# DEFINITION OF A GLOBAL ARCHITECTURE

# FOR

# SMART GRID APPLICATIONS

Version control:

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| Draft_04 | 19.09.2018 | Prof. Antonello Monti | Incorporating feedback from T&D Europe |
| Draft_03 | 20.08.2018 | Prof. Antonello Monti | Incorporating feedback from Atos |
| Draft_02 | 07.05.2018 | Prof. Antonello Monti | Second draft for stakeholder input |
| Draft_01 | 25.04.2018 | Prof. Antonello Monti | First draft for discussion with DG Energy |
| **Version** | **Date** | **Author** | **Content** |

## Forewords

This document presents a preliminary overview of data exchange and data format in the Smart Energy sector. Main goal is to understand how the energy system can transition to a Data Economy becoming part of the Digital Single Market. This document is intended as a working document where new ideas and results can be added up to reach the right level of maturity.

## Introduction

Modern grid applications regard the interaction of a variety of actors. The main goal of a smart grid implementation is the creation of an automatic process and then it is critical to define for every possible data exchange both the semantics of the information and the protocol of communication.

This task has been the focus of many studies and projects but, typically, each project has addressed the problem from a specific angle so that a comprehensive description of all the interactions are not collected and organized in a single document. This is the main purpose of this exercise.

As a *Comprehensive Architecture for Smart Grid (COSMAG)* we refer as the *collection of specifications able to define any possible data exchange among all the possible actors*. *This exercise is intended to check if current standards offer the proper roles interfaces to enable business processes, including new ones and to identify where new standards may be needed.*

The definition of COSMAG is based on a set of basic requirements:

- The set of interactions are defined so to support the implementation of the vision of the European Commission as from the Winter Package
- The architecture is built in such a way to offer “open gates”, i.e. data interaction points that can be used for future expansion and futuristic use cases
- COSMAG does not introduce any new standards but rather exploits and collects results of previous projects or standardization activities.
- Interactions that create single vendor or closed market situation should be avoided

A very important framework definition has been already offered by the work developed under the mandate M490, which brought to the definition of the Smart Grid Architectural Model (SGAM) that should be adopted to define any data exchange or communication solutions in power grid.

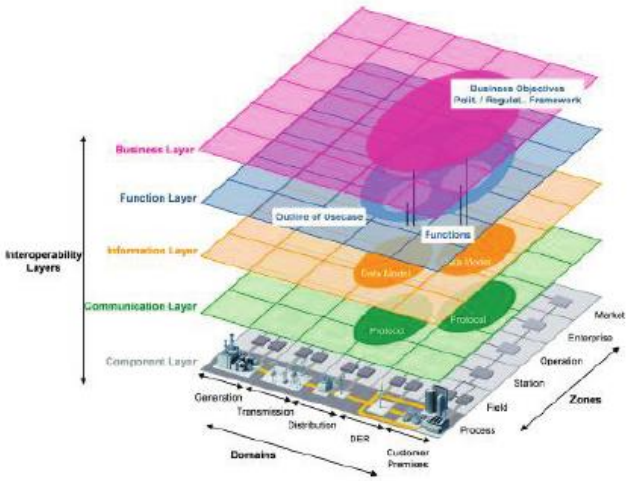



*Figure 1: The SGAM architecture*

## Preconditions

Starting point of the analysis is the picture reported in Figure 2.

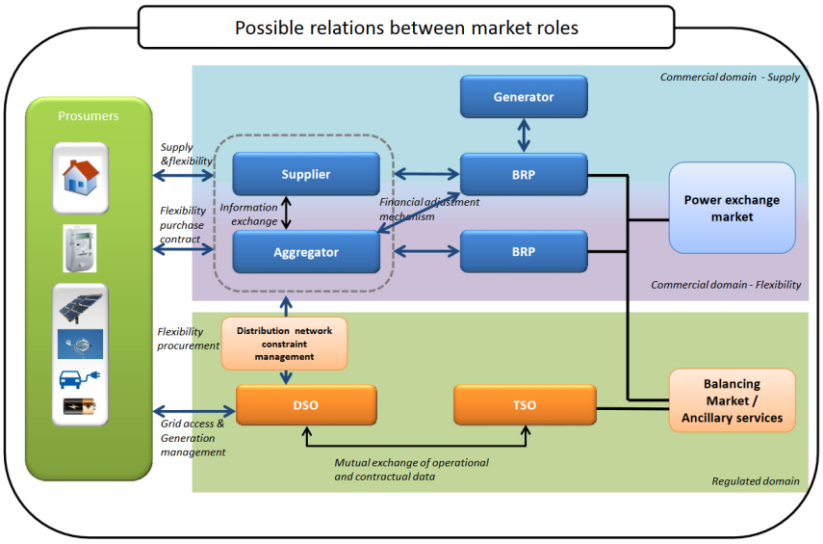



*Figure 2: The structure of the market and actor interactions*[1]

This picture describes all the interactions envisioned in the modern electricity market and it is used as a starting point to identify all the possible communication options.

