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Testing and certification of EVs and charging infra

Thijs van Wijk¹, Albert van den Noort², Ben Kootstra³

¹*ElaadNL / EVnetNL / Alliander, thijs.van.wijk@e-laad.nl,*

²*DNV GL, albert.vandennoot@dnvgl.com*

³*Liandon, ben.kootstra@alliander.com*

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Abstract

The ELaadNL foundation was initiated by the Dutch grid operators to ensure a smooth introduction of an electric vehicle charge infrastructure in the Netherlands and, by doing so, facilitating the emergence of electric vehicles (EVs). To accomplish this ELaadNL developed tests and test procedures for making sure charge stations owned by Elaad (and later EVnetNL) operated correctly with Electric Vehicles. These tests revealed various issues, related to interoperability, smart charging and to the impact of EVs on the grid. It was realized that with the increase of the numbers and variations of electric vehicles and charging infrastructure, testing and setting the right requirements would become more important. Also, ElaadNL realized that it could not handle all these tests alone. With this in mind, a plan was made with the ambition to create a certification process which allows for EVs and charging stations being certified on their smart charging and cyber security implementations and their grid impact.

This plan consists of two-phases; the first phase focusses on an impact analysis via the SGAM model and on performing and evaluating tests to gather test requirements. The gathered information will be used in the second phase to set up a certification process and evaluate the current standards via a GAP analysis.

During all these steps a special focus will be on the interoperability of the different EVs and Charging Infra systems in relation to the (smart) grid. Also, ElaadNL will focus on the creation of knowledge regarding the requirements, test, certification and standards and does not have the ambition to become a certification body itself. By doing this we want to make sure the large scale implementation of Electric Vehicles and new charging methods can be done smoothly in the Netherlands, and as a possible side effect throughout Europe, as long as the requirements are being met.

1 INTRODUCTION

The e-laad.nl foundation was initiated in 2009 by the Dutch grid operators to ensure a smooth introduction of an electric vehicle charge infrastructure in the Netherlands and, by doing so, facilitating the emergence of electric vehicles (EVs). The Dutch grid operators started this because they recognized that electrification of transport would start sooner or later and they should investigate the impact electric vehicles will have on the grid. This way they could prepare to mitigate the effects, for instance by introducing demand response in the charging cycle; so called smart charging.

To accomplish this e-laad.nl worked, together with partners, on the standardisation of plugs, charging cards and started the development of the Open ChargePoint Protocol (OCPP), in which the communication between charging station and backoffice system was standardised. Later on smart charging profiles were also added to the OCPP protocol.

To make sure all the charge stations owned by e-laad.nl had correctly implemented the standards and could (smart) charge the different Electric Vehicles, several tests procedures and test were respectively created and executed. This was continued when the e-laad.nl foundation was split into two parts; EVnetNL as charge point operator, and ElaadNL as charging infrastructure knowledge centre. The testing activities were positioned within ElaadNL and new tests, mostly related to more advanced smart charging and power quality, were created afterwards.

During the years of testing various issues came to light, related to interoperability, smart charging and to the impact of EVs on the grid. Cases were observed of EVs not listening correctly to the stations signals and of EVs creating harmonic distortions and short current peaks, see figure 1 and 2, which can have a big impact on the electricity grid.

