Part of Modelling and Optimal Management of Smart Grids

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Abstract

Smart Grids can be defined as the integration of electric grids, communications networks, specific hardware and computational intelligence (algorithms) to monitor, control, and manage the generation, distribution, storage and consumption of energy. However, making such a smart and complicated network is not at all easy.

For that a detailed modeling, to make the task easier and more achievable. Smart Grid presents a very complex system, the components and relationships between entities are difficult to model. Poor management can cause many system failures. Optimal energy management is necessary in this case. In conclusion, Smart Grids are expressions of the digital revolution in our energy networks and it is sure that they have begun, and will continue, to change the entire value chain. This work presents a new methodological vision for the modelling and optimal management of the energy of an intelligent multi-source electrical network. Indeed, it allows the study of the different structures of a Smart Grid and their optimization in an established regime, on the one hand, and the sizing of the various components of the system, on the other hand. This is why it takes into account smart electricity and ICT for sustainable development.

Keywords: Renewable energies, Smart Grids, modelling, optimal management.

1. Introduction

In order to cope with the energy changes, it is necessary to modernize the electricity system. Worldwide, designers and experts reach to develop electrical networks by the deployment of Smart Grid technologies rather than the replacement and massive reinforcement of the grid (Ourahou et al. 2018).

The advent of the Smart Grid is the combination of a more demanding business environment and new technological possibilities. Systems that have been unaffordable only a few years ago, could now be built easily.

The implementation of Smart Grid technologies can improve many performance indicators in all segments of the industry: generation, transmission, distribution and end-use consumption.

In recent decades, Smart Grid has an active research field, because almost all the technologies required to build a Smart Grid are mature enough. Thus, Smart Grid can reduce electricity consumption, it can also provide a more reliable and versatile service than the traditional power grid.

The question is how to use the massive data captured by smart meters to provide such "smart" services that automatically read the meter information.

One of the biggest issues in power grids is the analysis and modeling of a Smart Grid, which is a major challenge for security, automation, energy efficiency and power consumption. The full implementation of a Smart Grid will evolve over time. However, before a new set of infrastructure is invested to build the Smart Grid, proper analysis and modeling is required to avoid wasting resources (Neureiter et al., 2016). Modeling also helps to identify and prioritize appropriate systems.

In this paper, we study the intelligent grid "Smart Grid" in order to assess the different components of the electrical system and develop an energy management strategy.

2. Generalities on Smart Grids

The Smart Grid technologies can also allow the allocation of large amounts of renewable-based power generation paving the way for the decarbonization of the electricity sector. Smart Grids can be defined as the integration of electric grids, communications networks, specific hardware and computational intelligence (algorithms) to monitor, control, and manage the generation, distribution, storage and consumption of energy (De Oliverra-De Jesus and Henggeler Antunes, 2018). Smart Grid of the future will be distributed, interactive, self-healing and communicating with every device.

2.1 Architecture of Smart Grids

The architecture of Smart Grids can be divided into three levels (El Khaldi et al., 2021):

- A first layer of infrastructure composed of equipment used to carry electricity (lines, transformers, etc.).
- A second level formed by communication architectures (multi-media and multi-technologies) collecting data from different network sensors.
- A final level consisting of applications and services, such as monitoring, remote intervention systems, and automation of electricity demand responses using real-time information.

The energy transits on the network depend at each moment (Wertani et al., 2020):

