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Integration of Dutch Government's Geo-Information in Smart Grids

Jasper ROES, Jack VERHOOSEL
TNO, Capitool 10, Enschede, 7521 PL, The Netherlands
Tel: +31 88 8662453, Email: jasper.roes@tno.nl, jack.verhoosel@tno.nl

Abstract: Integration of existing information in smart grids is important in the energy domain as the development of smart grids can profit from the use of already existing information structures and available databases. This paper describes the use case the CERISE project is currently working on: the Smart Grids Information Broker, which makes it possible to combine existing information into new information in constantly changing ecosystems. The paper describes possible information mappings that can be used to combine information in different formats from multiple sources. Furthermore the paper describes the relevant standards for the smart grid in the energy, geo and government domain and describes the business case of combining information from existing sources instead of creating information.

1. Introduction

In the energy domain, the decentralized use of renewable energy sources is strongly increasing, e.g. via photovoltaic panels, windmills and electric vehicles. For the balanced operation of smart grids and for regulation by the government domain it becomes increasingly important to keep track of all these sources and their location. However, the information sharing of this geo-information between organizations in the smart grid domain and the Dutch government is still in its infancy.

In order to tackle this problem, the Dutch Ministry of Economic Affairs has initiated, as part of the Switch2SmartGrids topsector approach, a project (CERISE) on the alignment of the information infrastructure architecture of utility companies with related architectures. The project partners Alliander[1], TU Delft[2], TNO[3], Geodan[4] and Geonovum[5] are working on making the information exchange between the energy sector, government and the geo-world future proof and efficient. The incentive and added value of this project is to improve information exchange to make smart grids smarter.

The main challenge in this project is to bring the information exchange in the energy sector, the government sector and the geo-sector together, which is currently lacking. This is no easy task as the information infrastructure in each domain is realized, and large and complex in itself. For instance, the geo-domain is working on ISO TC211, OGC, and INSPIRE, the utility-domain on the Common Information Model (IEC61970/61968/61850), and the Dutch Government has developed the NORA, a Reference Architecture including the basic registry system. These domains cannot easily be adjusted given the mass behind it.

The CERISE approach covers two levels: technical (web services, exchange formats, protocols) and content (semantics, information models). In case of model mismatches between the different worlds, semantic model transformation services are developed. These semantic model transformations are new to the smart grid domain and make it possible to

[1] http://www.alliander.nl
[2] http://www.otb.tudelft.nl/
[3] http://www.tno.nl
[4] http://www.geodan.nl
[5] http://www.geonovum.nl

use geo-information in a standard way between the government sector and the smart grid domain.

The information mappings that will be developed are targeted towards use cases and tested in the domain of smart grids. The CERISE project will test the developed mappings in three use cases, the first use case to be worked out in 2013, the other two in 2014. The authors of this paper are involved in the CERISE project and are working on the information mappings between the energy, government en geo-information domain. Knowledge dissemination is targeted towards business society, leading to developing advanced products for the international smart grids market.

2. Objectives

The objective of the paper is to present the results of the work that has been done in the CERISE project for the first use case: The Smart Grid Information Broker. The CERISE project is not going to realize this use case, the use case is used as a framework to identify possible information exchanges and provides the project with a precise scope for the work to be done in 2013.

For the Smart Grid Information Broker use case we worked out which standards from energy, government and geo-information are important. We furthermore looked at the possibilities for exchanging the information to and from the Smart Grid Information Broker. While our main focus is on the use of information from the government and the geo-information domain in the energy domain, we also take into account that the information that is available in the energy domain might be of interest for the government and geo-information domain. While working out the possible information exchanges we therefore started looking for relevant information from the government and geo-information domain for smart grids and thereafter looked at relevant information from the smart grid domain for the government and geo-information domain. This paper will further provide a first insight into the methods to define mappings to map the geo-information between the Dutch government domain and the smart grid domain.

3. Methodology

This section provides a description of the use case that CERISE is working on in 2013, it provides an overview of the identified standards from the smart grid, government and geo-information domain that are relevant for the Smart Grid Information Broker use case and provides a first insight into possible methods to map information between the different domains and standards.

3.1 Use Case description

To improve the information exchange between the three domains, the CERISE project has defined 4 use cases that are used as a virtual environment to define and test mappings between standards in the three domains. The CERISE project is not focusing on the realization of the use cases, but is using them to validate and try out the mappings to show their need and prospect in real-world applications.

The use case that is first worked on is the Smart Grid Information Broker use case.