By using this picture as reference we can analyze each flow one by one to understand the current status of protocol definition and data models. Main purpose of this analysis is the understanding of the maturity level per type of flow. This is depending on regulation, business models, technologies, etc.

## Analysis of the data flows

To structure the document we consider each actor separately and consequently all the interfaces for each of the actors. From Figure 2 we can identify the following actors that are meaningful for this report:

- Prosumer
- DSO
- TSO
- Aggregator
- Wholesale Market

This list of actors derived from Figure 2 is any case not complete but it will be used for the purpose of this working document. It should be anyhow pointed out that other actors could be identified such as suppliers, community manager or data manager and others. A complete assessment of all the possible roles could be the work for a coming working group

We do not consider classical generation given that the operation of such a player is already well established. All the interfaces to Wholesale Market are also well established and then not considered in this report. On the other hand, it makes sense to consider also a hypothetical new player called local market operator. This operator could potentially be the DSO but this identification

[1] Smart Grids Task Force - Expert Group 3, "Regulatory Recommendations for the Deployment of Flexibility: SGTF-EG3 Report," 2015.
https://ec.europa.eu/energy/sites/ener/files/documents/EG3%20Final%20-%20January%202015.pdf

is not yet in general accepted and then it makes sense to keep it a separate. The option of local market is anyhow already envisioned in Smart Grids Task Force - Expert Group 3, "Regulatory Recommendations for the Deployment of Flexibility: SGTF-EG3 Report" available at https://ec.europa.eu/energy/sites/ener/files/documents/EG3%20Final%20-%20January%202015.pdf

In the following an analysis for each actor is presented. It should be underlined that the analysis mostly focuses on the current status. Referring on the discussion about actors, other possible evolutions and interactions could also emerge.

## TSO

The internal data flow for TSO is structured since long time and then no need of incremental considerations is envisioned.

### *TSO-Market*

This interface is already perfectly standardized

### *TSO-DSO*

This interface is currently under development. A significant work in progress is given by some on going H2020 projects such as SMARTNET. A good analysis can be found in the deliverable D1.3 available at http://smartnet-project.eu/wp-content/uploads/2016/12/D1.3_20161202_V1.0.pdf

## DSO

The internal data flow for DSO can be considered well structured even if not all the DSOs are already adopting the most recent solutions. Very important is the development of IEC61850 both as an automation protocol and as a data model for substations. Other key element of data standardization is given by IEC61970-301 and IEC61968-11 that defines the main element of the so-called Common Information Model (CIM). CIM is a complete data model for power system used to exchange also data among grid operators (both at TSO and DSO level). The adoption of all these standards should be encouraged within the DSO domain and to support also TSO-DSO interaction. A complete architecture for DSO automation has been proposed and formalized in the project FP7 IDEAL. A good reference document is given by deliverable D3.2 available together with annexes at http://www.tut.fi/eee/ide4l/D3.2/ide4l-d3.2-final.pdf.

This document fully describes the implementation details and applies formally the SGAM methodology mentioned above. Figure 3 is an example of architectural documentation in SGAM methodology extracted from the IDEAL deliverable.

