ENSE3 – Module Micro Grids, Smart Grids, Super Grids
2015-2016

ADVANCED DISTRIBUTION AUTOMATION FUNCTIONS (ADA) FOR THE INTEGRATION OF RENEWABLE ENERGIES

TEACHERS

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1. Objectives

The objective of this lab is to illustrate the impact of the connection of distributed generation (based on renewable energy or not) to the electrical distribution network and to study advanced distribution automation function to facilitate their penetration. In a first step, a preliminary study based on simulations will be done on the PREDIS distribution network using Matlab software. Then, the solutions found will be validated on the platform.

2. Description of PREDIS distribution network

The geographical view of the PREDIS distribution network (radial operation scheme) is depicted on Figure 1. This network is based on a real distribution network of ERDF but with a reduction ratio. All the electrical elements such as lines, transformers, generators, loads, asynchronous machines are real but with a reduction ratio to be able to work at 400 V instead of 20 kV. This network is looped but radially operated thanks to the presence of normally open switches. Loads are supplied thanks to three injection points (N2, N3, N11) representing three HV/MV primary substations. 5 distributed generations (DGs) can be connected to the distribution network.

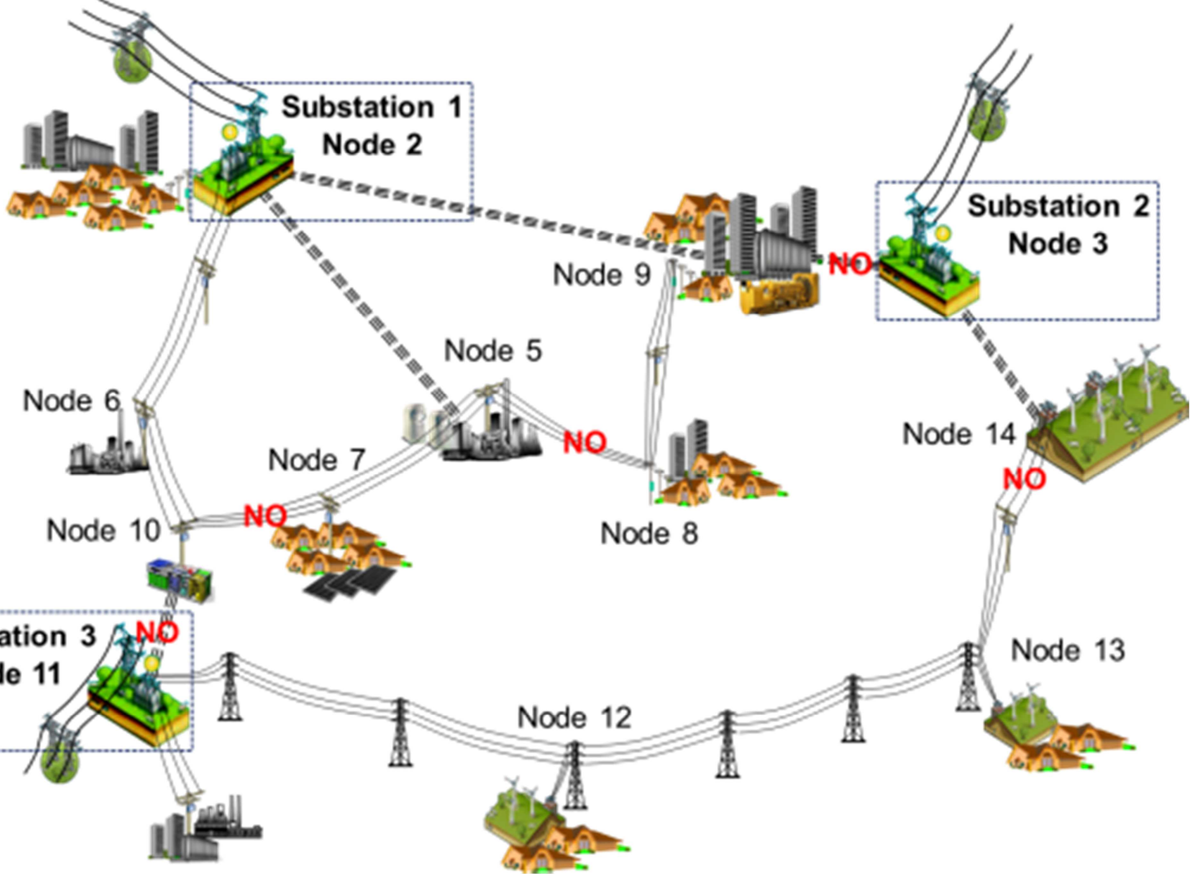

Figure 1 : Réseau de distribution de PREDIS

Figure 3 gives the electrical scheme of the PREDIS distribution network with the different injection and consumption points.

