FlexPlan

Letter of the Project Coordinator

Six further months and our project has reached one year of life, which corresponds to one third of its duration. As already mentioned in the previous newsletter issue, the first project year was mainly dedicated to lay down the theoretical background. In this direction, a big progress was achieved:

- the full equation set and the corresponding data requirements have been outlined and consolidated in a thick internal report;
- the concept of flexibility has been analysed in depth from the point of view of the services that can be provided and of the most suitable technologies to provide such services, with a particular focus to congestion management, the most pertinent to the grid planning activities.

However, some important theoretical analyses are still on-going:

- investigating on the opportunity to **reduce the very demanding computational load** to solve a mixed-integer investment optimization for the entire network (transmission and distribution) at nodal level and altogether for three grid years (2030, 2040, 2050). This can be carried out by adopting advanced numerical techniques allowing to carry out a stepwise optimization process for the three grid years by realizing at each step a partial relaxation of the integer variables set. A further point consists of investigating if, again by using opportune techniques, the optimization for the transmission grid can be decoupled from that of the distribution grid.
- **creating of a small scale implementation of the equation set** and of the decomposition techniques mentioned at the previous bullet. This bears the two-fold aim to double-check that everything works well and no modeling aspect was omitted in a reduced dimensionality environment which allows an easier interpretation of the obtained results and to create a first set of results upon which the full-scale planning tool, the realization of which has already started, can be validated.
- **setting up of the methodology for the pre-processor**, which is the tool that will provide the set of candidates to the planning tool (new lines/cables, storage elements, flexible exercise of existing big loads). In turn, the planning tool carries out an optimal selection of elements from this set by minimizing the sum of OPEX plus CAPEX. So, it is essential to obtain a valid set of candidates from the pre-processor in order to allow the planning tool to perform a really optimal selection. Unfortunately, unlike the planning tool, the pre-processor can't be created on the basis of a clear-cut set of equations but a heuristic technique, based on the results of a previously calculated optimization of dispatching costs for the non-expanded system, must be set up. The true difficulty is to incorporate in this heuristics the know-how human grid planners should dispose of.

As mentioned, the **creation of the full-scale grid planning** has already started and some strategic decisions have already been taken. A first full version of it is awaited by July 2021.

In parallel, a **comprehensive data collection** is being carried out for the three grid years and for the adopted storylines (corresponding to the three described by ENTSO-E in the Ten-Year-Development-Plan 2020). This is a titanic task: a huge amount of data (full T&D grid, generation set and load characteristics) is requested in order to allow a realistic grid planning analysis at nodal grid level for 2030-2040-2050 for all six

regions covered by the project simulation cases (actually, most of Europe). From the grid point of view, whereas present extra-high voltage networks (400kV and 220kV) are put available, yet in a simplified format, by ENTSO-E, data for the sub-transmission (150-130kV) and the distribution grids have to be collected from scratch. For sub-transmission, lacking direct TSO-provided data, we need to acquire (and validate) public Open Street Map data, whereas for distribution grids, whose complete dimension is clearly out-of-scope for our project, we reconstruct "synthetic" reduced-scale networks aimed at having the same characteristics as the original ones based on the collection of overall statistics from real country networks and on the analysis of some portions of real networks which are available to the consortium members. All these complex activities are now proceeding full steam and a clear timeline has been elaborated in order to complete the data collection process at least for one regional case by when planning tool and pre-processor will be ready to start their testing phase.

Gianluigi Migliavacca (RSE)

Proof-of-concept implementation for model validation

Hakan Ergun (KU Leuven) - WP1 Leader

During the last six months, the project focus has been on finalizing the mathematical foundations of the planning tool in the form of an internal deliverable and on creating the backbone of a proof-of-concept implementation of the planning model. We have created, *FlexPlan.jl,* a software package in the Julia language which will be dedicated to test the mathematical model of the planning tool. *FlexPlan.jl* allows all project partners to implement proof-of-concept models in a collaborative way. In particular, the creation of this software package aims at:

- achieving a software design where optimization solvers can be easily exchanged, allowing to test with different solvers the computational efficiency of the developed models
- extending in a flexible way the resulting model formulations
- experimenting different decomposition techniques without massive changes in the model implementation
- analyzing in depth certain modeling trade-offs by just including or excluding specific parts of the overall planning model in the optimization process. In this way, the testing can be done in a more agile way, without the need to solve a large complex mathematical model during the proof-of-concept phase.