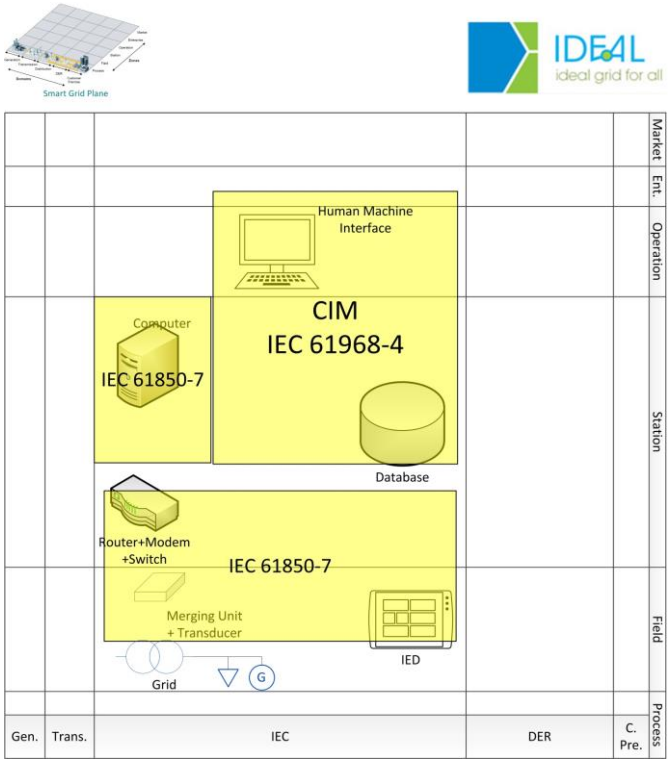



*Figure 3: Example of definition of domain use for the most important data standard according to IDEAL deliverable*

### *DSO-Local Market*

This interface is at the moment not present given that local markets are not in place. Some reference solutions are proposed also for this interface in the SMARTNET deliverable mentioned above.

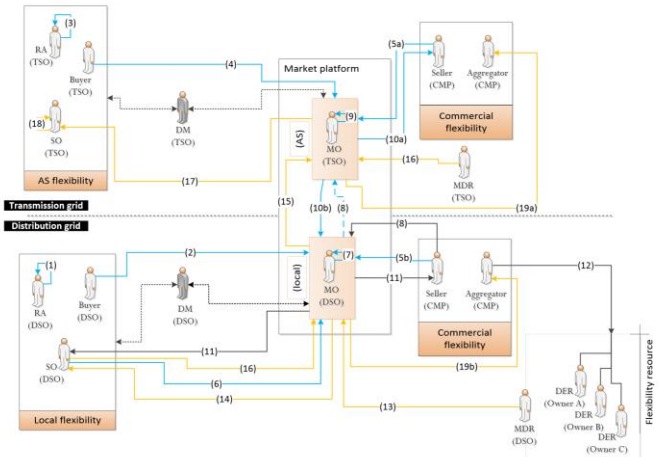



*Figure 4: Example of local market structure according to the SMARTNET deliverable*

### *DSO-Prosumer*

This relation is still under development even if many experiments in this area have been already performed. Main reason for data exchange at this level is related to the generation control. Available solutions are given again by IEC61850-7 and in the case of wind turbines IEC61400-25. In this case situations such as Demand Response are not included given that the channel DSO-Prosumer is here intended only for network operation and not for market services.

## Aggregators

Aggregators are new players recently introduced. Some real cases are available and they are mostly acting as link to the wholesale market. Here we will consider also the possible link to a local market.

### Aggregators-Local Market

This area is still widely uncovered. A set of tools for local market implementation has been proposed in the FP7 Project FINESCE. A complete set of open source API, compatible with the FIWARE platform, have been proposed and are available at http://finesce.github.io/api_table.html. An interesting extension to the already proposed solution could be given by adopting the SAREF data modelling as a way to exchange the information.

### Aggregators-DSO

This exchange is important to allow the integration of network constraints in the planning of an aggregator. So far, aggregators are operating under the "copper-plate" assumption but this option is supposed to lose value in the coming future. This interface is still open and there are no dominating standards. In the FINESCE project, ESB Ireland implemented a complete solution based on FIWARE technology but using proprietary protocols for the network management part. This case of link is also covered in the USEF architecture (https://www.usef.energy/).

### Aggregators-Prosumer

In this area the emerging standard is given by OpenADR. IEC has approved OpenADR as Publically Available Standard (PAS) (IEC/PAS 62746-10-1). As part of this process OpenADR data model has been also mapped to CIM. This process is part of the wider IEC work PC118 (Smart Grid User Interface). Recent work from TNO has shown the possibility of integrating the OpenADR approach with SAREF. TNO has also released the so called EFI (Energy Flexibility Interface) to model flexibility in support of all the market needs. Furthermore, a recent study, currently under finalization shown a great level of alignment of the SAREF approach with many existing standards[2]. This result shows the possibility to consider SAREF as an overarching ontology for data in Energy systems.

