FlexPlan

Letter of the Project Coordinator

The FlexPlan Project has now reached month 18 of its activities. This point is not only important because of the completion of the first project period, which implies administrative and technical auditing from the European Commission, but even more because it marks the halfway of the project duration. So, it is an important point to look at what has been achieved so far and what remains to be done.

For sure, one of the most brilliant aspects that have been tackled so far is the complete specification of the methodology for both the grid planning procedure and the pre-processor, the latter providing the list of the planning candidates to be examined by the planning tool.

Concerning the **methodology of the planning grid tool**, the key achievement obtained so far is not only the complete specification of the mathematical models for all system components (transmission and distribution networks AC and DC lines, phase shifter transformers, storage systems, flexible loads, etc), but also the specification of the full mathematical model for the optimization process. Regarding this latter aspect, the need to cope with unprecedentedly huge optimization systems and, thus, the need to pay particular attention to numerical tractability is very high in the project priorities. Two innovative system decoupling procedures should do the work: the former between the planning optimization of the transmission grid and the one for the distribution grids, the latter between the optimal grid dispatch problem and the candidate selection. Both these decomposition techniques have been tailored to the project needs and are now being tested on small-scale systems before they can be implemented at their full scale in the planning tool.

At the same time, also the **methodology specification for the pre-processor** has been completed and now a few small test cases are being carried out to fine-tune all aspects. For sure, the major difficulty here is that several aspects of the selection of the grid planning candidates should convey the experience of real planners into an automatic algorithm. A fine-tuning process must be carried out, trying to implement an intelligent algorithm mimicking flexibility and efficiency of typical man experience.

Meanwhile, **first partial releases of both the planning tool and the pre-processor** are available and the testing phase is progressing well. The first complete implementation of both tools should be available by June 2021.

By end of March, **the project pan-European market simulations have been finalized** for all three key years (2030, 2040, 2050) and according to all three public ENTSO-E TYNDP 2020 storylines. These simulations will allow adopting consistent border conditions for the flows exchanged between the six regional cases.

The **build-up of the six regional cases** itself is registering a very good progress, but also there the dimensionality problem is the source for important challenges: the planning tool is fed by a JSON -file, but the dimension of such file must be reduced by optimizing its structure in order not to overcome the maximum dimension that can be transmitted and read by the server.

The FlexPlan project attributes a primary importance to **dissemination**. So far, the project was represented in two 2020 conferences (UPEC and EEM), several workshops (many of which in synergy with ISGAN), journal papers (among which the very comprehensive 30-pages contribute recently published in open-access by the ENERGIES journal: https://www.mdpi.com/1996-1073/14/4/1194).
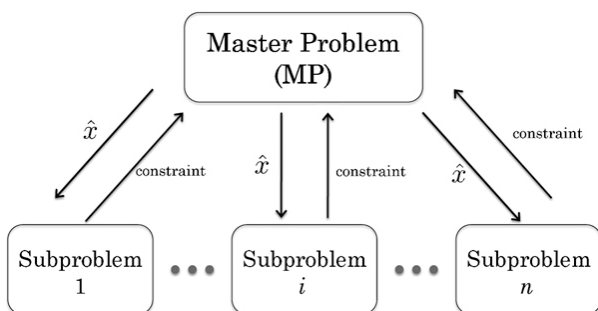
Another pillar for FlexPlan is the availability of a very competent and interested set of people following the project being members of its Advisory Board. In April 2021, a **new set of project web consultations** will be open to discuss important open issues for which the project calls for external expertise. This consultation will be not only open to the members of the Advisory Board, who are expected to provide a contribution by sharing their views, but, more in general, to whoever is following the FlexPlan project and wants to contributes with her/his expertise. As usually, non-technical two-pagers will be published for each consulted topic to introduce the open issue, along with a set of questions for which external experts are consulted. Answers will be collected through the project web site. Finally, for each topic a summary document will be posted summarizing the consultation outcome.

Stay tuned! The first half of the project has laid down a lot of good seeds, but we expect the most interesting project results to come later, in the first half of the year 2022.

Gianluigi Migliavacca (RSE)

Advanced numerical techniques to enhance computational tractability
Hakan Ergun (KU Leuven) - WP1 Leader; Marco Rossi, Dario Siface (RSE)

During the last six months, the project focus has been on the testing of the mathematical formulation of the FlexPlan model. Specific features of the planning model, such as, the modelling of flexible resources, storage modelling and joint modelling of transmission and distribution systems have been implemented in *FlexPlan.jl,* a new software package based on the Julia language. Using *FlexPlan.jl* a number of sensitivity tests have been performed on the most important modelling assumptions and the performance of scenario reduction techniques for increased computational tractability.

