- observed property (from dictionary e.g. geologicalProperty, HGProperty, geothermal Property)/should be GenericName
- phenomenon time (~ start of measurement)
- result time (~ end of measurement)
- contact (responsible party)
- parameters (describing the process eg.: samplingRate=1 ms, gridSizeX=5 m, ...)/ parameter name must be from the dictionary, value can be numeric, text, etc.

Observations are connected to **a) Parameters, b) Processes and c) Results.**

a) ParameterType (INSPIRE D2.9 Guidelines for the use of Sensor Web Enablement-related standards in INSPIRE Annex II and III data specification development) defines the datatype, unit of measurement for a parameter identified by name. Name should be GenericName).

b) Process is used to describe the generic procedure behind the specific observation. It may point to any URL, like a report download link. Name should be GenericName. Observation name may be the same as the name of the associated process.

c) Result is a switching table between the different kind of results and the observation. Result can be i) Resource, ii) TimeSeries, iii) Log and iv) Coverage. Other types may also be defined.

   i) Resource (INSPIRE Metadata Guidelines based on ISO 19115) contains access information to a data source that can be accessed and used by the system as it is. It can be a digital file, or a service. It has:
      - title (e.g. Contour map of temperature at 1000 m depth);
      - resourceType (from dictionary)/should be GenericName.

The example of code list for resourceType is shown below, but it can be extended considering the future data:

Table 10: Resource type

ResourceType
crossSection
contourMap
grid
compositLog
timeSeries
log

- distributionType (from dictionary)/should be GenericName

The example of code list for distributionType is shown below, but it can be extended considering the future data:

Table 11: Distribution type

DistributionType
digitalCopy
service
hardCopy

- format (from dictionary)/should be GenericName

The example of code list for format is shown below, but it can be extended considering the future data:

Table 12: Format

Format
shp
jpg
wms
tiff
pdf
doc
xls

- access (filename, URL…e.g. temp1000.hu.tif)

ii) TimeSeries

TimeSeries is a table that contains time – value pairs, describing the temporal change of a property, identified by parName (should be GenericName from dictionary).

iii) Log

Log is a table that contains depth range – value pairs, describing the change of a property along vertical axes (borehole). Property is identified by parName (should be GenericName from dictionary).

iv) Coverage

Coverage is a table of geometry – value pairs describing the spatial distribution of a property identified by parName (should be GenericName from dictionary). It can be used for view services (e.g.: contourMaps). Remark: This is model extension, which is not yet included in the physical model of the database. We should include it later, considering gathered data.

5.3. Open issues

Depending on the time frame of the DARLINGe project, the actual set and type of data will be finalized when WP6 and WP7 activities finish. Therefore, there may be modifications to the existing conceptual model in later phases.

In order to obtain as extensive picture of the final results, some typical use-cases were pre-collected to help us form the current conceptual model.

2. Some typical use-cases in DRGIP will be:
   - Display reservoir surfaces and temperature contour lines together with well locations, attribute tables with essential metadata should be available for viewing;
   - Display temperature surface and temperature anomaly point locations with traces of hydrogeological cross sections. Image of cross section should be available for viewing;
   - Display basement contour lines, with wells, boreholes. Borehole locations should be filterable by depth range. (Show boreholes reaching the basement);
   - Display sites with well temperature above 50˚C, attribute tables of sites, users, and wells.
   - Display reservoir surfaces and isothermal contour lines together with well locations, attribute table with main essential metadata;
   - Display isothermal surface and temperature anomaly locations with traces of hydrogeological cross sections. Image of cross section should be available for viewing;
   - Display basement contour lines, with wells, boreholes. Borehole locations should be filterable by depth range (or show boreholes deeper than the basement);
   - Display sites with well temperature above 50˚C; attribute tables of sites, users, and wells;
   - Display well data tables selected by queries based on arbitrary parameters, and heat market analysis results (images);
   - Display best practices of geothermal applications with site map, well locations. Attribute tables and related documentation should be accessible for view and download;
   - Display sites, boreholes within selected distance from a settlement, or a location;

- Display map of pilot areas with hydrogeological modelling results, contour lines, grids, raster maps, related documents;
- Display spatial distribution of reservoir pressure, temperature, time series charts, amount of exploitable energy.