## Prosumers

Interface to Prosumers have been introduced already in previous sections. Here we cover some other options of exchanges not covered in the previous sections

### Prosumers-Retail

The main exchange is related to Metering data. Different standards have been proposed for Metering data. The Open Metering System specification has developed proposal of standardization in this area (see https://oms-group.org/fileadmin/files/download4all/specification/Vol2/4.1.2/OMS-Spec_Vol1_General_v201_RELEASE.pdf). Three protocols emerged as standard in this area: M-BUS, DLMS/COSEM and SML. Different scenario of data management from metering are currently present in Europe depending on the regulation of the member states. One critical topic is that data from metering could be used also for grid operation as proposed in projects such as H2020 FLEXMETER in which a cloud-based platform for smart-meter based services have been proposed. Open Source Domain Specific Enablers and API have been also proposed as open-source solution in the project FINESCE assuming a FIWARE based platform. This option would enable the possibility to integrate smart metering data in the larger context of Smart City.

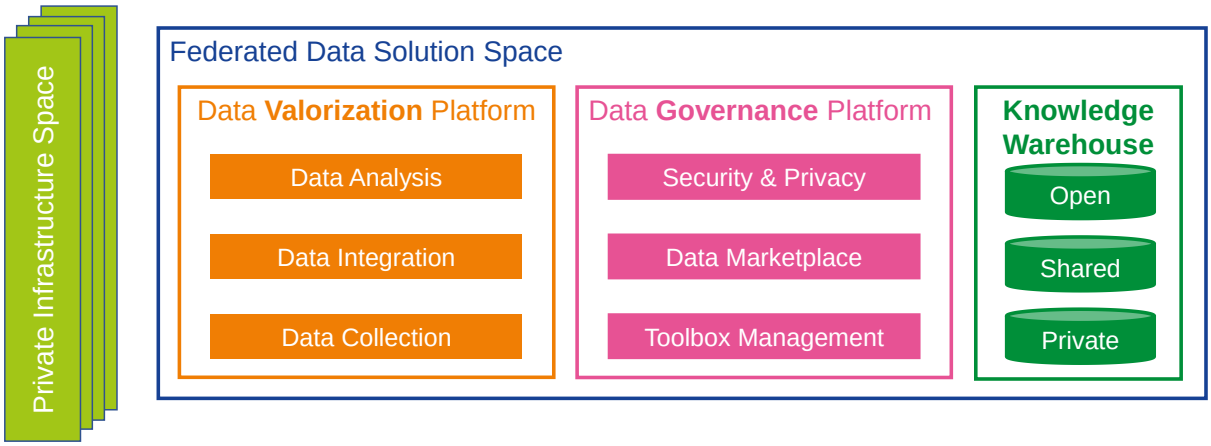
[2] "Study on ensuring interoperability for enabling Demand Side Flexibility" coordinated by TNO, DNV-GL, ESMIG for DG Connect (under finalization)

### Prosumers-Prosumer

Recently various project proposed solutions based on peer-to-peer markets which then requires a direct link among the customers and the possibility to define direct contract among the parties. This is for example considered in the on-going H2020 SHAR-Q. Most of the solutions proposed assumed in any the use of Blockchain technology for contract management.

## Towards a data economy

The digitalization of the energy sector demands higher levels of operational excellence with the adoption of disrupting technologies to foster cross-domain data sharing and data-driven innovation. The upper layers of the SGAM architecture, Function and Business, are not so simple to integrate into a single data management solution. Their services cover a wide range of functionalities and their business opportunities affect various vertical energy domains. In this context, new energy actors are not the only newcomers in this re-invented market value chain, as they are also relying on incumbent actors that bring emerging technologies at ICT level. In turn, this new landscape entails more complexity and fragmentation to an already heterogeneous environment. All in all, the goal of reference architectures is to contribute to the creation of secure, trust and controlled collaboration spaces in which existing and emerging technologies could better exploit in safe and trustable ways the data provided by energy actors and the insights derived by data innovators.




The collaboration must be orchestrated not only from the data analysis and exposure perspective, but also provide other supporting functionalities that will assure not only the coordination among the modules but also the sustainability of the solution. Three main areas are foreseen:

- A potential **Data Valorization Platform** should take into account that growth and competitiveness depend on the ability to collect, integrate, manage and transform data into business insights and outcomes.
- Dealing with **cybersecurity**, compliance, reliability and sustainability as major challenges, a Data Governance Platform shall offer scalability, elasticity, openness and security in the cloud, enabling fastest decision-making and greater accuracy to demonstrate the value of data through its exploitation using Big Data tools, and monetization via marketplaces.
- Once data is transformed into information and knowledge, a Knowledge Warehouse should be in charge of offering functionalities such as data persistence, interrogation, reporting and visualization, through the usage of OpenData Portals, dashboards, Open APIs and downstream applications.

