**This document is the reflection of the graduation project for the assessment P4, as part of the MSc graduation project for the track Building Technology, Master Architecture, Urbanism & Building Sciences, at the Delft University of Technology.**

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# Reflection

**Lorena Montenegro**
**Student number 4751701**

## Academic

The world is in need of innovation and integration of technology. The Dutch government and educational institutions are supporting greatly the exploration of new technologies to achieve the goals of the Paris agreement. The integration of shared renewable sources needs to happen in an optimal way in order to avoid mismatches or any other problem that might unbalance the energy system. Therefore, the built environment should be prepared to integrate renewable energy as the only source of energy for the buildings in a balance way between demand and supply.

The MSc in Building technology included courses such as climate design, zero energy buildings and other different studios that help to understand the possible parameters and technologies that can be implemented in the built environment to reduce the mismatch. Nonetheless, it is not common to discuss about the mismatch or the intermittences that happen because of the integration of shared renewable energy sources.

Moreover, the built environment is responsible for 40% of the energy consumption worldwide. During the master, the different ways to reduce the demand in a building and the different technologies of the supply are discussed. Nonetheless, the complementary energy systems and their efficiencies (heat and cold distribution systems, thermal and electrical energy storage systems, heat and cold booster energy systems, such as heat pumps, chillers and boilers) are not discussed. If this kind of topics were discussed during the master, the inclusion of shared renewable energies in the built environment will be easier and more balanced.

## Personal

This research did not encounter any moral nor ethical issues or dilemmas during the process.

The main research question worked during this research helped me to understand many concepts, parameters, factors, technologies and limitations involved in the renovation of a non-residential existing building towards energy flatness. Energy flatness is a new concept described by Vincent Höfte (Höfte, 2018) in his master graduation thesis. In this graduation thesis, the term was further explored and complemented. Nonetheless, more research should be developed in this topic in order to raise awareness on the importance to solve the mismatch between demand and supply of energy.

The research approach proposed has been very helpful, as most of it was aimed to understand and gain knowledge of the current and future energy mismatch that can happen when solar energy is supplied to existing buildings and the parameters and technologies that can help to reduced it for the renovation in non-residential existing building by following a three steps strategy. In addition, the research approach helped to define the design proposed for the renovation of the case study building towards energy flatness.

The planning scheme proposed at the beginning of the research was very hard to follow, because some steps such as the analysis of the current energy demand in the building, took more time than planned. In addition, the tool selected for the analysis of the demand, was not completely known which required additional time to learn how to use it and how to validate the output.

Because the data input of the energy demand analyzed many parameters and because design builder assumes a lot of information, it is hard to validate the accuracy of the basic energy model. For this reason, more time that the planned was required for the model. In addition, the given information of the building was not enough to fully understand the current final energy used by the building, and some assumptions had to be made in order to reach the final energy used as specified from TU/e (the owner).

The analysis of the mismatch in such detail such as the analysis in the hourly basis was part of the aim of this research. Furthermore, this analysis requires more time, which makes it hard to develop.

## Societal impact

The analysis of the toolbox provided in this research can be implemented for the analysis and proposal of the renovation of any non-residential existing building, because the analysis of the parameter was based on the current thermal and electrical balance in existing buildings. The analysis of the technologies is very brief, and it aims to give an overview of the possible technologies of the solar supply and complementary energy system that can be implemented in a non-residential existing building. A more detail investigation, a feasibility study and a cost analysis should be developed before any technology is proposed for the renovation of existing buildings.

Currently there is no so much research on how to reduce the mismatch in non-residential existing buildings. Therefore, this research is very useful in order to understand the problems related to the mismatch between energy demand and supply and the parameters and technologies that can help to reduce it. In this research only the solar renewable energy supply systems were analyzed, but for future investigations the analysis of wind and biomass technologies integrated in the built environment can be very useful.

Taking into account that 90% of the buildings that existing nowadays will remain on earth by 2050. Energy flatness in those buildings is a challenge and it should be the aim of the current governments and building owners.

The integration of renewable energies in the built environment is happening fast and without much planning, which in the future might cost an increment in the electricity bills, and the possible dependence on fossil fuels or nuclear energy to supply energy when the renewable energies cannot. This research aims to gain knowledge on how to reduce the mismatch between solar renewable energy supply and final building energy use with the integration of a complementary energy system that includes energy storage.

Renewable solar energy supply technologies should be more and better integrated in the built environment because these technologies have not much negative impact to the environment and use the available sources such as the sun to produce energy without putting in danger any specie. A good and balanced integration of renewable energy technologies in existing buildings will avoid the need for fossil fuels and reduce the $CO_2$ emissions responsible for the climate change.

The research on the possible thermal energy storage systems is useful for the environment because since it is a goal to promote the use of renewable energy sources such as solar technologies, thermal passive and active energy storage systems make more viable the utilization of renewable energy sources by reducing the unbalance periods. It also reduces the need for additional conventional energy supplied systems that depend on fossil fuels and the need for additional power plants.

**This reflection is also included in the final thesis report, but provided separately as requested by the Board of Examiners.**

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**Student number 4751701**