Upon presented use-cases features were identified as shown on the table below:

Table 13: Features Identified in typical DRGIP use-cases

Features Identified in Use Cases	Supported Layers	INSPIRE
Reservoir Outline	multiPolygon	AquiferSystem
Reservoir top, bottom surfaces	contour lines	SurfaceModel
Temperature surfaces	contour lines	SurfaceModel
Wells, Boreholes	point	ActiveWell, Borehole
Hydrogeological profiles	lineString	SurfaceModel
Basement surface	contour lines	SurfaceModel
Measurements - data files, images, docs	0D,1D,2D	Station, Profile, Swath
Models - data files, images, docs	2D,3D	Surface/SolidModel
Sites - location, data, related docs,...	multiPolygon	ProductionSite

But there are still some additional questions remaining, such us:

- Will there be any extra point locations for measures (observations, modelling) besides already included boreholes, springs and wells, which are in the table OBJECT?
- When data on site location will be displayed, will that be location of a site or a borehole?
- How the data on heat market will be collected and how the data should be presented on the portal?
- How data on time series will be presented, etc. through graphs?
- How the reports (in pdf) will be connected to spatial data? For example, picture of geological cross-section will be linked with its line on the map, what about other results?

As mentioned before, answers to these questions will be found later that is why, in this stage of the project some INSPIRE rules were not fully applied. Since DARLINGe project is focused and specific in contrast to broad and generic INSPIRE Directive, there might be some parts where INSPIRE rules will not be implemented.

Some examples of questionability of the INSPIRE rules for DARLINGe project are described later in this chapter.

5.3.1. GenericName

GenericName entity is simplified representation of a SKOS concept to model dictionary items that are used in the system. It has: namespace, name, prefLabel and definition.
Namespace identifies the domain in which name is a local identifier. Namespace can be a URL, and it may have an associated prefix. Namespace and name together is a global identifier. You can see some examples below:

confined artesian aquifer:
http://inspire.ec.europa.eu/codelist/AquiferTypeValue/confinedArtesian
namespace: http://inspire.ec.europa.eu/codelist/AquiferTypeValue/
name: confinedArtesian

If the namespace is associated with a prefix, e.g.: aqfrtp the above concept can be shortly referenced as aqfrtp:confinedArtesian.

This is a recommended usage of GenericNames in the database.

In this stage of the project we decided not to use GenericNames. We could include them later if there will be a necessity.

5.3.2. MappedFeature

In INSPIRE MappedFeature (ANNEX II: geology) is used to model an occurrence of a geologic feature. It provides geometry, and connection to a sampling feature. It serves as a switching table between different kind of geologic features like geologic units, faults, aquifers, mineral occurrences etc. In the DARLINGe data model only one kind of geologic feature – reservoir – is represented. (AquiferSystem in INSPIRE). For this reason Mapped Feature can be omitted from the model.

5.3.3. Sampling Feature Complex

SamplingFeatureComplex (SF_Complex) is used to connect sampling features. It has: source, target and role.

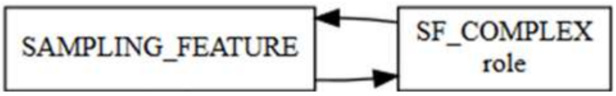

Figure 6: Sampling Feature Complex

5.3.4. Boreholes

Currently we have boreholes in the same table with wells and springs. This is not INSPIRE compliant structure. At the moment we set up a structure according to information on possible type of data we will gather in the project. If necessary, we will change this part of the concept in next working phases.

5.3.5. Concept of database and portal

Conceptual model of database (E-R) and conceptual model of web application are not fully harmonized (when comparing figures 7 and 8). We developed E-R model according to existing data and use-cases of usage of these data, but we expect some modifications in the next working phases.

Source and target are foreign keys to different sampling features that are connected somehow. The type of connection can be defined by the role attribute. Role must be a GenericName.

In this stage of the project we decided not to use SF_Complex. We could include it later if there will be a necessity.