We investigate and define the semantic interoperability under the assumption that the smart grid networks will be dynamic ecosystems. Networks of parties may change frequently and the ecosystem for semantic interoperability has to be able to deal with this. For instance, prosumers might have relationships with all different kinds of parties that are involved in their energy-ecosystem. They might be related to energy suppliers, energy collectives, lease companies for electric cars, the local authorities and the electricity network operators. In contrast to the traditional energy-ecosystem the relations in the new ecosystems are more flexible. Due to the speed the market for smart grids is developing, at this point in time nobody can foresee how the market is going to function in the future. We therefore assume that every market predicted now is a possibility and that the Smart Grid Information Broker needs to be able to handle all options.

To be able to guarantee the described flexibility it is necessary to define all information structures in a way that the aggregation of the information in all kinds of dimensions and for different goals is possible. There is therefore a need for a building block on the smallest level in the smart grid: the connection point. For the current electricity networks this may be the (smart) meter that is located in every house and building. For the future this might be the Home Energy Management System (that is normally behind the meter in a building). The model of the information available at the smallest level in the smart grid (at the connection point) is regarded as the central building block for the smart grid within the CERISE project. This information model and the information collected are called the 'Smart Grid Information Block'.

The Smart Grid Information Block forms the basis for the information exchange in the smart grid as supported by the Smart Grid Information Broker. The CERISE project takes the information in the Smart Grid Information Block as facts. The information model of the Smart Grid Information Block will define how the facts can be projected in multiple dimensions: time, objects, parties and actors. In the project no new standards will be defined, but the project will show how the information in the Smart Grid Information Block can be combined or coupled to information sources and existing standards from the geo-domain and the e-government domain. The Smart Grid Information Broker will help parties combine information from to Smart Grid Information Block to the following dimensions:

- Actor dimension: define which facts are shared with which party
- Time dimension: for how long, at which moment and for how long facts are shared
- Object dimension: which energy production and consumption units are used
- Geo dimension: where objects are located, what the weather is, geo-information

The Smart Grid Information Block defines the information in the central circle in Figure 1. The Smart Grid Information Broker makes it possible to combine the information from the Smart Grid Information Block with the information from the four dimensions (as shown in Figure 1).

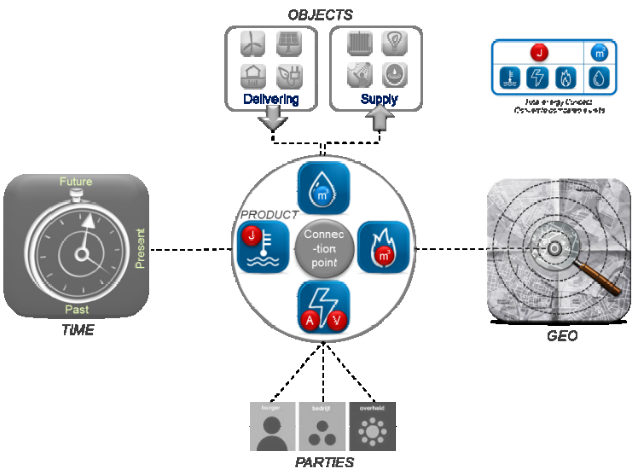


Figure 1: Connection point and dimensions

For each of these dimensions the CERISE project defines which standards are available, what their semantics are and how they can be used in conjunction with the facts from the connection point. An example of the possibilities: If a company has a smart grid dashboard and wants to visualise where solar panels are installed in The Netherlands and what the potential for new installations is, the fastest way to do this is to use the Smart Grid

Information Broker to obtain the information of the Smart Grid Information Blocks and to combine this information with the facts from e-government databases and geo-information, aggregated on a national level.

