

# Graduation Plan

## Studio

Name / Theme	Energy transition in the existing building stock
Main mentor	Queena Qian - MBE - DCM
Second mentor	Ad Straub - MBE - DCM
Argumentation of choice of the studio	I foresee a renovation 'wave' to respond to current sustainability issues and to keep up with worldwide targets concerning energy consumption, energy transition, and so on. This studio covers this topic perfectly and therefore has my main interest.

## Graduation project

Title of the graduation project	Energy-efficient and 'healthy' offices: An approach for office renovations towards EPC level C focused on energy-efficiency and IEQ
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## Goal

Location	The Netherlands
The posed problem	Recent studies showed that 11% of the Dutch office buildings have EPC class D or worse and lots of existing office buildings do not have an EPC yet. This calls for many renovations in the near future. However, there is a contradicting relationship between energy-efficiency measures and the IEQ post-renovation. A current approach of the renovation and construction of Dutch school buildings guides the process towards Frisse Scholen; energy-efficient and healthy school buildings for its users. Healthy buildings are buildings with sufficient IEQ which increases the overall satisfaction and productivity of its users. With many renovations of Dutch offices to be carried out, it is important to emphasise the importance of the IEQ for office workers and to ensure that the renovation does not neglect the IEQ post-renovation. A new methodology and process manual is designed with this research to guide this process of renovation; focused on energy-efficiency and healthy offices.
Research questions	MRQ: How can the renovation of Dutch commercial office buildings towards EPC level C be guided with a focus on energy-efficiency and IEQ? SQ1: What are the tools available for monitoring IEQ post-renovation and how are they experienced? SQ2: What are the motives of initiators to carry out energy-efficiency renovations of commercial offices, besides the obligation for EPC class C? SQ4: To what extent is IEQ taken into consideration by initiators of energy-efficiency renovations of commercial offices?
Design assignment	The outcome of my research is a methodology and a process manual to guide the renovation process of Dutch offices. This methodology and process manual can be compared with the existing Programma van Eisen Frisse Scholen 2021 which is currently in use for the renovation and construction of Dutch school buildings. However, these existing products will not be used as some sort of 'blueprint' for the setup of my research outcomes.