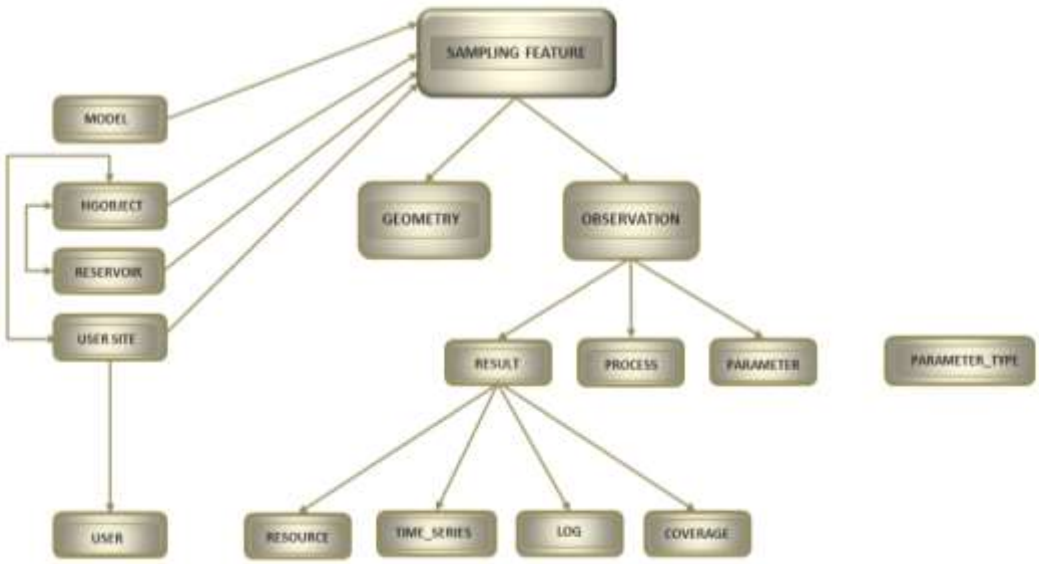

Figure 7: Current version of conceptual model of web application - status 31.12.2017

6. Conceptual model of the database

The Figure below (Figure 8) shows the conceptual model of the DARLINGe database, which was created upon all possible datasets and data to be created within DARLINGe project. Relationships among different data were set up according to INSPIRE rules, as explained in chapter 4: Mapping of DARLINGe conceptual model to INSPIRE Directive data specifications.

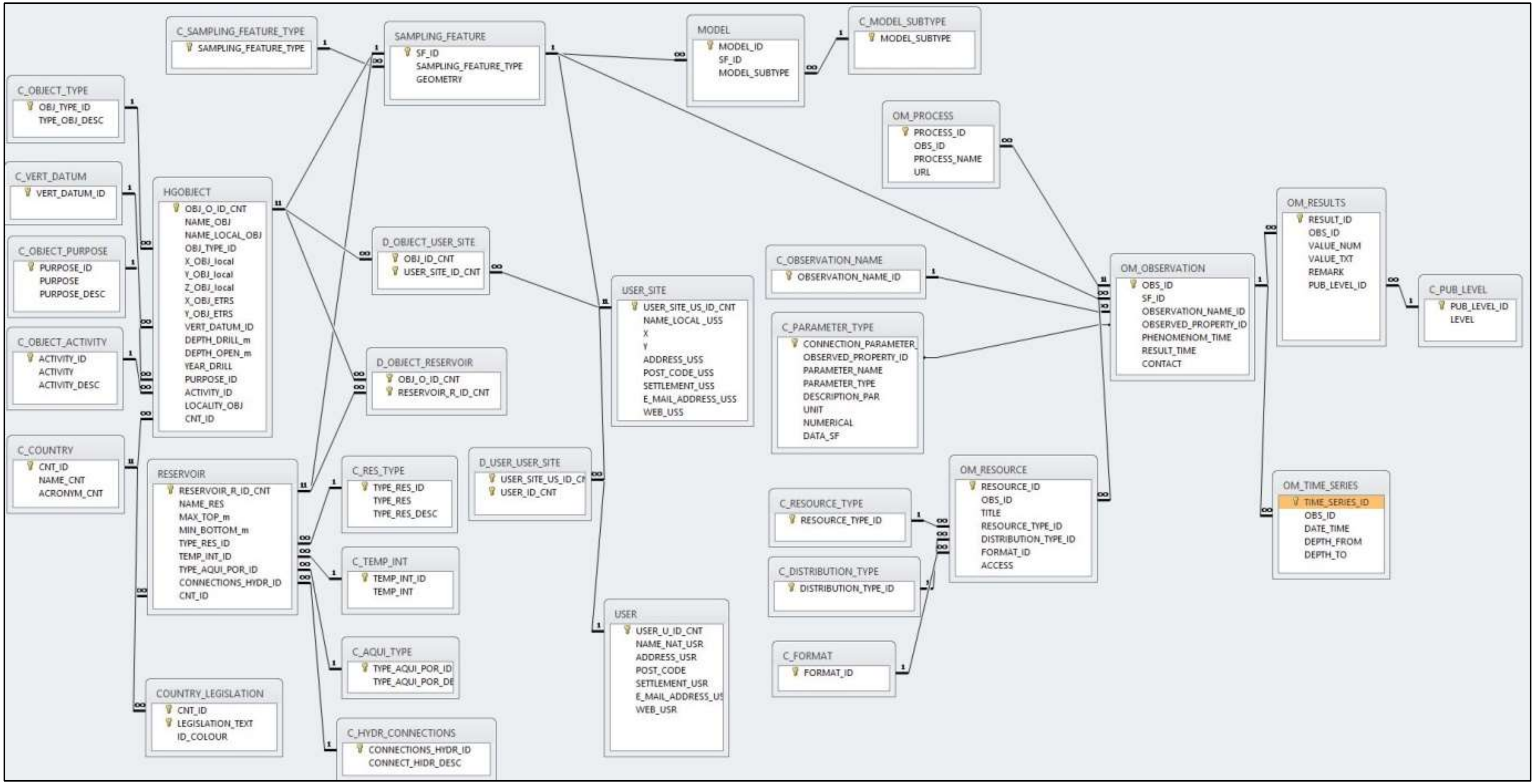

Figure 8: Current version of conceptual model of DARLINGe database - status 31.12.2017

As already mentioned the conceptual model of database (E-R) and conceptual model of web application are not fully harmonized (when comparing figures 7 and 8).

