Aalto University
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Variability of renewable electricity generation in a future climate scenario

Interim report

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Team FMI

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1 Status of Project

After the submission of the project plan, the advances in the project have been notable. A major concern related to project was the scope and precise setting, which would contribute towards the research question. Having familiarized with the topic, the project team has decided to proceed with a four-step roadmap. The tasks of the project have been selected such that the completion of each task produces a relevant contribution. The taskwise roadmap helps scoping the effort of the project team. Moreover, the division of project to tractable parts enables delivering the final results such that some unfinished aspect can be dropped without compromising the goal of the project. Division of project to tractable steps also complements the agile process of the project team. The four tasks of the project are

1. Determining the total production and demand for a location
2. The effect of spatial distribution of production
3. The effect of batteries and energy storage
4. Capacity expansion or optimization problem

The first task also includes definition of the shortfall in a holistic fashion. In the project, the shortfall refers to a deficit in production. Yet, there has been discussion on alternative definition related to production capability, which could be used determine shortfall events. Similarly, the second task includes analysis of the spatial distribution, i.e., correlation studies and other analysis aiming to justify the site selection of production, which could be used in the fourth item.

Adjusting the scope of the project has changed the direction of the project. The project will be considering more to a local setting in Finland and to consider the shortfalls in Finnish production grid. On the other hand, the project will not aim to predict of the shortfalls from climate data. The project will be more of an analysis of the simulated time series data. One reason for this is the limited work force available, but also that predicting using simulated data, will lead to unpredictable results, as deviations from the simulation data could lead to changes in the predictions on the longer haul. In the project plan, we also planned doing the literature review completely before starting the implementations. Yet, having discussed with the FMI, we decided to postpone the review as we had already adequate methods for initial implementation.

1.1 Completed Tasks

Some initial results have already been obtained. The initial results provide a proof of concept especially on the demand and production estimates, which are the basis of completion of task one in the roadmap.

We have gathered all required data, which includes the CMIP6 model (1) output providing the wind and solar conditions as well as the temperature data for about 30-year period. Using the data and conversion functions, the production can be determined for the whole 30-year period. The conversion functions were selected after having completed a brief initial literature review. The used conversion functions are the ones suggested by Van Der Wiel et al. (2).

The future demand data has been estimated utilizing historical data provided by Fingrid (3) and the future estimates by the European Commission's (EUCO) Clean Energy report (4). The datasets are used to form the future demand data by shifting and scaling the historical data in 5-year-periods with the estimated values presented in the EUCO Clean Energy report.

The future energy generation scenario, i.e., the estimated generation capacities of considered production methods, are selected to match estimates by the EUCO Clean Energy report (4). Using the predictions, we have been able to carry out initial analysis to get familiar with the effects caused by VRE. This has helped in forming a basis for defining shortfalls, which are understood as insufficient production with respect to demand.

With these resources we have built an initial model for delivering results on the production-demand balance and also, the frequency and magnitude of shortfalls. This analysis corresponds to the first task in the roadmap well even though it is not answering any of the questions directly.

1.2 Current tasks

Currently we are building a model that supports spatial distribution of production. We will learn about the frequency, magnitude and timing of shortfalls in different production locations and with different spatial distributions of the locations. This also enables considering correlations of productions in different locations. If there is not high correlation, then the spatial distribution can be used alleviate the shortfalls in the production systems, as spatial distribution diminishes the magnitude of shortfalls in total.

1.3 Next steps

Having been able to conduct the analysis, we should be able to answer the questions regarding the shortfall phenomenon and the spatial distribution. The next step in the project is to conduct proper analysis and implement the storage alternative, which is achievable with a small addition to the model described above. An initial idea of the implementation is to consider storing leftover energy up to a limit in a storage variable. The value of this variable is then increased in case of overproduction and decreased with the magnitude of a possibly observed shortfall once one occurs. The implementation of the storage variable allows considerations of needed storage capacity over the time-span of the simulated data.