Part I: Study of the impacts of renewable connection to the distribution network.

In this part, the open lines are lines 8, 10, 12, 13 and 17 to ensure a radial operation of the network.

Loads connected are:

- 2 industrial loads :
    - Load 1 and 2 at 3 MW, $\tan\varphi = 0.4$. These loads are supposed to have a constant consumption between 5h and 21h.
- Residential loads :
    - Load 6, 7, 9 and 10 have a maximal power of 1MW and are variable following the normalized profile of figure 3.

Depending on the scenario studied, one or several photovoltaic producers (maximal power of 4.7 MW) are connected to the distribution network. Their normalized profile is given by figure 3.

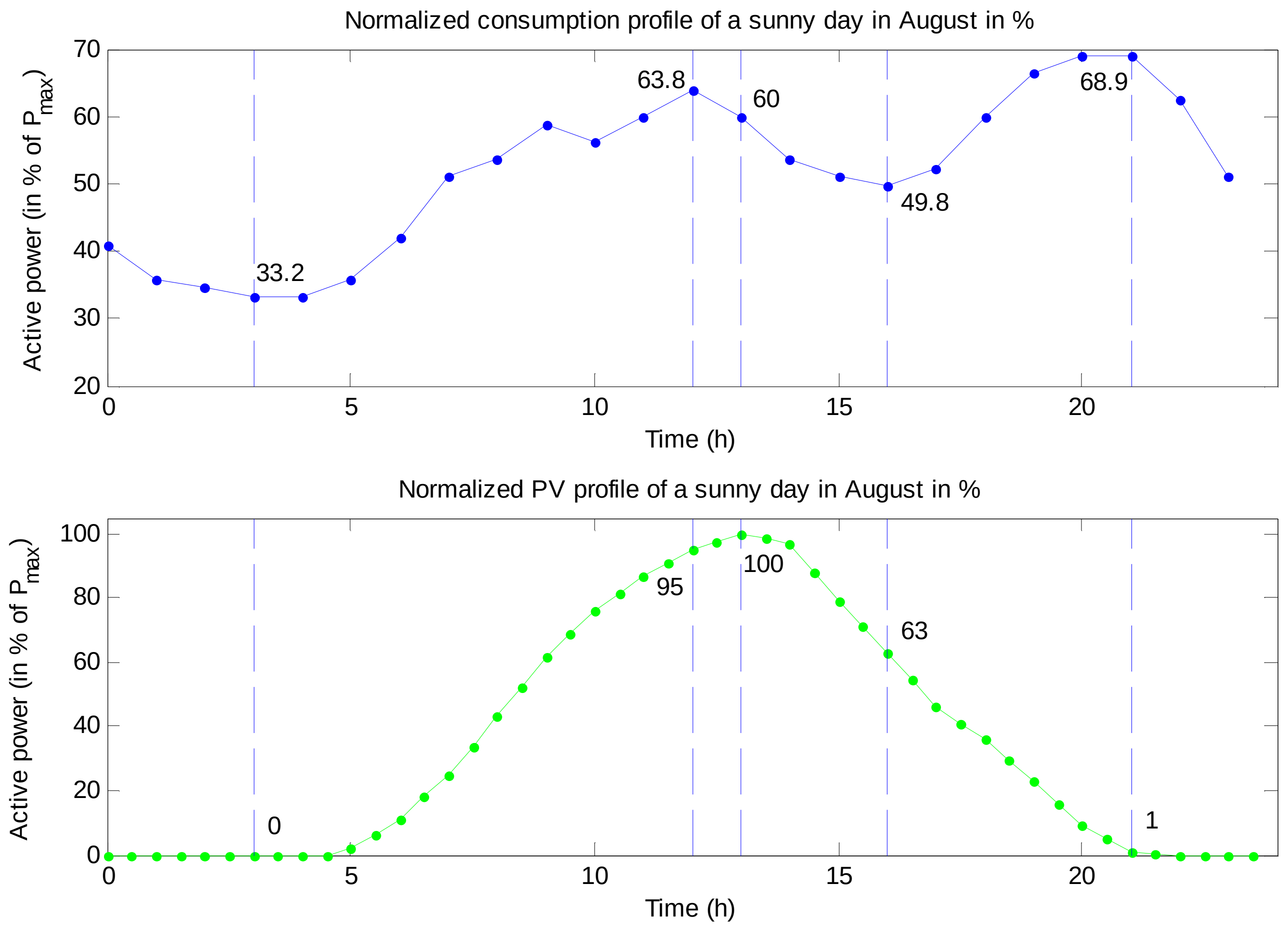

Figure 3: Residential normalized load curve and production curve during week day in summer.

In this part the scenario studied will be:

- *Scenario N°1: connection of a photovoltaic producer (Gen 4) at the node N°13*
- *Scenario N°2: connection of a photovoltaic producer (Gen 4) at the node N°9.*
- *Scenario N°3: connection of two generators (Gen 3 and Gen 4) respectively at the node N°12 andN°13.*

To do:

- *Question N°1.1: for the first scenario, make a simulation over 1 year. Comment*
- *Question N°1.2: what happens if the producers are based on wind power?*
- *Question N°1.3: for each scenario detailed below, simulate the 5 step times pointed out in figure 3. For each step times, in case of constraints, try to find the best settings of the OLTC of the three HV/MV substations.*
- *Question N°1.4: Conclude on the impacts of renewable generation connected to the distribution network.*

Part II: ADA (Advanced Distribution Automation functions) for the integration of renewable in distribution network

In some cases, classical voltage control does not enable to keep the voltage profile within the admissible limits (+/- 5% of the nominal voltage). Several solutions are under studied by the distribution system operators (DSOs) through demonstrators. In this lab, two of them will be studied: reconfiguration in normal mode and VVC (Volt Var Control).

✓ Reconfiguration in normal mode