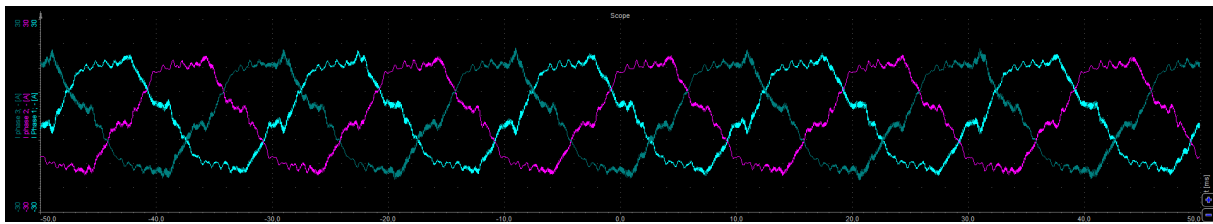


Figure 1: harmonic distortion of the current

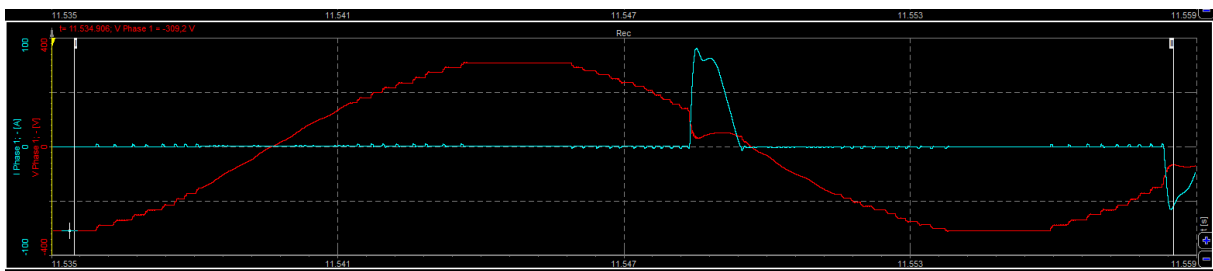


Figure 2: current peak (~90A) during start of charging process

Based on these results ElaadNL realized that, to make an increase of electric vehicles possible while also keeping the grid stable, the EVs, charging systems and the underlying systems should be tested more thoroughly and perhaps even be certified for (smart) charging on the public grid.

ElaadNL also realized that it would not be feasible to perform all these tests themselves. With this in mind, the following plan was made to create a process which should lead to all EVs and charging stations being tested before being charged on public stations via the Dutch electricity grid.

2. PROJECT PLAN

2.1 GOAL

The following chapter will concern the main goal of the Testing and Certification of EVs and charging infra plan and the related sub goals.

The main goal of this testing and certification plan is to make sure the Dutch electricity grid will be able to handle the significant increase in electric vehicles and charging infrastructure that is expected to happen in 2025. The expectation is that in 2025 The Netherlands will count about 1 million electric vehicles, of which most will be charged in the evening in residential areas. To be able to handle this cars will need to be able to smart charge and, if the car supports it, able to return electricity to the grid. This should be tested on EV-station level, but also on a higher system level to make sure the different protocols and systems needed for smart charging are functioning properly, are able to deliver the needed flexibility and are secure. Also, all these charging EVs should not lead to noticeable power quality issues in the grid which might damage or reduce the lifespan of DSO assets and/or household equipment. This results in the following main goal and sub goals:

Main goal:

Making sure the grid impact, related to both an increase in electricity demand on peak moments and a possible increase in power quality issues, is maintained within certain boundaries defined by the Dutch grid operators. This to prevent problems when the number of EVs and their cumulative impact on the grid significantly increases.

Sub goals:

- *Testing the interoperability between EVs and charging stations, with a focus on the correct execution of smart charging profiles and V2G, to the existing norms;*
- *Testing the proper function of smart charging on the energy system level. Making sure the different systems and protocols to allow smart charging on a system level work together, can work together with other demand response systems and are secure;*
- *Making sure the grid impact of the charging stations and the EVs is within certain norms which allow a significant increase of EVs without noticeable power quality issues.*

2.2 SCOPE

The scope of the plan is to focus on the knowledge creation part of testing and certification. It is not the ambition of ElaadNL to become a testing and certification organisation. ElaadNL wants to focus on creating use cases and test procedures so third parties can perform the required tests in a standardised way. To create these tests ElaadNL will run several tests themselves and will keep monitoring and testing new market and technical developments. Also, ElaadNL will perform tests to help set up requirements, best practices and, if required, to promote changes in related norms. This information will also be shared with the third parties so they can develop their products to meet those requirements and can use these for testing and certifying.