6.1. Data catalogue

Following data catalog contains database object definitions like base tables and code lists (list of table fields, their names, datatypes and descriptions), as seen in Figure 8.

A data catalog ensures capabilities that enable any users, from analysts to data scientists or developers, to discover and consume data sources.

6.1.1. Tables

COUNTRY_LEGISLATION		
Name of field	**Data type**	**Description**
CNT_ID	Number	Country identification number.
LEGISLATION_TEXT	Text	Answers to geothermal legislation questionnaire.
ID_COLOUR	Text	Identification of color for "semaphore" on DGRIP.

D_OBJECT_RESERVOIR		
Name of field	**Data type**	**Description**
OBJ_O_ID_CNT	Text	Unique identifier of object (form: country code_id of object).
RESERVOIR_R_ID_CNT	Text	Unique identifier of reservoir (form: country code_id of reservoir).

D_OBJECT_USER_SITE		
Name of field	**Data type**	**Description**
OBJ_ID_CNT	Text	Object identifier.
USER_SITE_ID_CNT	Text	User site identifier.

D_USER_USER_SITE		
Name of field	**Data type**	**Description**
USER_SITE_US_ID_CNT	Text	Unique identifier of user site (form: country code_id of user site).
USER_ID_CNT	Text	Unique identifier of user (form: country code_id of user).

GROUNDWATER_BODY		
Name of field	**Data type**	**Description**
OBJ_ID_CNT	Text	Unique identifier of object (form: country code_id of object)
GW_BODY_NUM	Number	National WFD groundwater body No.
GW_BODY_NAME	Text	If possible give English name of the delineated groundwater body; INSPIRE Hydrography: Groundwater bodies and aquifer systems

HGOBJECT		
Name of field	**Data type**	**Description**
OBJ_O_ID_CNT	Text	Unique identifier of object (form: country code_id of object) ID of object - specify (e.g. cadastral number, identification number in national database, etc.).
NAME_OBJ	Text	Object official name - well code and number/name of the well or spring e.g. K-57; INSPIRE list: Geology: borehole name or Hydrogeological object name/code.
NAME_LOCAL_OBJ	Text	Object local name if any.
OBJ_TYPE_ID	Number	Type of geothermal object/code list/Object type: spring: natural object with water discharge; well: artificial man-made borehole for water.
X_OBJ_local	Number	X-coordinate in local coordinate system.
Y_OBJ_local	Number	Y-coordinate in local coordinate system.
Z_OBJ_local	Number	Z-coordinate in local coordinate system/elevation of the surface (most other parameters refer to surface also).
X_OBJ_ETRS	Number	X-coordinate ETRS89.
Y_OBJ_ETRS	Number	Y-coordinate ETRS89.
VERT_DATUM_ID	Text	Vertical datum local system.
DEPTH_DRILL_m	Number	Original total drilled depth in m below wellhead.
DEPTH_OPEN_m	Number	This is the depth of the final well, which might be different from the depth of the original borehole. It is typical to have a deeper borehole which later is transformed to a well with a shallower depth.
YEAR_DRILL	Number	Year when the drilling was finalized.
PURPOSE_ID	Number	Object purpose/code list/.
ACTIVITY_ID	Number	Object activity/code list/.
LOCALITY_OBJ	Memo	Nearest settlement.
CNT_ID	Number	Country identification number.

MODEL		
Name of field	**Data type**	**Description**
MODEL_ID	Number	Unique identifier of model.
SF_ID	Text	Unique identifier of sampling feature.
MODEL_SUBTYPE	Text	Type of model/connection to code list.

OM_OBSERVATION		
Name of field	**Data type**	**Description**
Number	Number	Unique identifier of observation.
SF_ID	Text	Unique identifier of sampling feature.
OBSERVATION_NAME_ID	Text	Observation name/connection to code list.
OBSERVED_PROPERTY_ID	Text	Value from dictionary e.g. geologicalProperty, HGProperty, geothermalProperty
PHENOMENOM_TIME	Date/time	Start of measurement/inspire date yyyy-mm-dd.
RESULT_TIME	Date/time	End of measurement/inspire date yyyy-mm-dd.
CONTACT	Text	Responsible party/contact.