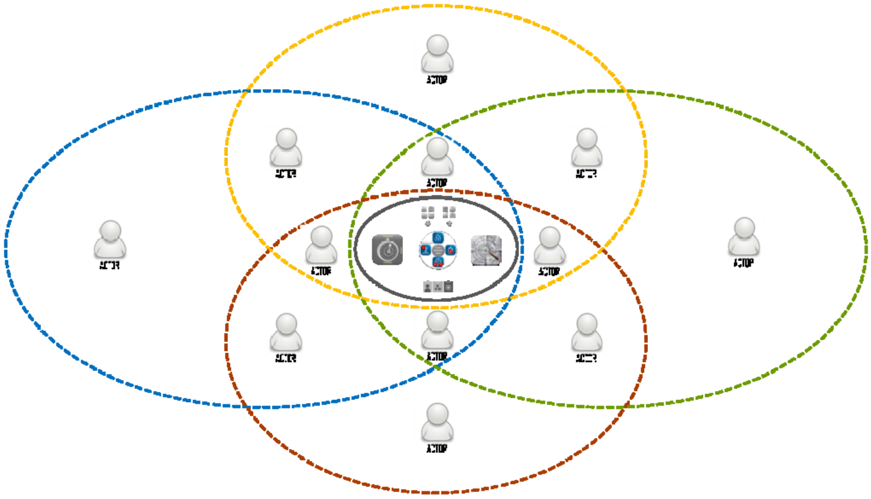


Figure 2: Schematic drawing of multiple ecosystems using the same information sources

3.2 Overview of standards

In the three domains, there are various existing standards or standards in development that can be used or combined with the Smart Grid Information Broker and the Smart Grid Information Blocks. In the smart grid domain, the International Electrotechnical Committee (IEC) is one of the most important bodies for standardisation. Figure 3 shows the most important technical committees and other groups within the IEC in relation to smart grid standardization. Committees 13 and 57 have developed most of the current standards for smart grids.

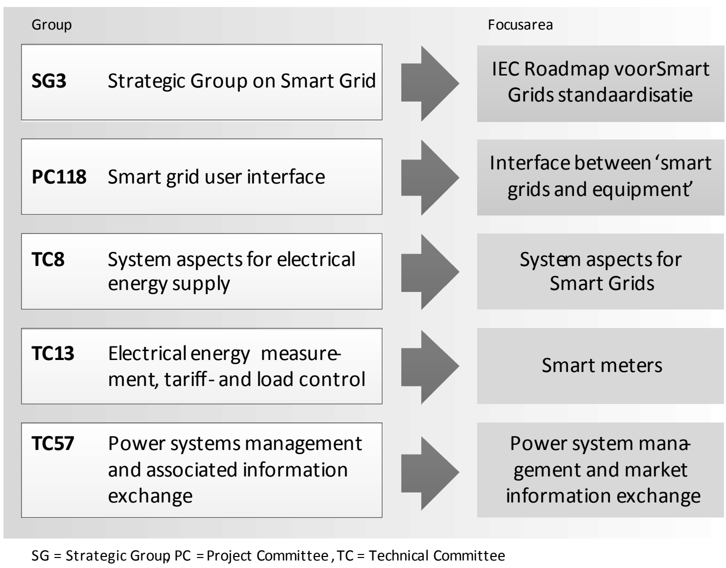


Figure 3: Most important technical committees within IEC on smart grid standardization.

Besides IEC, there are specific European standardization activities in CEN/CENELEC/ETSI and American activities within NIST. Both organizations are working on overviews of standards for smart grids and the gaps in this standardization landscape. The European Commission has initiated a mandate M490 in order to make such an overview and indicate which future activities on smart grid standardization have to be setup. The working group “Set of Standards” has developed a framework for positioning smart grid standards [1]. Some of these standards also contain geo-information elements to be used for location purposes of smart grid equipment. Also NIST has made such an overview and a roadmap that contains standards from various standardization organizations or initiatives such as ANSI, IEEE, IEC, OASIS, OGC and SAE [2].

In the geo-information area, standardization is done mainly at ISO, OGC (Open Geospatial Consortium) and INSPIRE (EU). Within ISO, TC211 is responsible for standardization of geo-information and they have produced abstract geo-standards like the 19000 series [3]. The OGC (Open Geospatial Consortium) is an important standardization organisation and discussion platform in the geo-domain [4]. One of the links with the smart grid domain is formed by the OGC Smart Grid Location Standards / Energy & Utilities Domain Working Group. This group is setup because the ability to communicate geospatial information is seen as a crosscutting requirement in smart grid standards efforts worldwide. The OASIS eMIX (Energy Market Information Exchange) standard uses the OGC Geography Markup Language (GML) Encoding Standard. The IEC CIM (Common Information Model) standard is "harmonized" with WXXM (Weather Information Exchange Model), an industry profile based on GML. However, more standards coordination and development is required to enable efficient geospatial communication within smart grids as well as between smart grids and related activities such as emergency response, disaster management, urban planning and building energy management [5].

