Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

Submit your Graduation Plan to the Board of Examiners (Examencommissie-BK@tudelft.nl), Mentors and Delegate of the Board of Examiners one week before P2 at the latest.

The graduation plan consists of at least the following data/segments:

Personal information	
Name	**Dick Adriaan Klijn**
Student number	4661036

Studio		
Name / Theme	Architectural Engineering	
Main mentor	Ir. Thomas Offermans	Architecture tutor
Second mentor	Ir. Siebe Broersma	Research tutor
Third mentor	Ir. Paddy Tomesen	Building Technology tutor
Argumentation of choice of the studio	This studio really focuses on the technical side of architecture, especially on the integration of aesthetics and technology. In my opinion this aspect is often overlooked by architects and they only look at aesthetics and space. This way there is little incorporation of technology in the architecture that will become a problem in the end phase of a design. Further I really like the research approach of this studio as you can dive into a topic that you want. So to gain more knowledge on the technical side of architecture and to incorporate technology early on in the design phase I chose this graduation studio.	

Graduation project	
Title of the graduation project	Unclogging the grid – A study on how deep energy renovations can reduce the load on the electrical energy grid and create a self-sufficient building.
Goal	
Location:	Haarlem, Boerhaavewijk
The posed problem,	The biggest problem is global warming due to human GHG emissions. On a smaller scale we see that existing houses are accountable for 36% of the energy use. Another problem is the energy dependency of some EU member states. If we zoom in to the Dutch context we can conclude that the deep energy renovation of these houses lag behind due to several reasons. One of the reasons for this is grid congestion caused by the large implementation of south facing roof PV and electrical heat pumps. This shows that the Dutch infrastructure is not capable to fit the energy transition with the current

	energy concepts that are being implemented. This leads to the following problem statement: *Due to the increasing amount of local energy production and electrification (use of heat pumps and EV charging) in the build environment energy demand and production are out of balance, creating grid congestion which might slow down the energy transition.*
research questions and	How can a typical existing building block, such as at Boerhaave, be made energy neutral and advance towards more self-sufficiency without increasing the peak load on the (local) electricity grid by optimizing energy reduction, local renewable energy generation, distribution and storage with the use of saltwater battery systems?
design assignment in which these result.	How can existing post-war building blocks be improved socially and technically without burdening the existing energy grid and the use of fossil fuels?

The aim of this paper is to gain more insight on how to improve the energy performance of a building without increasing the load on the electrical energy grid. This should lead to a program of demands on renovating existing houses that are not slowed down due to limited grid capacity. Furthermore this paper will provide a basis for a model to simulate the electrical load of buildings and how specific measures like insulation influence this.

Process

Method description

Due to the lack of a easy modeling tool I was not able to use this as a validation to model the current daily energy demand and the impact of certain peak shaving techniques. Therefore I used an other method; comparing load graphs. This method uses graphs of peak shaving techniques found in the literature that are all transformed to the same scale. These graphs were then traced and used to make a general assumption of the impact on the load graph of a building. This method was used to determine the new the daily load curve.

For the annual load curve the ZED-tool of dr. ir. Leo Gommans was used to model the impact of certain peak shaving techniques. A case study building in Haarlem was used to model the current annual load graph with the ZED-tool. Then different interventions, like adding insulation or solar panels, were added to see their influence on the annual load graph.