## Process

<p>Method description</p>	<p>For this research, qualitative data collection is used by means of case studies and in-depth interviews with initiators of office renovations. The cases have not been selected yet, but a case selection matrix is designed to determine the criteria on which the cases should be selected. The interviews are conducted in a semi-structured way and are recorded and transcribed to analyse. The analysis of the interviews is carried out using AtlasTI software. This software allows to find concepts in the transcripts and show the relations between these concepts. The outcomes of the interviews are used to interpret current shortcomings in the decision-making process of the initiators when it comes to focusing on IEQ during the renovation process. These insights are translated into a methodology and process manual.</p> <p>Besides, an extensive additional literature study is carried out to dive into the methods for monitoring IEQ post-renovation in offices. This literature study can also be substantiated with interviews with practitioners or other relevant individuals in this field to find strengths and weaknesses in these methods.</p>
<p>Literature and general practical preferences</p>	<p>Asero, L., &amp; Blumberga, A. (2018). Energy efficiency – indoor air quality dilemma in public buildings. <i>Energy Procedia</i>, 147, 445–451. <a href="https://doi.org/10.1016/j.egypro.2018.07.115">https://doi.org/10.1016/j.egypro.2018.07.115</a></p> <p>Ástmarsson, B., Jensen, P. A., &amp; Maslesa, E. (2013). Sustainable renovation of residential buildings and the landlord/tenant dilemma. <i>Energy Policy</i>, 63, 355–362. <a href="https://doi.org/10.1016/j.enpol.2013.08.046">https://doi.org/10.1016/j.enpol.2013.08.046</a></p> <p>Bedrijfsenergielabels. (2021, April 10). Energielabel kantoor. <a href="https://www.bedrijfsenergielabels.nl/energielabel-kantoor/">https://www.bedrijfsenergielabels.nl/energielabel-kantoor/</a></p> <p>Bhandari, P. (2022a, November 24). What Is Qualitative Research?   Methods &amp; Examples. Scribbr. <a href="https://www.scribbr.com/methodology/qualitative-research/">https://www.scribbr.com/methodology/qualitative-research/</a></p> <p>Bhandari, P. (2022b, December 5). What Is Deductive Reasoning?   Explanation &amp; Examples. Scribbr. <a href="https://www.scribbr.com/methodology/deductive-reasoning/">https://www.scribbr.com/methodology/deductive-reasoning/</a></p> <p>Blaikie, N., &amp; Priest, J. (2019). <i>Designing Social Research: The Logic of Anticipation</i> (3rd ed.). Polity Press.</p> <p>Broers, W., Vasseur, V., Kemp, R., Abujidi, N., &amp; Vroon, Z. (2019). Decided or divided? An empirical analysis of the decision-making process of Dutch homeowners for energy renovation measures. <i>Energy Research &amp; Social Science</i>, 58, 101284. <a href="https://doi.org/10.1016/j.erss.2019.101284">https://doi.org/10.1016/j.erss.2019.101284</a></p> <p>Choi, J. H., Loftness, V., &amp; Aziz, A. (2012). Post-occupancy evaluation of 20 office buildings as basis for future IEQ standards and guidelines. <i>Energy and Buildings</i>, 46, 167–175. <a href="https://doi.org/10.1016/j.enbuild.2011.08.009">https://doi.org/10.1016/j.enbuild.2011.08.009</a></p> <p>Creative Commons. (n.d.). Attribution-NonCommercial-ShareAlike 4.0 International – CC BY-NC-SA 4.0. <a href="https://creativecommons.org/licenses/by-nc-sa/4.0/">https://creativecommons.org/licenses/by-nc-sa/4.0/</a></p> <p>Dorizas, V., de Groot, M., &amp; Volt, J. (2019). Indoor environmental quality as a mean to catalyse the acceptance and implementation of the major new EPBD provisions. <i>ECEE Summer Study Proceedings 2019</i>, 7. Make buildings policies great again, 7-143-19. <a href="https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/indoor-environmental-quality-as-a-mean-to-catalyse-the-acceptance-and-implementation-of-the-major-new-epbd-provisions/2019/7-143-19_Dorizas_display.pdf/">https://www.eceee.org/library/conference_proceedings/eceee_Summer_Studies/2019/7-make-buildings-policies-great-again/indoor-environmental-quality-as-a-mean-to-catalyse-the-acceptance-and-implementation-of-the-major-new-epbd-provisions/2019/7-143-19_Dorizas_display.pdf/</a></p> <p>Dubbeling, D. J. (2014). Twijfel over energieprestaties van kantoorgebouwen: Energielabel geen garantie voor duurzaam gebouw. <i>Bouwmarkt</i>, 54(8), 5–7. <a href="http://resolver.tudelft.nl/uuid:4da9f4f2-a1dc-461e-91d6-845ab9018c72">http://resolver.tudelft.nl/uuid:4da9f4f2-a1dc-461e-91d6-845ab9018c72</a></p> <p>European Commission. (2016, November 17). EU buildings factsheets. <a href="https://ec.europa.eu/energy/eu-buildings-factsheets_en">https://ec.europa.eu/energy/eu-buildings-factsheets_en</a></p> <p>European Commission. (2020). A renovation wave for Europe: Greening our buildings, creating jobs, improving lives. <a href="https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&amp;uri=CELEX:52020DC0662">https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1603122220757&amp;uri=CELEX:52020DC0662</a></p> <p>European Parliament and the Council of the European Union. (2018). Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency. In <i>EUR-Lex</i>. Official Journal of the European Union. <a href="https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&amp;from=EN">https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L0844&amp;from=EN</a></p> <p>Flyvbjerg, B. (2011). Case study. In N. K. Denzin &amp; Y. S. Lincoln (Eds.), <i>The SAGE handbook of qualitative research</i> (4th ed., pp. 301–316). SAGE Publications.</p>

