French-German PhD Project Proposal

Design optimization of distribution grids by an arbitrage between grid reinforcement and new flexibility uses in a German planning context

Context

A French-German consortium of industry, research and academia offers the unique opportunity of transnational PhD research: **EIFER** – European Institute for Energy Research, based in *Karlsruhe*, was founded by EDF (Electricité de France) and KIT (*Karlsruhe* Institute of Technology), to bridge the gap between science and energy industry. The role of EDF R&D in *Saclay* is to support the EDF Group's operational branches in the development of the power system and power grid in France, in Europe and worldwide.

Together with **KIT** and **UHA** *Mulhouse* (Université de Haute-Alsace), **EDF R&D** will support the candidate to apply to a French CIFRE grant and to the related 3-year working contract with EDF R&D (https://www.anrt.asso.fr/sites/default/files/2024-start/cifre_2023_eng.pdf). The international opening will allow for staying up to 50% of the 3-years-period in Germany. This includes the possibility for a double degree (cotutelle) with KIT and UHA.

Background

The power distribution grid, managed by Distribution System Operators (DSO), will be particularly affected by the energy transition. All the scenarios for achieving carbon neutrality involve massive growth in decentralized generation. In Germany, the ambition regarding the energy transition (Energiewende) has dramatically increased, the share of renewables to be reached in the power mix by 2030 being set at 80% (against 47% in 2022). This development (mainly of wind and PV power) will be accompanied by new uses and technologies: electric vehicles, storage, demand response, production modulation, hydrogen, etc.

This new context is drastically changing power flows and voltage profiles. It thus creates, already, many grid congestions that require costly remedial actions such as renewable curtailment, for over 4 billion euros per year (Germany 2022). This calls for a rethinking of the local grid design, selecting the right levers to achieve decarbonization target efficiently. New grid planning methods need to be developed that allow arbitrating between grid reinforcement and local flexibility use, from a techno-economic perspective.

Objectives and Approach

The future of distribution grids is influenced by numerous factors that will have a lasting impact on grid operation. These include grid digitalisation, new flexibility options but also grid reinforcement. Starting from these upcoming changes, the key research question consists of identifying cost-efficient pathways to a new and resilient grid design. Main influencing parameters shall be identified in a varying local and regulatory context.

This PhD has the objective to identify and develop innovative methods for an optimal distribution grid design that considers existing and innovative levers to maintain grid safety (levers from the users or levers from the grid). These methods shall be generic enough to comply with different local energy configurations. It shall start from the current academic and industrial practices in Germany, then include comparison with France.
The general approach of the PhD includes:

- Analyze the state of the art of industrial and academic grid planning exercises, and grid design methods.
- Develop a simulation environment representing a distribution grid based on (open source) power flow tools (e.g. panda power) in a “prosumer” environment that includes intermittent renewable power production as well as “smart” devices.
- Implement new design approaches and tools (criteria, method, levers, and indicators), adaptable to different grid types and scenarios.
- Validate the proposed methods, and compare different approaches, including technical options and economic incentives for flexibility management, to quantify the added value of innovations.
- Scenario analysis by application of the developed method in realistic case studies: based on realistic local situations and grids, identifying reinforcement and flexibility solutions in different scenarios, to interpret results (technical and economical) and their sensitivities to parameters and local configurations.

Your Qualifications and Skills

A successful candidate has an advanced university degree (master) in electrical engineering, industrial engineering, or comparable program. Important skills and competencies include knowledge in electrical engineering and power grids, knowledge in optimization, experience in scientific programming, particularly in Python and/or Matlab-Simulink and good written and oral skills in German and English. French would be an advantage.
Knowledge in costs-benefits analysis and experience with code management tools (e.g. Git) will be appreciated together with soft skills such as rigor in programming (programs must be clean, commented and documented) and in writing and presentation (conferences, reviews, manuscript, defense...). We welcome team spirit, curiosity, interest in research, proactiveness and autonomy with ability to step back and interpret.

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