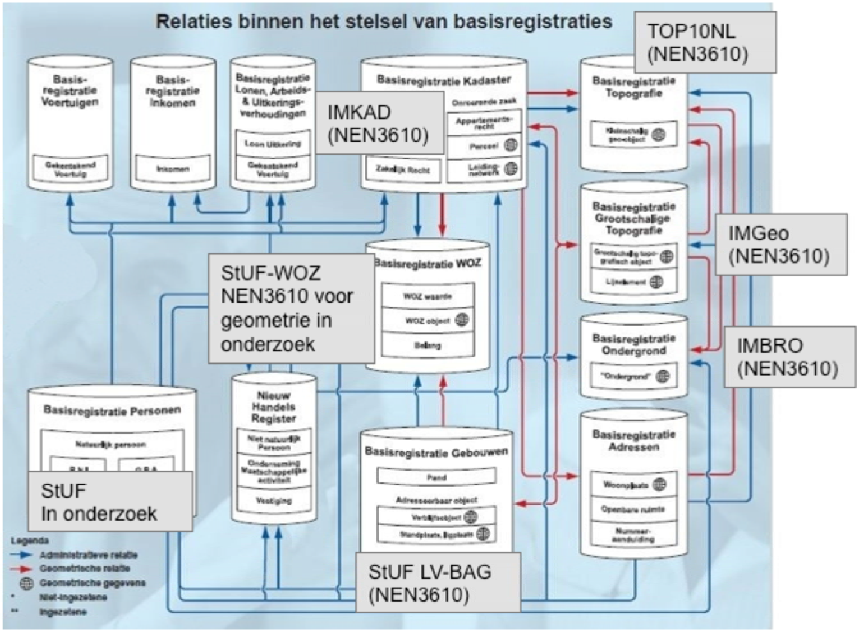
Besides ISO and OGC, the INSPIRE initiative is also important for the exchange and harmonisation of geo-data in Europe. This initiative has led to formal regulation in the form of Directive 2007/2/EC of the European Parliament [6]. The purpose of this Directive is to lay down general rules aimed at the establishment of the Infrastructure for Spatial Information in the European Community (INSPIRE) for the purposes of Community environmental policies.

With respect to geo-information, the Dutch government has established 13 basic registries with core information on various objects under responsibility of the government, such as the topographic landscape, addresses and buildings. This system of basic registries consists of individual registries that are coupled via common data-interfaces, a catalogue of services and technical interfaces for information exchange as shown in the figure below [7].

For the use case of the Smart Grid Information Broker, the following basic registries are relevant:

- Basic registry Large-scale Topography (BGT)
- Basic registry Topography (BRT)
- Basic registry Kadaster (BRK)
- Basic registry Underground (BRO)
- Basic registry Addresses and Buildings (BAG)

Each of these registries contains geo-information that is relevant for the operation of certain parts of the smart grid.



3.3 Possible mappings and transformations

The information model for the Smart Grid Information Block is based on standards. The information that is stored and exchanged conforms to widely-used open standards that make it easier to reuse the information. The fact that the information model is based on widely used standards does however not guarantee that the information coupled to the Smart Grid Information Block also uses the same standards. For instance in the Smart Grid Information Block all energy consumption and production is defined in Joules (J). In standards focussing on electricity, the energy consumption and production is often defined in kilowatt-hour (kWh). To be able to combine this information it is therefore necessary to transform the information from one of the sources to the other one. As CERISE defined the Smart Grid Information Block to be the main building block to base transformations on, we transform the kilowatt-hour information to Joules by multiplying the kWh number with '3600000'.

Another example of a possible transformation is the transformation of GPS coordinates. GPS coordinates can be defined base on multiple standards (Decimal Degrees, UTM, 'Degrees, Minutes and Seconds'). As these different standards can all define the same spot on earth, it is also possible to transform information based on one of the standards to information based on one of the other standards. As long as the semantics of the GPS coordinates are defined by the source so that one knows in what format they are, the information can be transformed.

When combining information from two XML-standards it might be possible that the semantics of the information are equal, but that the way the XML-standard is defined is different. If this is the case, and we know for sure that the information contained in the XML-files is semantically identical, it is possible to use XSTL-stylesheets (Extensible Stylesheet Language Transformations) to transform the information in one XML-standard to information based on another XML-standard.

In case the information contained in two standards is not equal, and thus the semantics are different, transformations become more complex. If two information fields in the base share the same definition, but one of the two fields has a more restricted option, it might only be possible to transform the information from the standards with the stricter definition, and not the other way around. For example: if standard A allows the values 'Yes' and 'No', for a specific field, and standard B allows the value ‘Yes’, ‘No’ and ‘Maybe’ for a field with the same definition it is possible to transform the information from standard A to standard B without losing information. The other way around (from B to A) is not possible as the option ‘Maybe’ is not available in standard A.