After considering different storage options in the model, we will proceed to our final step. In the project plan this was introduced as an economic analysis. However, given the information and resources we have, the step may involve, for example, simple optimization over the spatial distribution of locations. We could also proceed to build an economic model and find the economic consequences but this decision will be made later after all current work is done and we have had further discussions with the FMI.

After implementing the final step of the roadmap, and completed the analysis related to the obtained results, we write the final report. In the final report, we include the literature review and compare our results to those of the other studies, in order to verify and validate the obtained results.

2 Schedule

The project follows the initial schedule as planned. The progress was quite slow in the beginning, but after the implementation of the computational model proceeded, the progress has been rapid.

The changes in project scope discussed earlier in this report have also forced to make small changes to schedule, but the changes have been relatively small. The largest change is the postponement of the literature review, for which we will need to allocate time later. Yet, the good progress of the project has freed time from the implementation of the computational model, and hence this should not become a problem.

By the submission of the interim report, we wish to have all the on-going steps done. In this case we would have roughly six weeks to finish the analysis and write the final report. The team considers this to be very feasible and is, moreover, planning to have an internal deadline for the report by the beginning of May, after which the final report is only improved and discussed with the FMI.

3 Risks

The updated main risks of the project are presented in the Table 1. In comparison to the previously estimated risk levels, the new values are set after the likelihood has been better observed.

Table 1: Updated table of risks related to the project and the relevant issues regarding them. The strike through words indicate changes to previous estimates.

Risk	**Likelihood**	**Impact**	**Effect on project**	**How to prevent**
Ill-posed scope	Very Low (~~Low~~)	Mid-High (~~High~~)	Irrelevant work	Agile methods i.e. iterative way of working
Too much focus on too small details	Mid	Low	Too much work, over-quality in some parts and maybe lacking quality in other parts	Clear definition of subgoals and iterative upgrades on features later
Too large project	Very Low (~~Low~~)	Mid (~~High~~)	Project does not get ready within the given time	Iteration of objectives
Lack of stakeholder involvement	Low	Mid-High	Either more work or worse results	Be prepared for any meetings to prevent unnecessary and frustrating work
Data is not suitable	Very Low (~~Low-Mid~~)	Mid	Misleading results	Planning and iterative progress
Lack of capabilities	Low (~~Mid~~)	High	Oversimplified analysis or incorrect results	Either more research or change of the scope
Lack of reasonable results	Very Low (~~Mid~~)	Low	Might not be able to answer any objectives	Use of good enough methods and resources

The progress in the work and especially, further planning has reduced the risk of ill-posed scope, lack of reasonable results and the excessive expansion of the project. As the progress has been promising, the probability of facing issues in the scope and size of the project are small. Moreover, the involvement of the FMI has been great and we do not expect to face this to change in the reminder of the project. Yet, as the analysis part is about to begin later, then the support is even more crucial, which maintains the high impact. The proceeding with building the computational model has alleviated the doubts related to data. There have been only minor issues in handling the data, but the team has been able to sort these issues out. The data has been seen to be valid and it should allow good results, which again alleviates the risk of lacking results. Due to good proceeding and involvement of the FMI, the risk of lacking capabilities has also diminished as most of the implementation issues have been solved and there should be less complex task further on in the project.

References

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[2] K. van der Wiel, L. P. Stoop, B. Van Zuijlen, R. Blackport, M. Van den Broek, and F. Selten, "Meteorological conditions leading to extreme low variable renewable energy production and extreme high energy shortfall," *Renewable and Sustainable Energy Reviews*, vol. 111, pp. 261–275, 2019.

[3] Fingrid, "Data portal." `https://data.fingrid.fi/open-data-forms/search/en/index.html?selected_datasets=`. Accessed: 20th March 2021.

[4] European Commission, "Results of the euco3232.5 scenario on member states." `https://ec.europa.eu/energy/data-analysis/energy-modelling/euco-scenarios_en`. Accessed: 20th March 2021.