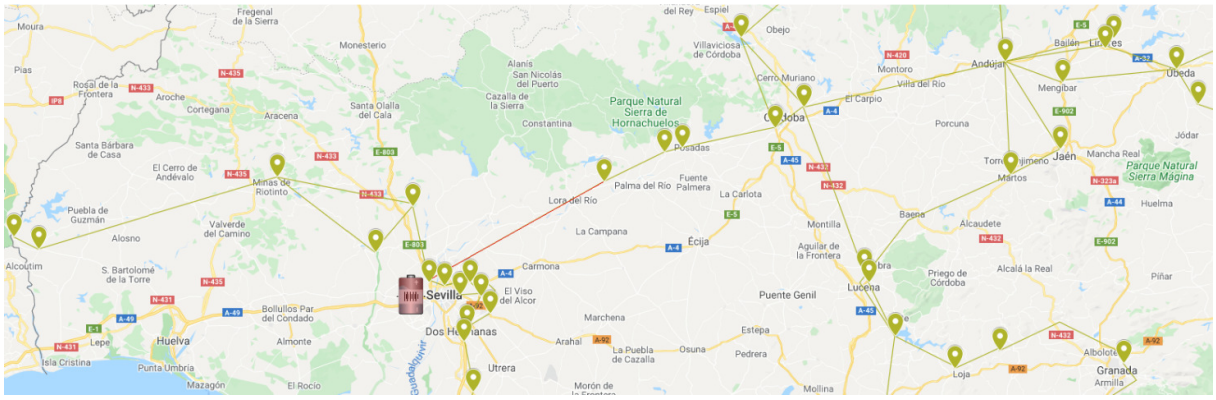
All proof-of-concept tests are being conducted on a small-sized network (see figure above), which was adapted to the Italian geography and allows to represent the environmental impact-related costs as part of

the FlexPlan model. In a second phase, this network module will be replicated a high number of times in order to test possible model scaling up issues before passing to real-size test cases.

Eventually, the *FlexPlan.jl package* will also serve to provide a first validation of the planning tool, currently being implemented in parallel to the proof-of-concept tests.

A pre-processor tool to set planning candidates

Raúl Rodriguez (TECNALIA) – WP2 Leader



The increasing participation of variable wind and solar energy production plants in the power system requires flexibility from other resources, such as fast reacting generation assets, storage and demand response. 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.

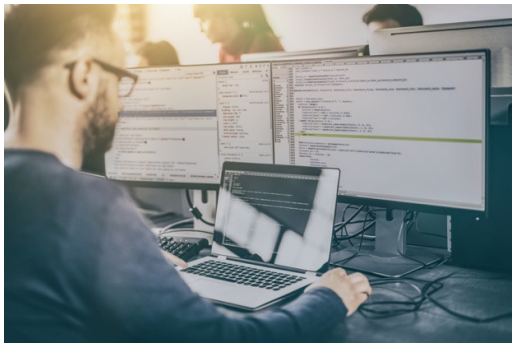
Two deliverables (D2.1 and D2.2) have been already produced on the characterization of flexible resources and on the main applications of storage and demand response for the power system, focusing on congestion support. Both are available at the link https://flexplan-project.eu/publications/. From these references, a pre-processor tool is in definition process to interact with the planning tool, as part of the planning methodology proposed in the frame of the project.

The pre-processor will receive as input both the results from an Optimal Flower Flow (OPF) executed for the non-expanded network under evaluation and the electricity network model. With this information, the tool will provide outputs back to the planning software, including a selection of locations (buses & branches) and candidates for network extension. The planning tool will then select among the candidates those that optimize the network expansion.

Within the next six months, a first version of the pre-processor will be already available, and the validation process of the tool will start.

The planning tool: a complex software engineering work

Maxime Hanot (N-SIDE) – WP3 Leader



During the last three months, the FlexPlan project has undertaken one of its most challenging activities: the creation of the planning tool. This daunting task consists in designing, implementing and testing a new T&D planning tool, inclusive of Graphical User Interface (GUI), and supporting large-scale tests performed on the six regional cases. The new T&D planning model is a huge mixed-integer optimization problem, very innovative with respect to current TSO/DSO tools.