2.3 STAKEHOLDERS

The stakeholders involved in the ElaadNL testing and certification process are the following

- *Automotive parties: EV manufacturers*
- *Charging station manufacturers: manufacturers of charging infrastructure*
- *(Backoffice) system developers: developers of IT systems needed to allow stations to smart charge. For instance developers of charge station back office systems and flexibility aggregators.*
- *Test labs: Other testing facilities, can be related to the certification bodies*
- *Certification bodies: parties which certificate products which have been tested and met the requirements.*
- *DSO: Distribution System Operator; the grid operators of the distribution grid. ElaadNL will focus on the Dutch DSOs. Information from the DSOs will be used to set up requirements*

2.4 PROCESS OVERVIEW

The process overview below shows the ElaadNL goal of a certification process for Electric Vehicles, Charging Infra and related ICT systems and the position of the ElaadNL test Centre within this process. The tests will be focused on DSO related subjects; Grid Impact, Smart Charging and Cyber Security. To develop these tests input will be used from market and technical developments, from the DSOs and from tests to identify possible issues with new EV- and charging technologies. All the gathered information will be used to set up test procedures, best practices and requirements which will be made available for the manufacturers and the different testing and certification facilities. They can use this information in their turn to test if the products are ready to be introduced.

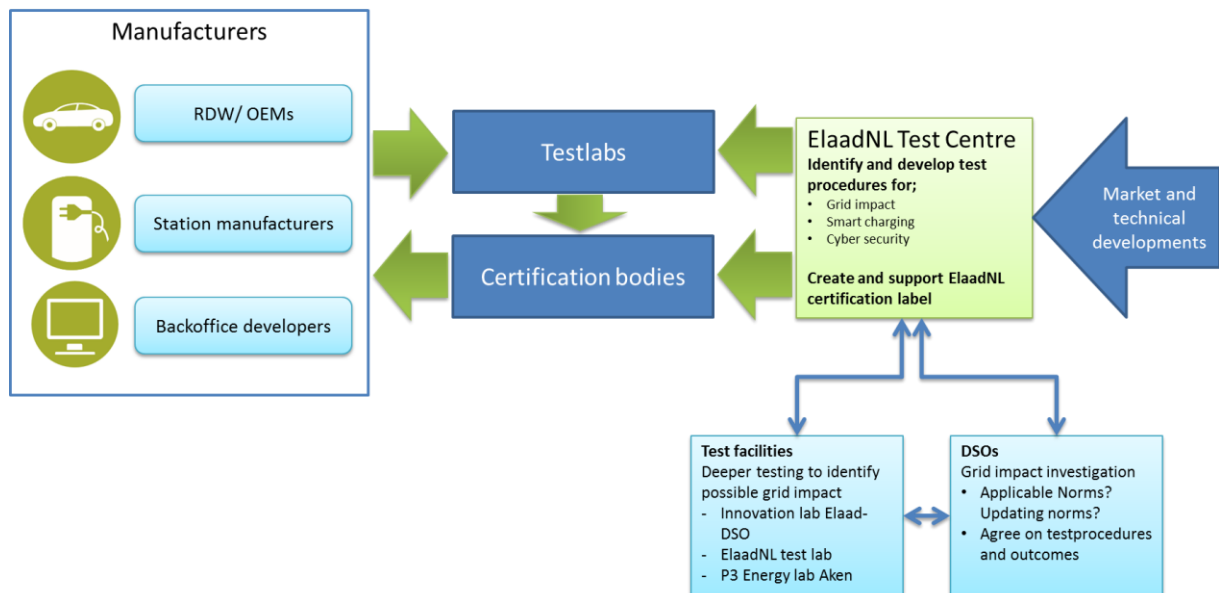


Figure 3: ElaadNL Test Centre goal

3. Method

To achieve the above set goals a four-phase project has been set up; the first phase focusses on the creation of knowledge needed to set up test procedures and requirements. The gathered information will be used in the second phase to set up the test procedures and testing facilities. In the third phase tests will be performed to acquire the best practices/requirements which will allow smooth introduction of large amounts of electric vehicles. The fourth phase focuses on setting up the certification process and influence relevant norms. This phase can partly run in parallel to the first three phases because it takes time to become a member in the relevant commissions.