If difference in semantics increase, or the differences are more complex it might not be possible to define straight one-on-one transformations. An option to explore in this case is the use of ontologies as these offer possibilities to reason about the data. This might make it possible to combine the information from multiple fields to get the semantics of the data to be transformed clear and to define a transformation. For instance, if we have two standards about persons one standard might define whether a person is male or female, while another standard might only define that a person is a sister or a brother. If we then define a higher-level ontology that defines that a sister is always a female and a brother is always a male, it would be possible to transform the information in one standard to the other standard, based on ontologies.

4. Business case

In the energy sector the energy-balancing topic is important as imbalance in the consumption and production in the networks might lead to disruptions in the supply of energy. While the current production facilities can be easily managed to produce more or less electricity, this is more difficult with new electricity producers like photovoltaic panels and windmills. Their production depends on sun and wind, which cannot be managed. Energy balancing in the networks therefore become more difficult, this is where smart grids can come into action. If the predictions about the consumption and the production of energy can be better matched with the help of more information, the chances of disruptions become smaller and parties do not need to pay fines for creating an imbalance. The Smart Grids Information Broker use case works on realizing better information-exchange to make energy-balancing smarter. Although the real-time balancing of a network is an interesting subject, the main focus in the use case is on the administrative balancing of the smart grid, in which the balancing takes place on a scale of minutes/hours/days, instead of on the millisecond. The information domains that are taken into account in the use case are:

- Balancing domain: information exchange between current international, national, and future inter-local and local parties about the planned and actual energy supply and usage. The value of the balancing needs to be invoiced to the suppliers and consumers. This is information that needs to be exchanged between the balancing domain and the customer domain.
- Geo-infrastructure domain: the unplanned grow/building of new decentralized production units or large-scale consumers needs to be mapped onto the locations where these parties are connected to the energy networks (and therefore the smart grid). This asks for information exchange between the balancing domain and the geo-infrastructure domain.
- Customer domain: Information exchange about the status of balancing combined with geographical location information serves as the input for several services that can be provided in the customer domain: information about energy consumptions and possibilities to match production and consumption.

As mentioned before, CERISE is not realizing the Smart Grid Information Broker in itself. We assume that there will be a Smart Grid Information Broker in the near future and from that starting point we define the information need for consumers, producers and the parties responsible for maintaining the energy distribution networks. Based on this information need, standards are identified that can be used to exchange the information, and based on the overview of applicable standard we define semantic model transformations between these standards.

The advantage of having standards for smart grids, geo-information and government very well aligned is that information can be exchanged much more easily. As a consequence, many more sources of important information for maintaining balance and avoiding congestion in the energy distribution networks become available. Especially, in a world where local, distributed generation of renewable energy is increasing enormously, this optimal information provisioning is of utmost importance. This holds for the distribution network provider, the prosumer of energy at household level, the energy production company, the (inter) national transport operator and the local energy market operator of the future.

5. Conclusions, lessons learned and recommendations

The lessons learned in defining the use cases for the CERISE project and during the work on the first use case are that there are many interesting use cases in the smart grid domain. Each use case presents different challenges with respect to the information exchange between the geo-information, government and smart grid domain. Therefore, it was not easy to find the best use case to start defining semantic transformations, but the Smart Grid Information Broker was chosen as this use case is in the core of the smart grid world. Developing semantic transformations in this use case enables the use of the provided information in other use cases and makes it possible to realize more business potential.

We furthermore learned that there are many standards that are used in all three domains and that it is not possible to fully cover all possible transformations between these standard. We therefore start with the transformations that are necessary to be able to realize the use case, and we believe that the transformation method we define can also be used to realize mappings between standards that were not in our scope when defining the transformations.

A couple of recommendations that we have derived are:

- The Smart Grid world is a fast changing world, information mappings need to be able to handle more than one ecosystem
- There is no such thing as one smart grid world: different people and parties look at it from their own perspective, the information broker should make all views possible
- When defining information models try to define them on the smallest possible unit, this makes the information as flexible as possible
- When defining transformations make sure that there is a clearly define scope as this helps in making the necessity for the transformation clear
- Multiple transformation methods can be used to realize mappings: do not focus on only one option
- Do not define new standards but make use of existing ones: these are often already implemented and parties are not waiting for another standard that needs to be implemented
- Reuse information that is available within other parties and the government as this might make your own work easier and the maintenance of the information will be a shared goal.

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