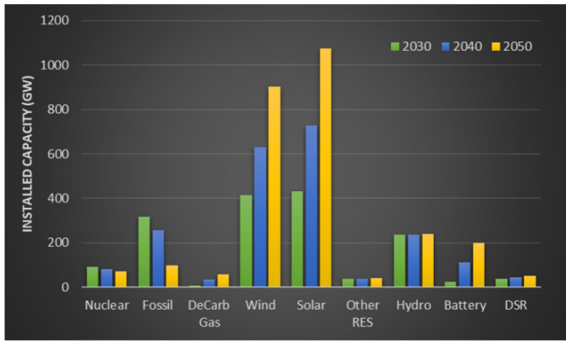
This complex software engineering work has started with a design phase. This design phase should end late October and is crucial to align the expectations of the different partners, to make sure that the developments can start smoothly and to establish a rigorous timeline. In addition, during this phase, several important questions are being answered:

- How to gather the needed data and in what format?
- How to interact with the pre-processor tool?
- What are the best technologies to develop the software?

After the design phase, the development of the tool itself will start. For this task, the FlexPlan team has decided to work in an agile way, starting from the requirements and quickly developing a Minimal Viable Product (MVP) and then improving it in terms of algorithms efficiency, GUI and other while keeping testing it. The team has therefore given itself very ambitious targets: the purpose is to get the availability of a reduced version of the tool (i.e. able to run optimal power flows) by the end of 2020 and a first complete MVP by June 2021. This MVP will then be extended by improving the efficiency of the planning algorithm, by developing an intuitive GUI and a documentation such as to ensure an easy handling by all kinds of users.

Downscaling pan-European energy scenarios to regional case level

Jawana Gabrielski (WP4 Leader); Nuno Amaro (WP5 Leader)



The FlexPlan tool will be tested and validated through six ambitious regional cases covering almost all Europe. A comprehensive set of three energy scenarios per year was created for 2030, 2040 and 2050. 2030 and 2040 scenarios are directly obtained from ENTSO-E TYNDP 2020 with minor adaptations. However, due to the absence of this data in TYNDP, 2050 scenarios are created using a two-step methodology, validated by the

consortium members and by several members of the Advisory Board, through a performed web-consultation. A first linear approach from 2030 and 2040 data in TYNDP 2020 is performed, followed by a validation of obtained results with relevant scenarios from "A Clean Planet For All" energy long term strategy from the European Commission. The created scenarios, whose methodological development and exemplary results are available in FlexPlan Deliverable 4.1 (available in: https://flexplan-project.eu/publications/), allow having a pan-European energy vision, while providing a detailed analysis at country level. The enclosed figure depicts the example of the evolution of installed capacity in Europe for the scenario "Distributed Energy". Answering to current environmental targets, fossil fuel power plants almost disappear in 2050 and the few existing ones are based on environmental friendly solutions such as decarbonized gas.

Data from these pan-EU scenarios is broken down to a regional level. As renewable energy sources depend on location and weather conditions, a regionalization methodology is applied. At first the regional distribution of the national data is calculated through statistical parameters. Based on this, regional feed-in and load time-series are determined using weather data. The process will result in a nodal distribution for each one of the simulated years. This data will be used together with the detailed grid models to fully test the functionalities of the FlexPlan tool. Regional cases grid models, currently under development, consider the existence of full geo-referenced transmission and distribution systems, existing and planned power plants and realistic load distribution. The transmission systems are based on a dataset received from ENTSO-E (extra-high-voltage grid) complemented with national level and open source data (e.g. TSO network development plans and Open Street Maps) for the sub-transmission levels. Distribution systems are built using synthetic networks, which are representative of real distribution networks around Europe. Additionally, and because FlexPlan also considers the environmental impact of grid reinforcements and thermal generation, a complementary set of data is currently being collected, allowing to have a full vision of carbon footprint and air quality around thermal power plants, which should still be operating in each one of the three target years for the FlexPlan studies. This complex and ambitious simulation process is ongoing and results will start to be delivered as of the beginning of 2021, when the first 2030 scenarios will start being simulated.

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