ST7 – 78 – ENERGY TRANSITION IN ISOLATED SITES

Dominante : GSI (Large Interacting Systems), ENE (Energy)
Langue d'enseignement : English
Campus où le cours est proposé : Rennes

Engineering problem

This topic focuses on the problems associated with a transition to a more just and sustainable world in terms of access to energy. Indeed, some sites, houses or others, are not and cannot be connected to the distribution network because of the technical complexity of connection and extension of the network or because the cost of such an operation is either not justified or is not feasible for areas located in poor regions of the world. It is therefore necessary to propose solutions based on the development of microgrids. Microgrids allow the local deployment of small-scale collective installations thanks to hybrid systems with decentralized production and storage as well as intelligent management of production, storage and demand for each user.

The deployment of microgrids requires a system approach where the following questions arise:

- how to manage a multi-component system subject to different constraints,

- how to manage and take into account the multiplicity of stakeholders: users, communities, financiers, standards, etc.

- how to manage the trade-off between economic cost, environmental impact on life cycle, and quality of service.

Throughout the thematic sequence (context and issues modules, specific course, project) students will address these issues. They will be interested in defining the need for a given situation, in modeling and formalizing the optimization problem. They will be led to propose technically and economically reliable solutions in an uncertain environment.

Advised prerequisites

Modeling, Probability/Statistics course

Context and issue modules: These modules include an introductory lecture on the theme, presentations on the technological and scientific challenges, and a presentation of the associated projects.

Specific course (60 HEE) : *Renewable energies and microgrids*

Brief description : Faced with the negative environmental impacts of all energy production and the depletion of fossil resources, the transition to renewable sources is a fundamental trend. While renewables provided only 25% of global electricity production in 2018, this share is growing rapidly, with wind and solar tripling over 10 years.

These new energies raise specific questions that this course proposes to address:

- what are the wind and solar energy sources and the main principles of their conversion into electricity?

- What are the storage technologies, in particular batteries, capable of handling the variability of these sources?

- What are the technical, environmental and economic challenges of these technologies?

Moreover, wind and solar power are much more decentralized sources than traditional thermal power plants. Thus, the production of electricity is closer to the places of consumption, which gives rise to the notion of "microgrid", analogous to the short circuits in agriculture.

A microgrid is a small electrical system that integrates production and consumption in a defined area (building, district, island, etc.) and is equipped with local management of energy flows. A microgrid can be autonomous or connected to a large network. If it is connected, it behaves as a single, intelligent player, capable, for example, of buying electricity from the wholesale market at the best times or providing network services. The integration of all these components and functions poses system optimization questions addressed in this course.

Due to their small size, reliability is an important issue for microgrids. This course proposes to study the methods of dependability to analyze the risks of failure, plan maintenance and react to failures...

Project: *Decarbonized island microgrid*

- Associated partner:

- Location: Rennes campus

- Brief description : Nearly one billion people still do not have access to electricity (IEA 2018). These populations are often in remote areas in rural or island regions. Thus, for 3/4 of them, it is not economically efficient to bring electricity to them by expanding existing large-scale power grids. Electrification must therefore be done on a local scale, through what are known as microgrids.

The generation of electricity in a microgrid can be done by fossil fuels (diesel generators) or by renewable energies (solar panels...). Thanks to technological progress, the latter are generally less expensive. However, their intermittency pushes to complete them by more expensive but controllable means (Diesel, battery storage, hydrogen...). The size of each of the components of a microgrid (called its "dimensioning") must therefore be optimized according to various criteria: economic cost, of course, but also quality of service, energy independence or greenhouse gas emissions. The management of energy flows (e.g.: arbitration between diesel and battery/hydrogen) is also to be optimized. This project proposes to address these different optimization issues on the concrete case of isolated sites.