Frontczak, M., Schiavon, S., Goins, J., Arens, E., Zhang, H., & Wargocki, P. (2011). Quantitative relationships between occupant satisfaction and satisfaction aspects of indoor environmental quality and building design. *Indoor Air*, 22(2), 119–131. <https://doi.org/10.1111/j.1600-0668.2011.00745.x>

Jensen, P. A., & Maslesa, E. (2015). Value based building renovation – A tool for decision-making and evaluation. *Building and Environment*, 92, 1–9. <https://doi.org/10.1016/j.buildenv.2015.04.008>

Jin, Q., & Wallbaum, H. (2020). Improving indoor environmental quality (IEQ) for occupant health and well-being: A case study of Swedish office building. *IOP Conference Series: Earth and Environmental Science*, 588(3), 032072. <https://doi.org/10.1088/1755-1315/588/3/032072>

Juan, Y. K., Gao, P., & Wang, J. (2010). A hybrid decision support system for sustainable office building renovation and energy performance improvement. *Energy and Buildings*, 42(3), 290–297. <https://doi.org/10.1016/j.enbuild.2009.09.006>

Kim, J., & de Dear, R. (2012). Nonlinear relationships between individual IEQ factors and overall workspace satisfaction. *Building and Environment*, 49, 33–40. <https://doi.org/10.1016/j.buildenv.2011.09.022>

Kwon, M. (2020). *Energy-efficient office renovation: Developing design principles based on user-focused evaluation*. Adfo Books.

Kwon, M., Remøy, H., & Van Den Dobbelen, A. (2019). User-focused office renovation: a review into user satisfaction and the potential for improvement. *Property Management*, 37(4), 470–489. <https://doi.org/10.1108/pm-04-2018-0026>

Mahbob, N. S., Kamaruzzaman, S. N., Salleh, N., & Sulaiman, R. (2011). A correlation studies of Indoor Environmental Quality (IEQ) towards productive workplace. 2nd International Conference on Environmental Science and Technology, 6.

McCombes, S. (2022, December 1). *Sampling Methods | Types, Techniques & Examples*. Scribbr. <https://www.scribbr.com/methodology/sampling-methods/>

Ministry of General Affairs. (2022, August 22). *Mandatory EPCs for buildings*. Government.nl. <https://www.government.nl/topics/energy-performance-certificates-for-homes-and-buildings/mandatory-epcs-for-buildings>

Ministry of the Interior and Kingdom Relations. (2023, January 1). *Artikel 5.11 Labelverplichting kantoorgebouw*. Bouwbesluit Online. [https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2012\\_nvt/artikelsgewijs/hfd5/afd5-3/art5-11](https://rijksoverheid.bouwbesluit.com/Inhoud/docs/wet/bb2012_nvt/artikelsgewijs/hfd5/afd5-3/art5-11)

Mitchell, C. S., Zhang, J. J., Sigsgaard, T., Jantunen, M., Liou, P. J., Samson, R., & Karol, M. H. (2007). Current State of the Science: Health Effects and Indoor Environmental Quality. *Environmental Health Perspectives*, 115(6), 958–964. <https://doi.org/10.1289/ehp.8987>

NEN. (2021, December 28). *NTA 8800:2022 nl*. <https://www.nen.nl/nta-8800-2022-nl-290717>

Netherlands Enterprise Agency. (2017, May 30). *Energielabel utiliteitsgebouwen*. RVO.nl. <https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/energielabel-utiliteitsgebouwen>

Netherlands Enterprise Agency. (2018, October 29). *Energielabel C kantoren*. RVO.nl. <https://www.rvo.nl/onderwerpen/wetten-en-regels-gebouwen/energielabel-c-kantoren>