OM_PROCESS		
Name of field	**Data type**	**Description**
PROCESS_ID	Number	Unique identifier of process.
OBS_ID	Number	Unique identifier of observation.
PROCESS_NAME	Text	Name used to describe the generic procedure behind the specific observation. Observation name may be the same as the name of the associated process.
URL	Text	Any URL, like a report download link.

OM_RESOURCE		
Name of field	**Data type**	**Description**
RESOURCE_ID	Integer	Unique identifier of resource.
OBS_ID	Number	Unique identifier of observation.
TITLE	Text	Resource title (e.g. Contour map of temperature at 1000 m depth).
RESOURCE_TYPE_ID	Text	Resource type/from code list.
DISTRIBUTION_TYPE_ID	Text	Distribution type/from code list.
FORMAT_ID	Text	Format of resource/from code list.
ACCESS	Text	Access to resource (filename, URL…e.g. temp1000.hu.tif.)

OM_RESULTS		
Name of field	**Data type**	**Description**
RESULT_ID	Number	Unique identifier of result.
OBS_ID	Number	Unique identifier of observation.
VALUE_NUM	Number	Numerical value of parameter.
VALUE_TXT	Text	Textual value of parameter.
REMARK	Text	General remark of measurement.
PUB_LEVEL_ID	Number	Level of publicity (project partners/public, connection to code list).
OM_TIME_SERIES		

Name of field	Data type	Description
TIME_SERIES_ID	Number	Unique identifier of time series.
OBS_ID	Number	Unique identifier of observation.
DATE_TIME	Date/time	Date/time of the measurement/inspire yyyy-mm-dd.
DEPTH_FROM	Number	Depth of interval top [m].
DEPTH_TO	Number	Depth of interval bottom [m].

RESERVOIR		
Name of field	**Data type**	**Description**
RESERVOIR_R_ID_CNT	Text	Unique identifier of reservoir (form: country code_id of reservoir).
NAME_RES	Text	Name of reservoir/give the formation name as you will use it everywhere e.g. Upper Pannonian sands in Slovenia; INSPIRE Hydrogeology: name of aquifer system.
MAX_TOP_m	Number	Maximum top level of reservoir in m/the highest elevation of the delineated reservoir layer in meters above sea level - be careful to define it for the right reservoir type and temperature interval (reservoir outline).
MIN_BOTTOM_m	Number	Minimum bottom level of reservoir in m/the lowest elevation of the delineated reservoir layer in meters above sea level - be careful to define it for the right reservoir type and temperature interval (reservoir outline).
TYPE_RES_ID	Number	Type of reservoir/code list/reservoir in the basement rocks forming the basin (usually carbonates, metamorphic, igneous).
TEMP_INT_ID	Number	Reservoir temperature interval/code list.
TYPE_AQUI_POR_ID	Number	Type of aquifer porosity/code list/the type of porosity is used as given in the INSPIRE Hydrogeology: Aquifer Media Type Value.
CONNECTIONS_HYDR_ID	Number	Hydraulic connections/code list/.
CNT_ID	Number	Country identification number.

SAMPLING_FEATURE		
Name of field	**Data type**	**Description**
SF_ID	Text	Unique identifier of sampling feature.
SAMPLING_FEATURE_TYPE	Text	Type of sampling feature /connection to code list.
GEOMETRY	Text	GM_object (point, line, polygon...).

USER		
Name of field	**Data type**	**Description**
USER_U_ID_CNT	Text	Unique identifier of user (form: country code_id of user).
NAME_NAT_USR	Text	User name (national)/Owner of the borehole/well - named user in the database; can manage several user sites; INSPIRE Responsible party role: owner.
ADDRESS_USR	Text	Address: street, number of user.
POST_CODE	Number	Post code of user.
SETTLEMENT_USR	Text	Name of settlement.
E_MAIL_ADDRESS_USR	Text	e-mail address of user (mandatory in INSPIRE).
WEB_USR	Text	URL of user (official website)

USER_SITE		
Name of field	**Data type**	**Description**
USER_SITE_US_ID_CNT	Text	Unique identifier of user site (form: country code_id of user site).
NAME_LOCAL _USS	Text	A site where the wells are positioned: may be a sub-company/branch of the USER; the owner Co (USER) and the site Co (USER SITE) can be identical company then you copy it twice; INSPIRE Responsible party role: user.
X	Number	X-coordinate ETRS89.
Y	Number	Y-coordinate ETRS89.
ADDRESS_USS	Text	Street and number of the site/if address is not possible to give, leave blank.
POST_CODE_USS	Number	Post code of settlement/if address is not possible to give, leave blank.
SETTLEMENT_USS	Text	Name of settlement.
E_MAIL_ADDRESS_USS	Text	e-mail address of user site (mandatory in INSPIRE)
WEB_USS	Text	URL address (official website) of user site/if address is not possible to give, leave blank.