In a given distribution network, several radial configurations to supply the consumers exist due to the presence of normally open switches remotely controllable. The objective here is to find the one that minimize power losses. Indeed, the reduction of power losses induces the reduction of active power flows circulation through the lines and will limit the voltage drop.

To do:

- *Question N°.2.1: Find the optimal configuration for each scenarios and each step times of part I.*
- *Question N°2.2: Does a unique configuration exist for the entire day enabling to respec the technical constraints of the network at each step times?*
- *Question N°2.3 : PREDIS experimentation*

This year, you cannot make experiments on the PREDIS platform. Then the teachers will provide the results for the scenarios 1, 2 and 3 of part I with the associate OLTC settings and with the optimal configurations found for the step time 13h.

  - *Check the results of your simulations with the ones of the PREDIS experimentation.*
  - *Conclude*

✓ VVC (Volt Var Control)

Producers can inject or absorb reactive power on the distribution network. Today, the reactive setting of producers is fixed (or equal to 0). The injection/ absorption of reactive power tend to increase power losses. The objective here is to found the optimal reactive settings of generators that minimize power losses and enable to respect the technical constraints.

_To do_:

- *Question N°2.4: find the reactive settings of generators associated with the OLTC settings for each scenarios of part I and each step times.*
- *Question N°2.5: Compare the results gotten with the ones of PREDIS experimentation provided by the teachers for the step time 13h.*
- *Conclude*

Part III: Technical and economic analysis

The final choice of the DSO will be done using the discount cost technic presented during the course. This method enables to take into account not only the initial CAPEX that is necessary but also the OPEX over the life duration of equipments.
Currently, when a technical constraint appears, the DSO reinforces the network (replacing an existing conductor by a conductor with a higher section). In this part, the reinforcement and the VVC and the reconfiguration deployment will be compared using the discount cost.

