NGI101x - 4.3 - Smart grids and ICT

Hello! I am Geert Deconinck. Welcome at the University of Leuven.

I am going to talk to you about Smart Grids. Smart Grids, electric power systems, they exist for more than a 100 years already. Components of different generations fix together and have to inter-operate, have to work together, into one smooth smart grid.

I will introduce to you the smart grid reference architecture model (SGAM) as a conceptual framework that allows you to design a better smart grid, working smoothly together for the future.

Welcome back in this web lecture.

I am going to present to you the smart grid reference architecture model as a conceptual framework that allows different actors in the smart grid to discuss about smart grid applications. Different designs can be discussed, different implementation options can be discussed, and so on.

You have learned about smart grids in other sessions. Smart grid applications exist in many different flavors and tastes. We have a number of monitoring applications, metering data from the smart grid to the grid actor actors, aggregating information about profiles, profiling particular customers, analyzing the power quality, etc.

Besides of monitoring applications we also have a lot of control applications.

Control applications can have to do with controlling the grid – secondary, tertiary control - about the voltage settings, about the most economic power plants that are running. It can be about reconfiguring the topology of the grid.

It can be about protecting it, refuses and the like. It can be about mitigating power quality problems.

Besides grid control applications, we also have the control of the generation of electricity. If there is lot of demand for electricity you can start up additional supply of electricity. You can start up a coupled heat power plant for instance or combined heat power plant when there is a need for electricity - not only when there is a need for heat.

Besides generation and grid control, there could also be storage control.

For instance if you have batteries in the grid - when there is surplus of electricity produced - you can store it locally and then use it later when there is a shortage.

A lot of smart grid applications have to deal with demand control, load control. Loads could be startups, stops, dimmed, whenever there is a different variation in the supply of the electricity.

You can match the demand to the supply. If there's a lot of sun, you're going to use the electricity at the same moment. You can shave the peaks if you have load control. That means that if there's a lot of electricity used, you can dim some of that usage and then re-enable that device a bit later. You can shift loads overtime, over seasons, and you could use it to flatten the load.

These are all types of applications in the smart grid. Many more exist. But how do we discuss and design such a smart grid application in a way that the different actors -from the business level to the implementation level- can jointly understand what is the smart grid application to be deployed.

Well for this context the CEN, CENELEC and ETSI Standardization units have developed the smart grid reference architecture. This reference architecture is a kind of conceptual framework for discussing the applications in the smart grid with as major goal to allow interoperability. That means that you are able to deploy services of different devices from different manufacturers together.

Interoperability has been defined by the IEC- the international Electro Technical Commission - in its standard 61/ 850, as being the ability for two or more devices from the same or different vendors to exchange information and to use that information for correct corporation.

So effectively - if you have a system from one manufacture and the other- they need to speak the same language, they need to exchange information in order to implement an application.

In the smart grids reference architecture model, this general IEC based center for interoperability - which consisted f 8 different layers, has been simplified to 5 layers. You see them here: The Business Layer, The Function Layer, The Information Layer, The Communication Layer and The Component Layer.

At the highest level is the Business Layer and the lowest level is the Component Layer. It is about the interoperability between the different systems and those different levels.

The smart grid reference architectural model is a 3D-model and one of the dimensions is these different layers. Let's first take a look at these different layers and then come back to the dimensions.

At the business layer, we have a representation of the smart grid applications from a business perspective. Which information needs to be exchanged between the different actors? Which type of business models can be deployed? Which type of market information needs to be there in order to implement something You can also draw the business processes in this context.

If you look at the smart grid application from the business layer perspective, then it allows the business executives that have to do some decision making to talk about the business models without having to care about the practical implementations and the ' nitty –griddy 'details at the lowest levels.

If you go one level below that, the function layer, we are talking about the functionality that is supported by the different smart grid applications.

Which type of functions and services need to be implemented for a smart grid application to be operational?

For instance, if you would like to deal with voltage problems, - over-voltages under -voltages- you need to provide a service that is able to react at the voltage level. Could be locally in a substation, could be done locally at the customer site. But somewhere this functionality has to be available.

So independent of actors and physical implementations, the function layer allows to mention these functions and to deploy these services somewhere in the smart grid. So at that level of the function layer, you are able to draw the use cases that are needed for the smart grid algorithms.

If you go one level below that, at the information layer, there we describe how the different functions and services will talk to each other.

How the information needs to be represented by one actor when it is sent to the other actor.

In fact it contains the representation of the information objects and the data models underlying that. So that if one object, one actor sends particular value to anther object (or to another actor), that there is some meaning to the data. If the number 17 is sent from one to the other, the actors need to know where that represents active or reactive power, or energy, as well as the direction. In fact, providing information onto the data is the goal of the information layer. It represents semantics for the functions and the services at the higher level. It allows to define for the lower levels which type of information to be exchanged.

If we go to the level of the Communication Layer, we are going more towards the practical deployment, there we identify which type of mechanisms and protocols are used for exchanging the information between different actors. So in the communication layer, we identify- based on the information model used above- which type of communication infrastructure needs to be deployed for sending information from one actor to the other. This depends on the use case, the functionality, the service that is needed.

Finally, at the component layer, we have the emphasis on the physical distribution of the components- necessary for those algorithms in a grid context.

So there we identify which type of the application, which part of the application, will be running on a sensor, or an actuator, in the substation, at the home appliance and the like.

So basically, it identifies the system actors from the power system, from the applications, and how they are interacting at the level of components, at the level of the communication, at the level of computing and processing power.

So if we have these dimensions summed up as different layers, we are able to talk about the smart grid applications. How are we going to deploy them?

That is represented by the other two dimensions of the smart grid reference architectural model.

These two dimensions are in the so called domains and zones.

The domains - that cover the generation, the transmission, the distribution, the distributed energy resources and the customer premises- they allow to differentiate the different processes of the electricity generation towards end usage.

Final dimension, the zones, is about the different levels from the process, the field level within the customer premises, all the way up towards the markets.

And so if you go from process to field, to station, to operation level, you can go to the enterprise and the markets.

Together we have the three dimensions - the zones, the domains and the layer, that allow to represents the different smart grid applications visually - so that the designers and the ones that have to deploy the system have a joint framework to discuss how to implement a particular smart grid application. And each one of them can do that in their own level; of a business perspective down to the physical implementation of communication protocols and the communication needs.

Let's take an example for the voltage control by controlling the reactive power. This is called Volt VAR Control. Voltage was controlled by the reactive power of distributed energy resources controlling that particular element.

This is something which is typically described at the function layer. So there are a number of actors involved, there is a SCADA-system (NB: Supervisory Control and Data Acquisition, meaning a system operating with coded signals over communication channels so as to provide control of remote equipment), there are some distributed energy resources, there is some data acquisition that takes place. Somewhere the Volt VAR Control needs to be deployed. It can be deployed at the high level, -at the level of the operation which is more or less within the distribution system operators premises. Or it can be deployed much closer to the end user at the field level (somewhere in the neighborhood of the renewable energy sources- the wind power, the PV installation). In the first case we have more kind of centralized approach. In the second case, we have a more distributed approach.

So this concludes our lecture on the smart grid reference architecture model. We have introduced to you the 3D-model as a conceptual framework to describe a lot of smart grid applications. I hope you enjoyed the lecture and any of you have a questions please discuss them in the discussion forum.

Thank you!