6.1.2. Codelists

C_AQUI_TYPE		
Name of field	**Data type**	**Description**
TYPE_AQUI_POR_ID	Number	Unique identifier of type of aquifer.
TYPE_AQUI_POR_DESC	Text	Description of aquifer type porosity/the type of porosity is used as given in the INSPIRE Hydrogeology: Aquifer Media Type Value

C_COUNTRY		
Name of field	**Data type**	**Description**
CNT_ID	Number	Country identification number.
NAME_CNT	Text	DARLINGe PP country full name.
ACRONYM_CNT	Text	DARLINGe PP country short name.

C_DISTRIBUTION_TYPE		
Name of field	**Data type**	**Description**
DISTRIBUTION_TYPE_ID	Text	Type of resource distribution.

C_FORMAT		
Name of field	**Data type**	**Description**
FORMAT_ID	Text	Type of resource format.

C_HYDR_CONNECTIONS		
Name of field	**Data type**	**Description**
CONNECTIONS_HYDR_ID	Number	Unique identifier of hydraulic connections.
CONNECT_HIDR_DESC	Text	Description of hydraulic connections.

C_MODEL_SUBTYPE		
Name of field	**Data type**	**Description**
MODEL_SUBTYPE	Text	Subtype of model.

C_OBJECT_ACTIVITY		
Name of field	**Data type**	**Description**
ACTIVITY_ID	Number	Unique identifier of object activity.
ACTIVITY	Text	Object activity.
ACTIVITY_DESC	Text	Description of object activity.

C_OBJECT_PURPOSE		
Name of field	**Data type**	**Description**
PURPOSE_ID	Number	Unique identifier of object purpose.
PURPOSE	Text	Object purpose.
PURPOSE_DESC	Text	Description of object purpose.

C_OBJECT_TYPE		
Name of field	**Data type**	**Description**
OBJ_TYPE_ID	Number	Identifier of object type.
TYPE_OBJ_DESC	Text	Type of geothermal object.
C_OBSERVATION_NAME		
Name of field	**Data type**	**Description**
OBSERVATION_NAME_ID	Text	Name of observation/connection to code list.

C_PARAMETER_TYPE		
Name of field	**Data type**	**Description**
CONNECTION_PARAMETER_ID	Auto number	Unique identifier of record.
OBSERVED_PROPERTY_ID	Number	Unique identifier of parameter.
PARAMETER_NAME	Text	Parameter name.
PARAMETER_TYPE	Text	Parameter type.
DESCRIPTION_PAR	Memo	Parameter description.
UNIT	Text	Parameter unit.
NUMERICAL	Number	Is parameter numerical? [Yes(1) / No(0)]
DATA_SF	Text	Which SF is measured?

C_PUB_LEVEL		
Name of field	**Data type**	**Description**
PUB_LEVEL_ID	Number	Unique identifier of public level
LEVEL	Text	Assigned level of publicity of each parameter

C_RES_TYPE		
Name of field	**Data type**	**Description**
TYPE_RES_ID	Number	Unique identifier of type of reservoir.
TYPE_RES	Text	Reservoir type.
TYPE_RES_DESC	Text	Reservoir type description.

C_RESOURCE_TYPE		
Name of field	**Data type**	**Description**
RESOURCE_TYPE_ID	Text	Type of resource.

C_RES_TYPE		
Name of field	**Data type**	**Description**
TYPE_RES_ID	Number	Unique identifier of type of reservoir.
TYPE_RES	Text	Reservoir type.
TYPE_RES_DESC	Text	Reservoir type description.

C_SAMPLING_FEATURE_TYPE		
Name of field	**Data type**	**Description**
SAMPLING_FEATURE_TYPE	Text	Type of sampling feature.

C_TEMP_INT		
Name of field	**Data type**	**Description**
TEMP_INT_ID	Number	Unique identifier of reservoir temperature interval.
TEMP_INT	Text	Reservoir temperature interval.

C_VERT_DATUM		
Name of field	**Data type**	**Description**
VERT_DATUM_ID	Text	Vertical datum local system.

7. Metadata catalogue

Metadata is information about data. Similar to a library catalog record, metadata records document who, what, when, where, how, and why of a data resource. Geospatial metadata describes maps, Geographic Information Systems (GIS) files, imagery, and other location-based data resources.

Metadata, as a critical component of the SDI, allows for the documentation, discovery, assessment, integration, distribution and archival of geospatial resources.

Geographic metadata is used to document the attributes of geographic data, e.g. database files and data developed within a Geographic Information System (GIS). Geographic metadata seeks to answer questions such as: who developed the data, when was the data created, how the data were processed, how are the data attributes defined, in what formats the data are available, how does one obtain the data. The information in the metadata provides context for the data and supports the effective application of the data.