First phase (knowledge creating phase):

- Creating an overview and assessing the relevant developments in the field of electric vehicles and charging infrastructure
- Creation of an overview and assessment of grid impact power quality effects.
- Gathering requirements for the use cases and test procedures from the DSOs.
- Using the Smart Grid Architecture Model (SGAM), see appendix I) to define which domains, dimensions and zones of the electricity system are involved and which relevant standards already exist for these.
- Creation of (smart) charging uses cases, for instance V2X (especially islanding mode), Inductive charging and (Ultra) Fast DC Charging
- In relation to this future scenarios will be created, both of green field (new grids) and brown field (existing grid), which will take into account increases in numbers of EVs, solar panels, heating pumps and household equipment known for generating harmonic distortion (a power quality effect) like LED lighting.

Second phase (setting up test procedures and facilities)

- In the next phase the use cases will be used to set up test cases/procedures
- The testing procedures, along with the DSO requirements and the future scenarios, will be used to set up the ElaadNL testlab and/or seek collaboration with third party testing facilities

Third phase (testing and setting requirements)

- Tests will be performed by introducing electric vehicles and charging infra in the test lab to different defined grid topologies and future scenarios.
- The limits of the DSO grid and the DSO and consumer electronics will be explored to find suitable requirements
- These requirements will be documented and publicly shared

Fourth phase (certification process and evaluating standards)

- Setting up the certification process
- Assessing which requirement/norm commissions are relevant
- Joining and influencing the relevant norm commissions

4. PHASES

4.1 First phase (knowledge creating phase):

This phase has been used to gather and create knowledge as input to the use cases and future scenarios. To summarize a brief look into the use cases and the scenario building will be shown here. The use cases will focus on Net (Grid) impact and System interoperability

Use cases

Net impact

Uncontrolled charging (UC) is the most basic form of charging. It concerns the interoperability of physical components, without any form of explicit communication or control.

Charging with demand response (DR) introduces communication with an external device or party, such as a Home Energy Management System (HEMS) or aggregator. This type of communication can control the flow of power, and slow down or stop the charging process when necessary.

(Re/de)charging introduces the possibility of feeding stored electricity back into the grid, enabling V2X solutions. This requires information on financial or other incentives for feed-in.

System interoperability

Ensuring interoperability and settlement (IO) ensures that all relevant information flows for settlement are included in the system. It does not concern itself with the content, but judges whether the individual components in the system communicate successfully.

Manage charge infrastructure (MCI) looks at the content of the information flows in the IO case to determine whether they are suitable for providing the services intended by the consumer.

Market mechanisms (MM) places all the previous in the business context to determine whether it aligns with the business goals of the customer.