_To do:_

- *Question N°3.1: Economic study of the reinforcement of the network*
    - *Question 3.1.a: simulate the network for the two following extreme cases:*
        - *Minimal consumption (20% de la maximal consumption) et maximal production and OLTC settings : 1.03*
        - *Maximal consumption and minimal production (0)*
    - *Question 3.1.b: reinforce the network to solve the constraints*
    - *Compute the discount cost of the reinforcement solution*
- *Question N°3.2 : compute the discount cost of the deployment of the VVC*
- *Question N°3.3 : compute the discount cost of the deployment of the reconfiguration*

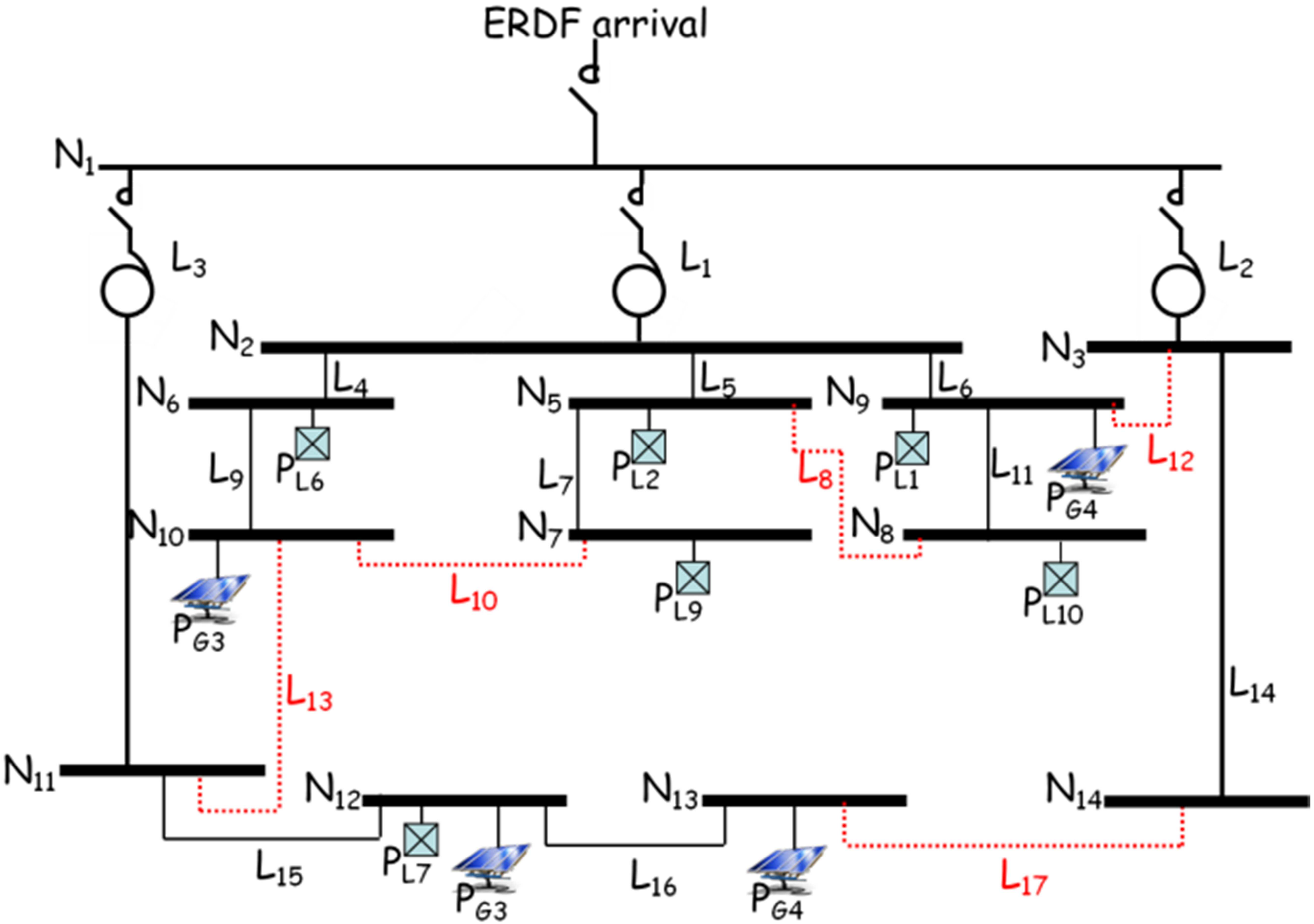

Figure 2 : Electrical view of the distribution network