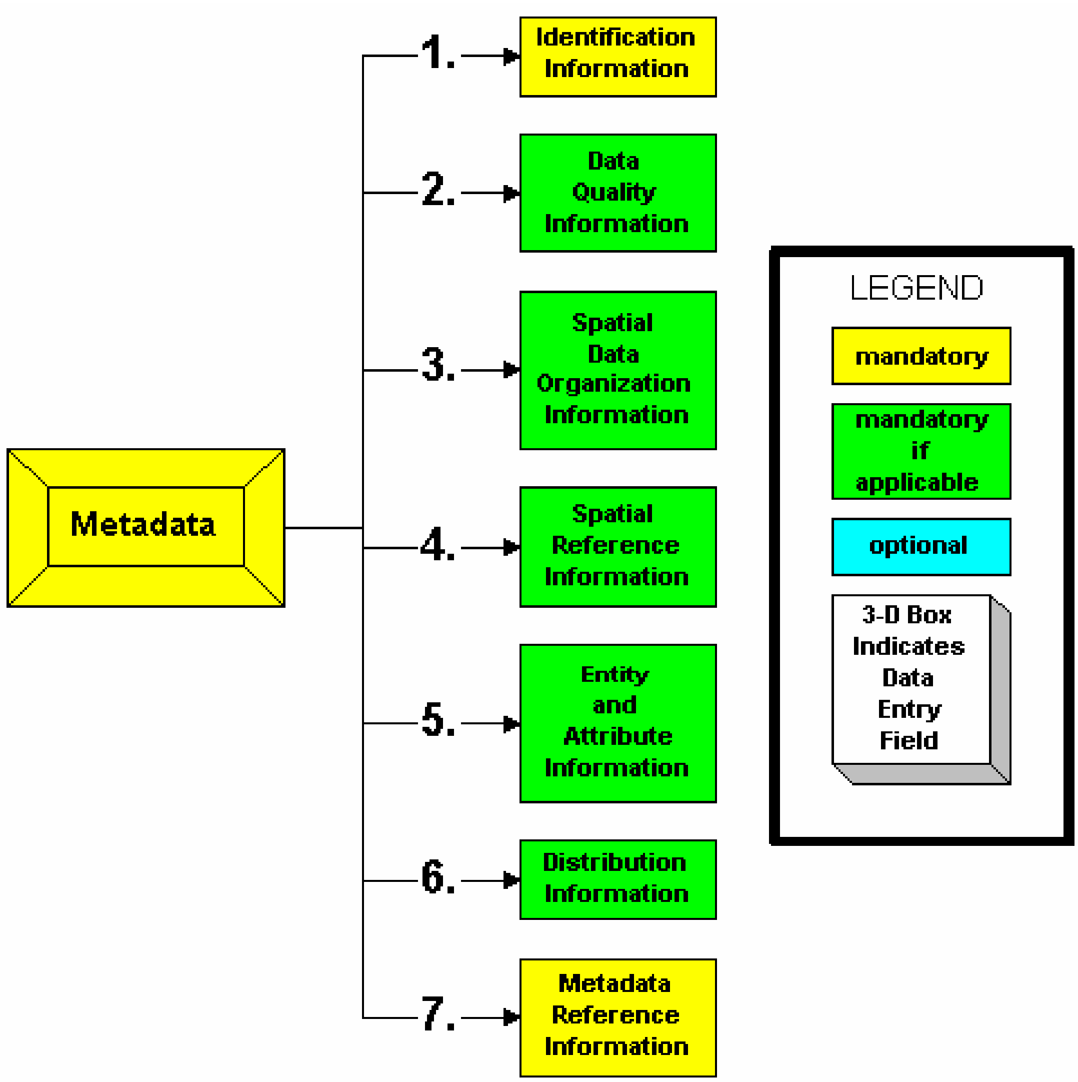

Figure 9: Metadata scheme

Metadata catalogue services support the ability to publish and search collections of descriptive information (metadata) for data, services, and related information objects. Metadata in catalogues represent resource characteristics that can be queried and presented for evaluation and further processing by both humans and software. Catalogue services are required to support the discovery and binding to registered information resources within an information community.

OGC Catalogue interface standards specify the interfaces, bindings, and a framework for defining application profiles required to publish and access digital catalogues of metadata for geospatial data, services, and related resource information. Metadata act as generalized properties that can be queried and returned through catalogue services for resource evaluation and, in many cases, invocation or retrieval of the referenced resource. Catalogue services support the use of one of several identified query languages to find and return results using well-known content models (metadata schemas) and encodings.