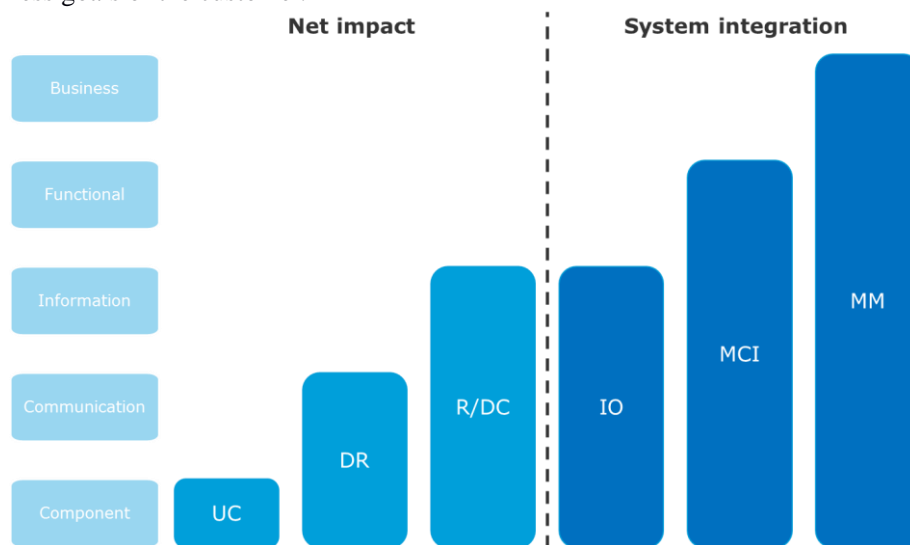


Figure 4: use cases

Use case structure The use cases are built up to describe all currently possible facets of the consumer's charging experience. This starts by describing the action employed by the consumer: the basis of the use case. Based on where this action takes place, a number of possibilities exist for what type of charging technologies are available for a consumer. Finally, after the charging process is finished, the consumer will be charged based on the tariff employed. The charging technologies and tariffs are what ties the use case to the test cases described in a later deliverable.

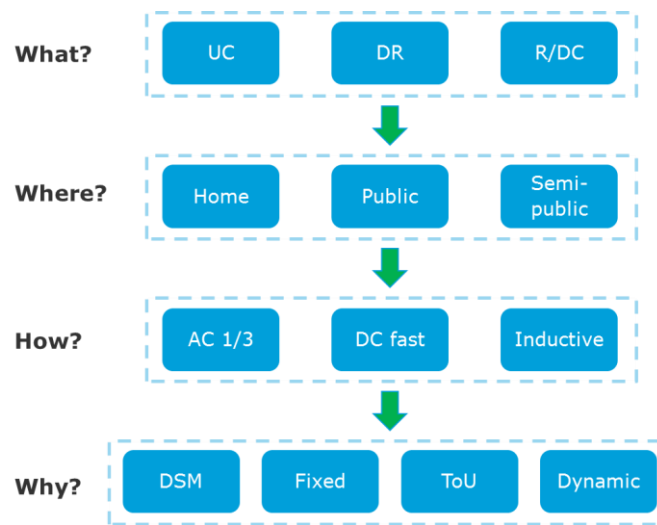


Figure 5: Use case structure

Future scenarios

In relation to this future scenarios will be created, both of green field (new grids) and brown field (existing grid), which will take into account increases in numbers of EVs, solar panels, heating pumps and household equipment known for generating harmonic distortion (a power quality effect) like LED lighting.

4.2 Second phase (setting up test procedures and facilities)

In a continuous effort ElaadNL will test the impact of EVs and charging infra on the grid and use this info to set the requirements and keep them up to date. Because of the continuous growth of EV and Charging infrastructure in the Netherlands the requirements will be set in such a way that they will allow the integration of these products on a large scale in the Dutch DSO grids.

To set the requirements earlier test experiences will be used and the products that have shown noteworthy behaviour will be retested in a broader interoperability and power quality test scope. Here tests can be performed with simulated data and data from a live grid. This allows for deeper testing of interoperability and system integration for smart charging solutions in a smart grid. This way the impact of (new) technologies and products can be tested in real-life situation and in future scenarios in which more EVs and locally produced renewable energy are connected to the grid. The type of testing to be used is the “Hardware in the loop” test, which sets a certain environment and the to be tested object is introduced to this. See figure 4 for an overview of this.