An important milestone of the project has been reached with the publication of the project deliverable "Probabilistic optimization of T&D systems planning with high grid flexibility and its scalability" (*https://flexplan-project.eu/wp- content/uploads/2021/03/D1.2_20210325_V1.0.pdf*). This comprehensive deliverable describes the full mathematical model, details of the implementation within *FlexPlan.jl* and
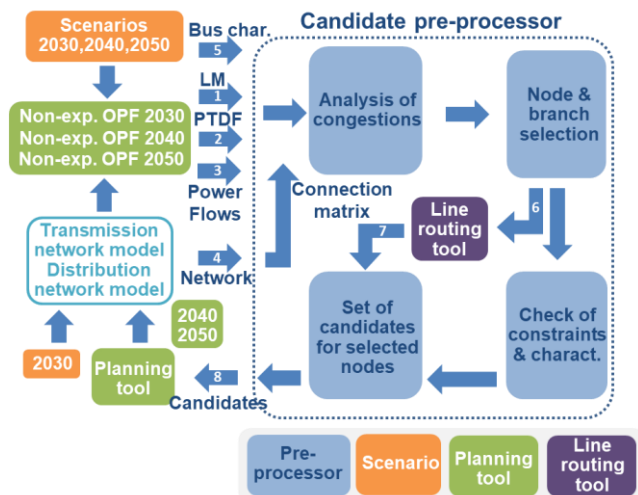
detailed results showcasing the performance of the developed model. The deliverable further discusses advanced model decomposition techniques to further increase the computational tractability which are currently being implemented within *FlexPlan.jl*. One of the most important features in that respect is the decomposed transmission and distribution system modelling, where distribution grid expansion strategies are provided as potential expansion candidates for the transmission system, allowing to represent a large number of distribution grids in the planning problem. This decomposition technique on one side reduces the dimensionality of the optimization problems, thus helping to preserve numerical tractability, on the other side notwithstanding the implementation of an integrated transmission-distribution grid planning approach, the actions to be carried out by the two system operators are decoupled and this could favour the practical application of the methodology. Secondly, a novel decomposition technique has been formulated to iteratively solve the planning and operational problems, while preserving the stochastic nature of the planning problem. This decomposition, while separating the solution of the investment problem from the calculation of the optimal dispatch, also allows to easily integrate different variants of load and RES generation timeseries into one only investment decision process.

We are also very happy to announce that *FlexPlan.jl* will be made available to the research community as an open-source software package in the months to come.

A complex methodology to provide the best planning candidates
Raúl Rodriguez (TECNALIA) – WP2 Leader

The increasing integration of variable wind and solar generation in the power system requires getting flexibility from other resources, such as storage and demand. Storage, other than pumped-storage hydropower, and demand response have not been considered in traditional network planning procedures and it is the aim of FlexPlan project to revert this situation, where flexibility resources are presented as candidates for network planning, competing with new line construction.

To help the planning tool in the candidate selection process, a pre-processor tool methodology has been defined during the last six months and the first version of this software has been produced. The pre-processor software receives as input:

- the results from an Optimal Power Flow (OPF) run on the non-expanded network model;
- the network model and scenario;
- a characterization for network nodes (useful to decide which technologies can be hosted in each place);

- a set of pre-defined network candidates provided by the user (especially useful for new grid expansion corridors).
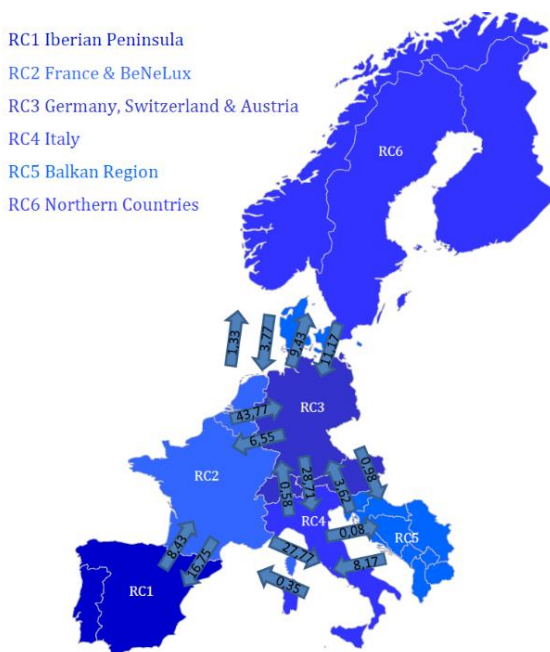
With these inputs, the pre-processor tool is able to locate congestions in the network and select a preferred bus for the installation of flexible resources. For each of the identified locations, it proposes a set of candidate technologies, such as storage and demand response, but also conventional grid expansion solutions, such as lines and Phase Shifting Transformers (PST). As last step, for each of the proposed technologies, a size and cost is provided.