The DRGIP portal will include an ISO- and INSPIRE-compliant metadata catalogue. The DRGIP Metadata Catalogue will be the access point to metadata describing geothermal data that will be created in the DARLINGe project and represented on the DRGIP portal. It will provide a compilation of these metadata in a standardized format that will allow users to effectively search through the resources and data. The catalogue and metadata will comply with international standards (ISO and INSPIRE). Digital and structured information (spatial datasets or dataset series and spatial data services - WMS, WFS) will be described by metadata in this catalogue.

8. Status

Following the process of creating a data model for setting up the DRGIP, INSPIRE Directive rules, accessibility and availability of geothermal data across DARLINGe project area, the status of conceptual model of the DRGIP at the end of year 2017 is as shown on Figure 10.

Depending on the development of the project and considering that some activities are only beginning (WP6 and WP7), the conceptual model of the DRGIP, status 31.12.2017, is subject to possible minor modifications at later stages, in particular in terms of providing better functionalities and higher quality of the portal.

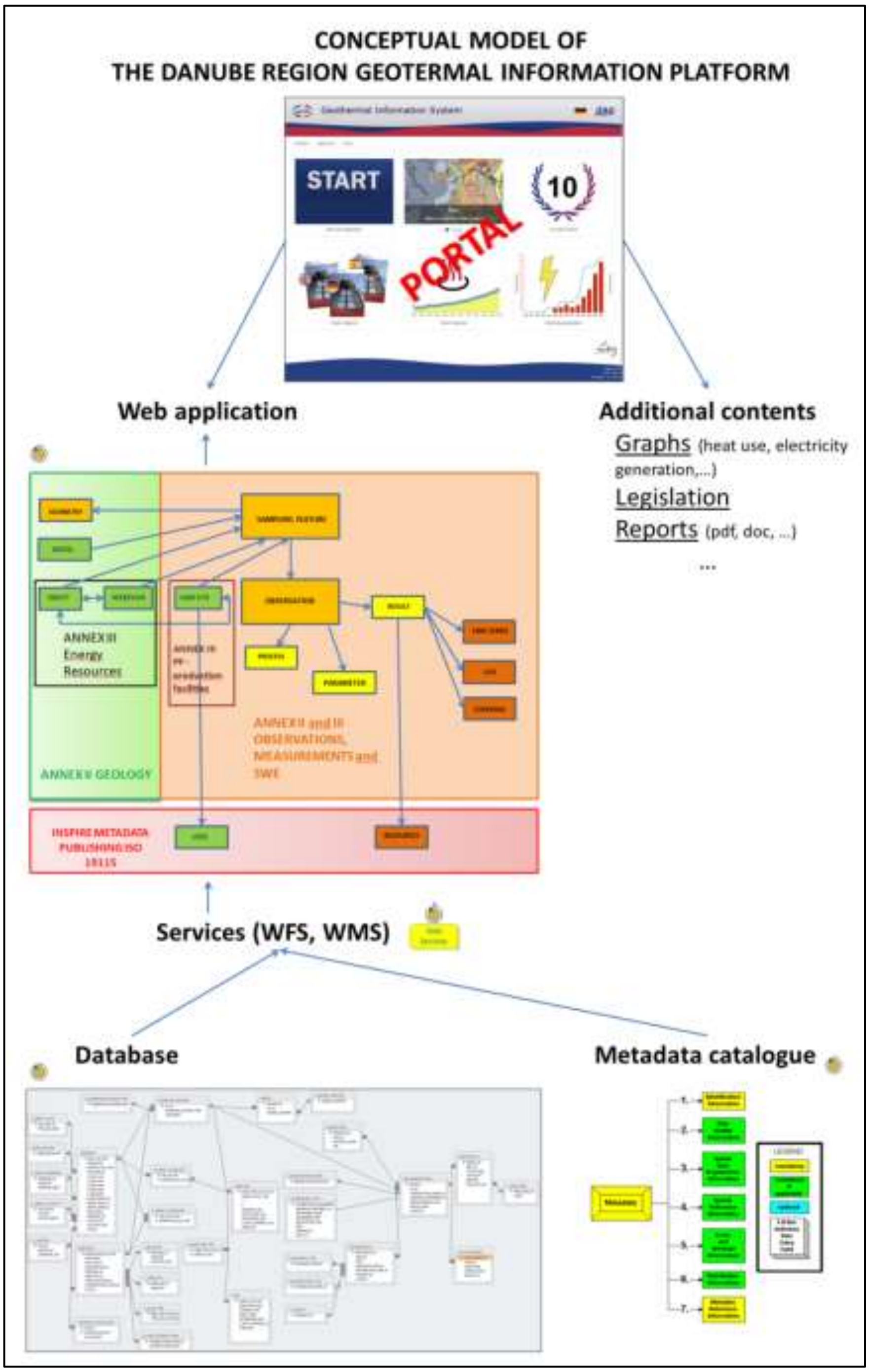

Figure 10: Conceptual model of the DRGIP - status 31.12.2017