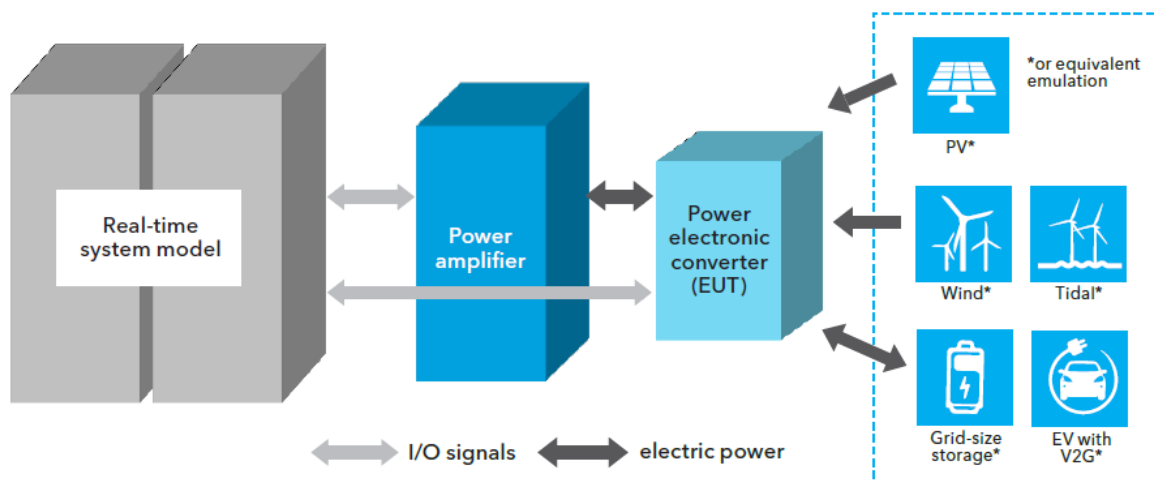


Figure 6: hardware in the loop testing

4.3 Third phase (testing and setting requirements)

To keep the requirements up to date new market and technological developments will be closely monitored and new products will be tested as soon as feasible. The ElaadNL test lab will be used for functionality and interoperability tests between the EVs and Charging systems. Deeper testing of grid impact will be performed at the Innovation test facility of the ElaadNL DSO. An assessment of other test facilities will be made to identify possible alternative tests and test locations.

4.4 Fourth phase (Certification process and evaluating standards)

The information gathered will be used to create a library of test requirements, which ElaadNL will use to create new or updated tests and test procedures. These tests requirements will specially focus on interoperability. All documents regarding test methods and procedures will be made publicly available as best practice documents.

To ensure the required tests will be performed and the results are being verified, a certification process like seen in figure 3 for EVs and Charging Infrastructure focussing on smart charging, grid impact and cyber security should be created. ElaadNL aims at setting up this process by creating the needed test requirements and by working together with certification bodies to create an “ElaadNL” certification label. The founding DSOs of ElaadNL can ensure that these requirements are met by requiring this certificate before a charging station will be connected to the grid. Also, ElaadNL will promote these requirements at different (contracting and/or governmental) organisations. ElaadNL does not have the ambition to act as a certification body herself. We envision one or multiple qualified certification bodies to handle this. ElaadNL will create or join a related Quality/Test Working Group to solve issues with the test procedures and to keep them up to date.

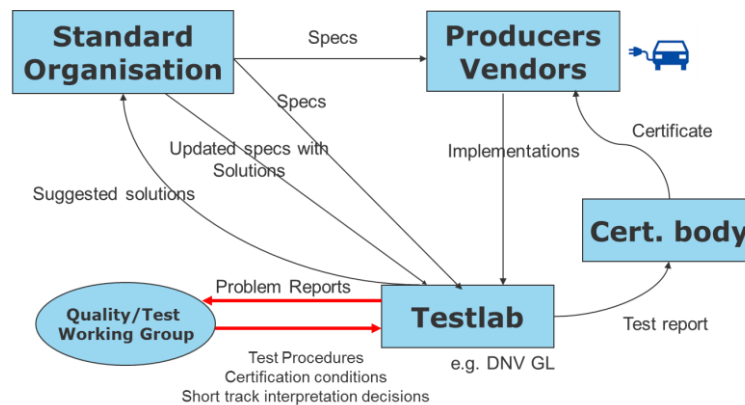


Figure 7: a standard certification process

Secondly, the gathered information will be used to run a GAP analysis on the current applicable standards in comparison with the possible impact of EVs and charging infra and the demands of the DSOs. When existing standards are not sufficient to ensure large scale implementation of EVs, ElaadNL will suggest adaptations to the relevant commissions or even actively join the corresponding standard commission to promote the change. By doing this we want to make sure the introduction of Electric Vehicles and charging infrastructure can be done smoothly in the Netherlands and Europe.