- Of all consumption.
- Of all production (international or national).
- Network architecture.
- Contractual flows subject to minimum and maximum values on the lines
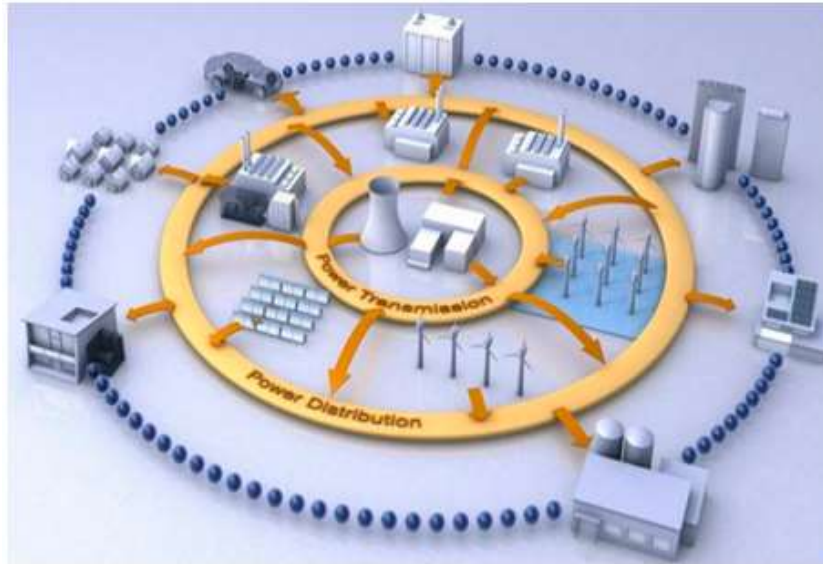
2.2   Objectives of Smart Grids

The main objectives expected of Smart Grids are (Jabban, 2013):

- A high capacity to introduce new services.
- Reduced time and cost of development.

•New functions introduced within the network to allow each user to personally manage their data.

Figure 1: Schematization of the network

Source :Siemens

3. Dimensioning and energy optimization

Smart Grids aim to smooth the consumption curve, reduce overall consumption, balance supply and demand, and integrate new technologies. The constraints are to send the energy orders/requirements and to optimize the energy flow, to carry out preventive maintenance, to control permutations and minimizing loads to optimize investments, while dealing with the generation of renewable energies (with erratic production) and storage (Guerard, 2014).

Until now in the literature, the optimization of multi-source systems connected to the network concerned rather the dimensioning of an installation and the management of the storage.

3.1 Dimensioning

In order to make hybrid electric technology more competitive, the design and operation of these systems must be improved in order to ensure reliability, longevity and minimized installation costs. This type of system is designed according to four aspects; study, dimensioning, modeling and maximization of use of the renewable source.

To do this, the sizing and the choice of the operation of the components are carried out taking into account the available energy source, as well as the constraints of use.

to succeed in our dimensioning, we must follow the following steps:

- Study the energy potential in the target site.
- Determine the load profile of consumers.
- To make the dimensioning and the numerical simulation of the various components.

3.2 Energy optimization

 The optimization of a complex system is difficult and requires a particular methodology. defines a first resolution approach. First, optimization algorithms appropriate to each system application must be selected. Second, the parameters of the algorithms must be tuned to improve efficiency (Grefenslette, 1986). In fact, optimizing energy management requires adjusting energy flows at all times. This imposes a suitable approach in order to have acceptable calculation times.

3.2.1   The different optimization problems

Depending on the nature of the variables and the elements of the model, an optimization problem can be more or less complicated to solve.

The elements that influence the complexity of the problem are (Banos et al., 2011):

- The nature of the variables (continuous/discrete);
- The nature of the constraints (equality/non-equality; linear/non-linear);
- The nature of the performance index (linear, quadratic, convex, etc.);

- The number of objective functions (single objective, multi objective).

3.2.2 Types of optimization

Depending on the nature of the problem, two types of optimization are distinguished (Kanchev, 2014):

- static optimization for which the objective function depends only on the values of the variables at a given time;
- dynamic optimization for which the objective function depends on the decisions taken previously as well as on the current state of the electrical system and which is to be carried out over a given time interval.

4. Conclusion

Smart Grids are the expression of the digital revolution in our energy grids and it is certain that they have started and will continue to change the entire value chain. They are not intended to replace the existing electrical network, but to improve it. In order to guarantee efficient network modeling and rapid energy optimization.

Smart Grid must reconcile internal emergence and self-organization by external factors in order to find the most optimal balance of energy distribution in real time.

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