Then, this set of locations and candidates is provided to the planning tool, which will select among the candidates those that minimize total network expansion costs (CAPEX + OPEX).

Within the next six months, the current version of the pre-processor will be tested and tuned, through the analysis of Regional Use Cases. Another aspect to be fulfilled is the adequate integration between the pre-processor and both the planning tool and a line routing software, which will provide line technology and cost inputs to evaluate AC and DC branches as network expansion options.

Pan-European market simulations for three storylines at 2030-2040-2050

Jawana Gabrielski (Technische Universität Dortmund) – WP4 Leader

RC1 Iberian Peninsula
RC2 France & BeNeLux
RC3 Germany, Switzerland & Austria
RC4 Italy
RC5 Balkan Region
RC6 Northern Countries

The innovative FlexPlan grid planning tool will be validated and applied to run six regional cases, covering almost all Europe. As the European energy system is a meshed interconnected system, cross border effects between the different regions have to be considered. For this, a set of pan-European simulations is carried out, providing coherent border conditions as a common ground for the following regional cases.

Data for 2030 and 2040 drawn from the three scenarios described by ENTSO-E in the "Ten-Year Network Development Plan 2020" was further elaborated and extended to 2050 during a complex data collection and processing activity. The pan-European simulations set-up followed a two-step approach. First, hourly renewable energy sources injection as well as load time series were determined on a regional level, in order to feed the regional cases with nodal information that is coherent with the overall scenario. Based on this, in a second step, market simulations were carried out, running an integrated unit commitment and dispatch model, which determines power plant and storage schedules, as well as hourly cross border exchanges between European countries. The underlying optimization took into account different constraints as the

reserve power to be maintained, available transmission capacities between the different countries and the time coupling restrictions of generation units and storages.

More details on the methodology as well as some exemplary results are presented in FlexPlan Deliverable 4.2 (*https://flexplan-project.eu/wp-content/uploads/2021/03/D4.2_20210326_V1.0.pdf*).

New ideas for the dissemination of the project results

Stefania Ballauco *(WP7 Leader)*

The 2030 and 2050 targets for full decarbonization are closer than they seem.
The FlexPlan project, whose scope is in line with the goals and principles of the new EC package *Clean Energy for all Europeans,* is now at the halfway point, after 18 months of intense activity. Now the purpose is to address the effort also in the direction of dissemination, communication and exploitation of FlexPlan objectives and in sight of the next important project results.

The website https://flexplan-project.eu/ is an important and useful showcase and it will continue to be used for every update. Web users can find here project news and inspiration to foster discussion on current topics on the energy world. We aim to make it a hub of useful updates for all our audiences.

Fortunately, we a have a lot of traditional and digital channels and tools we can use to communicate our results and to create awareness among all stakeholders and the general public. Social networks are one of the most popular ones. We are going to focus on LinkedIn, where FlexPlan has its official page and where dynamic interaction and debate can give wide visibility to the project, through a sharing activity by our followers, who can use the @Flexplan project TAG.

Events are also a very important opportunity to stimulate the exchange of opinions, gather inputs and present the project outcomes. In addition to the organization of the final project workshop and of the six regional workshops to illustrate the final project results, we will take part to the most relevant international conferences, webinar or meeting where our goals and expected outcomes can be shared.

Next to the ongoing scientific outputs, such as publications of papers on hight impact scientific journals, we will plan press releases, articles and interviews on national press and magazines in order to involve journalists on our project activity and, at the same time, to speak to our heterogeneous audience, taking care to adapt the language and the message to the different targets: scientists, decision makers, press&media, interested people. We will also be promoters of editorial initiatives, to collect and to comment the results of our research activity.

Communication and storytelling are challenges that we can win and what we can do is explained in an Emily Dickinson quote: "I know nothing in the world that has as much power as a word. Sometimes I write one, and I look at it, until it begins to shine". So, let's make our words shine!