References

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Authors



ir. Thijs van Wijk has been working for 7 years for the Dutch DSO Alliander and has been posted for the last 5 years at the ElaadNL foundation. Here he has gathered considerable knowledge of EVs, charging infra, and the interconnecting systems and interfaces during these years. Currently he is active as the ElaadNL backoffice system architect, running the test lab and as project leader for setting up the new test and certification process. Thijs holds a bachelor degree in electrical engineering (2005) and a master degree in Innovation Sciences (2009).



Dr. Albert van den Noort is an experienced consultant and project manager in various smart energy projects within DNV GL. He gained knowledge on electricity and gas markets, smart grids and the energy transition. Albert holds a Master of Science and PhD degree in respectively Chemical Engineering (2002) and Applied Physics (2007). In 2009 he switched to the energy sector and joined DNV GL.



Ben Kootstra is an experienced consultant and project manager in various smart energy and sustainable mobility projects within Alliander and ElaadNL. He gained knowledge on smart grids and the energy transition in particular interoperability and system integration. Ben is educated in Electric engineering, information technology and business administration

APPENDIX I: SGAM MODEL

The Smart Grid Architecture Model (SGAM)¹ will be used as a framework to describe the different aspects.

The SGAM Framework aims at offering a support for the design of smart grids use cases with an architectural approach allowing for a representation of interoperability viewpoints in a technology neutral manner, both for current implementation of the electrical grid and future implementations of the smart grid. It is a three dimensional model that is merging the dimension of five interoperability layers with the two dimensions of the Smart Grid Plane, i.e. zones (representing the hierarchical levels of power system management) and domains (covering the complete electrical energy conversion chain). See Fig. 2.

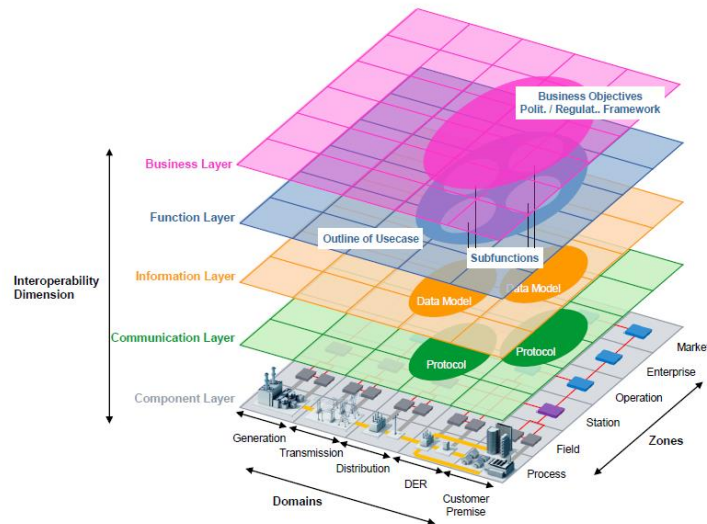


Figure 8: SGAM model¹

This model can be used to analyse EV charging use cases, for instance inductive EV charging, for their relevance on the different layers of interoperability, the zones and the domains. These use cases will be retrieved from the IEC Smart Grid Standards Map^[2]. If needed, new use cases will be created. In the use case the underlying process and the corresponding stakeholders are clearly defined, which allows identifying the zones, domains and systems covering the use case. With this information, the relevant standards to the use case can be defined. The SGCG Interoperability IOptool^[3], an overview of the smart grid standards, will be used for this. This overview includes Electric Vehicle and EV charging standards, which on their turn will be examined for information relevant to smart charging, grid impact, cyber security and testing. This information will be collected and used as input for the creation of test requirements and the GAP analysis.