One important aspect still relies on the interoperability between the key elements of each platform and spaces. Common standards, agreed data models and ontologies, comprehensive documentation and Open APIs harmonise the access to data and data processes, and facilitate the interactions among the different actors and platforms in the Federated Data Solution Space., ensuring the achievement of fastest adoption, continuous integration, deployment and evolution of the implemented solutions.
Summarizing the following key elements in data management in support of a data economy can be summarized:

- **Data model/Semantics**: definition of an appropriate data model beyond a single sector is a ky ingredient for interoperability
- **Context:** the definition of the context is a key ingredient for bridging through different verticals
- **Soverignity**: to unlock the market is key to offer the possibility to define who can manage the data and for which purpose to protect privacy and customer interest
- **Open API**: close solutions will not create a real open and competitive market. Open API offer the perfect bridge between private infrastructure spaces

### Sector Coupling

Local energy community is an emerging solution that does not fit perfectly in the picture reported in Figure 2. The main characteristics of the local energy community is the integration of different energy vector to increase the level of local flexibility. Such a solution requires to go beyond the electricity sectors and then it goes beyond the work performed by IEC.

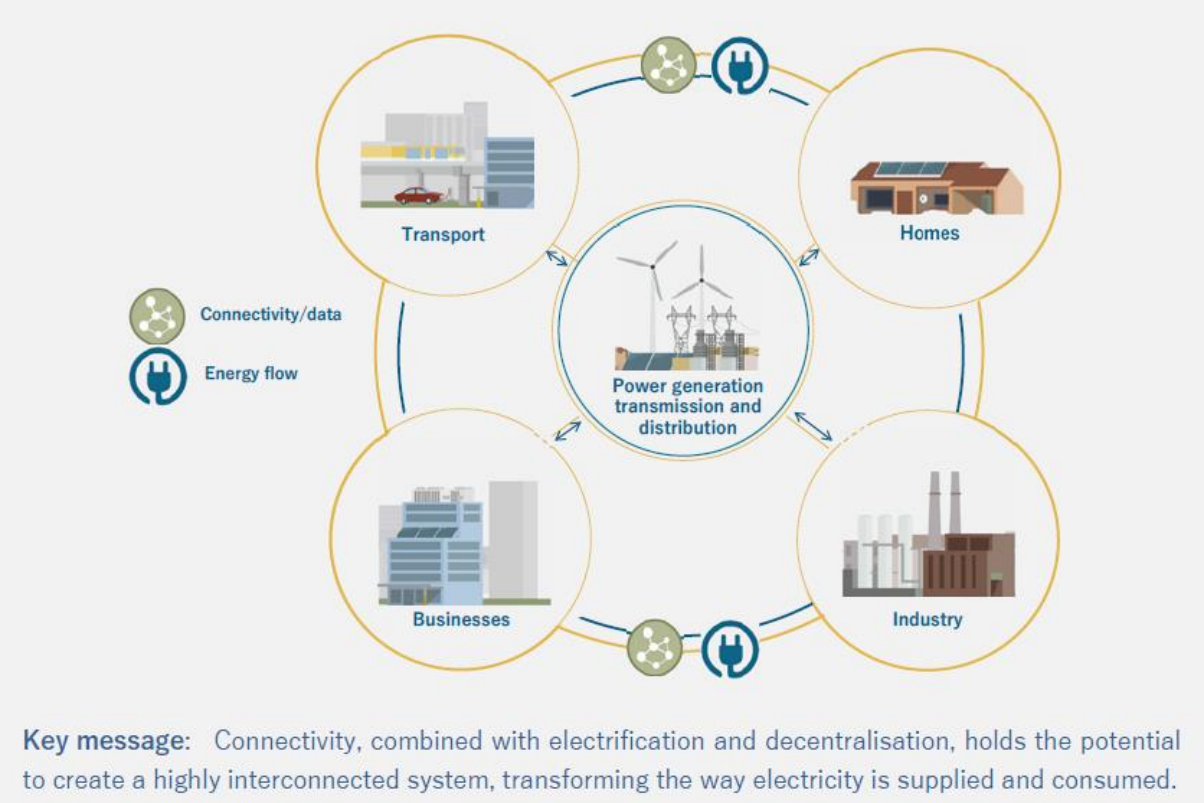
Solutions such as the FIWARE Context Broker could support a seamless merge of sectors assuming to extend the set of Contexts present in the ETSI CIM standard. Such an extension could be built on top of the SAREF data modelling.