Literature and general practical preference

- *Agrawal, V. K., Khemka, A., Manoharan, K., Jain, D., & Mukhopadhyay, S. (2016). Wind-solar hybrid system — an innovative and smart approach to augment renewable generation and moderate variability to the grid. 2016 IEEE 7th Power India International Conference (PIICON). https://doi.org/10.1109/poweri.2016.8077152*
- *Awad, H., & Gül, M. (2018). Load-match-driven design of solar PV systems at high latitudes in the Northern hemisphere and its impact on the grid. Solar Energy, 173, 377–397. https://doi.org/10.1016/j.solener.2018.07.010*
- *Couto, A., & Estanqueiro, A. (2020). Exploring Wind and Solar PV Generation Complementarity to Meet Electricity Demand. Energies, 13(16), 4132. https://doi.org/10.3390/en13164132*
- *Filippidou, F., Nieboer, N., & Visscher, H. (2017). Are we moving fast enough? The energy renovation rate of the Dutch non-profit housing using the national energy labelling database. Energy Policy, 109, 488–498. https://doi.org/10.1016/j.enpol.2017.07.025*
- *Freitas, S., & Brito, M. (2019). Non-cumulative only solar photovoltaics for electricity load-matching. Renewable and Sustainable Energy Reviews, 109, 271–283. https://doi.org/10.1016/j.rser.2019.04.038*
- *Gram-Hanssen, K. (2014). Existing buildings – Users, renovations and energy policy. Kovač, M., Stegnar, G., Al-Mansour, F., Merše, S., & Pečjak, A. (2019). Assessing solar potential and battery instalment for self-sufficient buildings with simplified model. Energy, 173, 1182–1195. https://doi.org/10.1016/j.energy.2019.02.024*
- *Heide, D., von Bremen, L., Greiner, M., Hoffmann, C., Speckmann, M., & Bofinger, S. (2010). Seasonal optimal mix of wind and solar power in a future, highly renewable Europe. Renewable Energy, 35(11), 2483–2489. https://doi.org/10.1016/j.renene.2010.03.012*
- *Mertens, S. (2022). Design of wind and solar energy supply, to match energy demand. Cleaner Engineering and Technology, 6, 100402. https://doi.org/10.1016/j.clet.2022.100402*
- *Staats, M., de Boer-Meulman, P., & van Sark, W. (2017). Experimental determination of demand side management potential of wet appliances in the Netherlands. Sustainable Energy, Grids and Networks, 9, 80–94. https://doi.org/10.1016/j.segan.2016.12.004*
- *Thebault, M., & Gaillard, L. (2021). Optimization of the integration of photovoltaic systems on buildings for self-consumption – Case study in France. City and Environment Interactions, 10, 100057. https://doi.org/10.1016/j.cacint.2021.100057*
- *van Westering, W., & Hellendoorn, H. (2020). Low voltage power grid congestion reduction using a community battery: Design principles, control and experimental validation. International Journal of Electrical Power &Amp; Energy Systems, 114, 105349. https://doi.org/10.1016/j.ijepes.2019.06.007*
- *Watson, S., Lomas, K., & Buswell, R. (2021). How will heat pumps alter national half-hourly heat demands? Empirical modelling based on GB field trials. Energy and Buildings, 238, 110777. https://doi.org/10.1016/j.enbuild.2021.110777*
- *Yanovshtchinsky, V., Huijbers, K., Blokland, E., & van den Dobbelsteen, A. (2012). Architectuur als klimaatmachine: handboek voor duurzaam comfort zonder stekker (1st ed.). Sun.*
- *Zappa, W., & van den Broek, M. (2018). Analysing the potential of integrating wind and solar power in Europe using spatial optimisation under various scenarios. Renewable and Sustainable Energy Reviews, 94, 1192–1216. https://doi.org/10.1016/j.rser.2018.05.071*

Reflection

1. What is the relation between your graduation (project) topic, the studio topic (if applicable), your master track (A,U,BT,LA,MBE), and your master programme (MSc AUBS)?
    a. The relation between my graduation topic and the studio topic is that they both combine the technical and social aspects of architecture. As the research focuses on the local energy generation to reduce the energy use and peak loads of the grid and the design focuses on the integration of these measures while updating post-war architecture. This last part links the Architecture track to my topic as my design seeks a new aesthetic to retrofit post-war architecture to make these existing buildings more energy efficient and improve social interaction in the building. Because changing a building has impact on all levels I feel this graduation project touches all the specialisations (A,U,BT,LA & MBE) within the Master, with a focus on architecture as I am designing a building in the end. I feel like my project will affect the Urban context as I am improving the social interaction with my design. Furthermore my design has a technical character to make sure the load on the grid is not burdened by reducing demand and implement energy generation which is connected with Building Technology.

2. What is the relevance of your graduation work in the larger social, professional and scientific framework.
    a. The relevance of my graduation work in larger social framework is to provide a solution to speed up the energy transition, to densify and improve post-war neighbourhoods. Especially now that energy prices are high low income households struggle to make ends meet. Thus by lowering the energy consumption of a building the energy costs for households will drop improving their financial situation. Now that the Dutch government is planning to abolish the net-metering regulations, the financial incentive to implement renewable energy sources (RES) as a household is lower. This hits the low-income households the most as installing RES costs a lot of money and without the net-metering rule it becomes harder to earn back their investment. By installing RES in the way that is proposed in this research will increase the self-consumption of energy lowering the amount of energy bought from the grid thus, lowering the energy bill and decreasing the amount of fossil fuels. In the professional framework my work will provide a new insight in transforming post-war dwellings as there are a lot of similar buildings in the Netherlands that have use a lot of energy contributing to the climate change. And the scientific framework my graduation will give more insight in peak shaving measures and provide a basis for a tool to simulate the load profile of a household. This tool can be used by designers to test different energy concepts to lower the load on the grid and become more self-sufficient in energy use.