Breaking data silos, cross-domain opportunities increase the potential impact and benefits coming from the energy sector. IEA has reported the impact digitalization of energy brings to the transport, home, business and industry domains[3]. The new business models should accommodate not only incumbent energy actors (DSO, TSO, Service Providers, Energy retailers and the installation and maintenance providers), but also the new ones entering the domain (prosumers, aggregators, PV and smart meter manufacturers…), and what is also important as presented, the new entrants coming from different sectors such as transport, logistics, smart home or infrastructure managers.

The way the collaboration among all these actors take place is based on services benefiting from platform openness (see Open API in what above). In some cases, multipurpose platforms can act as the glue for the exploitation of the data coming from different domains, as it happens with FIWARE with its generic enablers[4] facilitating the collection of data from multiple sources. In other cases platforms drive the connection via Marketplaces as it happens with Open Data platforms. But in all the cases, the digitalization creates new opportunities, new services and new revenue streams for all the actors involved in this inclusive ecosystem.

[3] Digitalization and Energy – 2017 – IEA - http://www.iea.org/publications/freepublications/publication/DigitalizationandEnergy3.pdf
[4] https://www.fiware.org/2017/04/10/fiware-and-the-connecting-europe-facility-advancing-the-digital-single-market/

Business models also evolve and can be not only B2B or B2C as it was before, but also more complex ones such B2B2C and C2C. A service acting in B2B2C scheme is weather forecasting, it can serve private customer or a DER operator. For the C2C, we can envision a collaboration scenario among two prosumers transferring energy between them.




Src : IEA – Digitalization and Energy – 2017

### Link to third parties

One of the interesting aspects offered by the availability of data platform is the possibility to create open interfaces that could be exploited by third party providers that can bring innovative services to the energy domain. This is a typical area in which Start-ups are particularly active. The project FINESCE developed a complete set of API in this direction that could be offered by data platforms such as the one collecting metering data to provide new and innovative services to the customers. As in the previous case the best option would be given by the extension of the Context Broker by introduction of a new domain for energy.

### Link to Smart City platforms

As discussed in the previous paragraph this case could be easily covered adding the domain energy in the FIWARE Context Broker. This option is particularly interesting for the special case of sector coupling energy-mobility created by the e-mobility development. The open API interface would serve as a bridge also to possible proprietary solutions making the FIWARE the perfect glue among different context and providers and removing data silos.

## Conclusions

This document presents a preliminary overview of data exchange and data format in the Smart Energy sector. Purpose is to use this document as a working document where new ideas and results can be added up to reach the right level of maturity.

Some conclusions can anyway be drawn also at this point:

- Many standards are available and many data exchanges are already formalized. Nevertheless, some emerging changes in the market structure may bring some significant element of novelty (e.g. local markets)
- Most of the open points are around the customer/prosumers. Given the future role of this actor, the interfaces at this level are extremely important. In the future, it is expected that a large amount of data will be related to the customer level. In this respect data platform able to aggregate data are an important part of the picture. Those data will play a key role in every element of the energy system.
- Other important element to keep into account is the emerging role of sector coupling making critical to avoid data silos. In this respect new standards as emerged from the recent work of ETSI, e.g. ContextBroker, are an important piece of the puzzle.
- It is important that data platform will be based on open standards to support open competition. In this respect solutions such as FIWARE can be considered as the right approach
- Data models are also a critical aspect. In this respect, SAREF extended to cover the whole energy value chain is a very valuable candidate.

## Next Steps

This document should be considered as an open draft to be continuously updated to be sure that the opinion of each relevant stakeholder is included.

Some key actions can anyway be identified:

- The focus should be placed on some of the key topics. The most compelling items are
    - Selection of the appropriate ontology for energy systems
    - Definition of a strategy for data platform management and integration of those platforms in the energy architecture
    - Integration of the IoT world in the energy context and vision
    - Definition of an approach for Peer to Peer solutions for customer aggregation