Netherlands Enterprise Agency. (2021). *Frisse scholen proceshandleiding 2021*. In RVO.nl. <https://www.rvo.nl/sites/default/files/2022-08/frisse-scholen-proceshandleiding.pdf>

Netherlands Enterprise Agency. (2022a, July 27). *Ruim de helft van de kantoren niet klaar voor energielabel C*. RVO.nl. <https://www.rvo.nl/nieuws/ruim-de-helft-van-de-kantoren-niet-klaar-voor-energielabel-c>

Netherlands Enterprise Agency. (2022b). *GIS-viewer : Label C kantoren (2021.07) [Dataset]*. <https://ez.maps.arcgis.com/apps/webappviewer/index.html?id=fc93368c-c92a4a39b5acc34017365c4f>

Netherlands Enterprise Agency. (2022c, November 14). *“Energielabel C voor kantoren is goed te doen.”* RVO.nl. <https://www.rvo.nl/praktijkverhalen/energielabel-c-goed-te-doen>

Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M., & Charles, K. (2009). Linking indoor environment conditions to job satisfaction: a field study. *Building Research & Information*, 37(2), 129–147. <https://doi.org/10.1080/09613210802710298>

Nielsen, A. N., Jensen, R. L., Larsen, T. S., & Nissen, S. B. (2016). Early stage decision support for sustainable building renovation – A review. *Building and Environment*, 103, 165–181. <https://doi.org/10.1016/j.buildenv.2016.04.009>

Polonsky, M. J., & Waller, D. S. (2019). *Ethical considerations*. In *Designing and managing a research project: A business student’s guide* (pp. 53–75). SAGE Publications.

Ribeiro, F. L., & Videira, S. I. (2008). Management of the built heritage in the Lisbon’s central downtown. *International Journal of Housing Markets and Analysis*, 1(2), 110–124. <https://doi.org/10.1108/17538270810877754>

Riopelle, K. (2022, October 30). *Interview analysis that helps you leverage every piece of data*. ATLAS.ti. <https://atlasti.com/interview-analysis-tools>

Rogers, E. M. (1983). *The innovation-decision process*. In *Diffusion of innovations* (3rd ed., pp. 163–209). Free Press. <https://teddykw2.files.wordpress.com/2012/07/evertt-m-rogers-diffusion-of-innovations.pdf>

	<p>Roumi, S., Stewart, R. A., Zhang, F., &amp; Santamouris, M. (2021). Unravelling the relationship between energy and indoor environmental quality in Australian office buildings. <i>Solar Energy</i>, 227, 190–202. <a href="https://doi.org/10.1016/j.solener.2021.08.064">https://doi.org/10.1016/j.solener.2021.08.064</a></p> <p>Roumi, S., Zhang, F., Stewart, R. A., &amp; Santamouris, M. (2023). Weighting of indoor environment quality parameters for occupant satisfaction and energy efficiency. <i>Building and Environment</i>, 228, 109898. <a href="https://doi.org/10.1016/j.buildenv.2022.109898">https://doi.org/10.1016/j.buildenv.2022.109898</a></p> <p>Shahzad, S., Brennan, J., Theodossopoulos, D., Hughes, B., &amp; Calautit, J. K. (2017). Energy and comfort in contemporary open plan and traditional personal offices. <i>Applied Energy</i>, 185, 1542–1555. <a href="https://doi.org/10.1016/j.apenergy.2016.02.100">https://doi.org/10.1016/j.apenergy.2016.02.100</a></p> <p>Singh, A., Syal, M., Grady, S. C., &amp; Korkmaz, S. (2010). Effects of Green Buildings on Employee Health and Productivity. <i>American Journal of Public Health</i>, 100(9), 1665–1668. <a href="https://doi.org/10.2105/ajph.2009.180687">https://doi.org/10.2105/ajph.2009.180687</a></p> <p>Sipma, J. M., Kremer, A., &amp; Vroom, J. (2017). Energielabels en het daadwerkelijke energieverbruik van kantoren. ECN. <a href="https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-E--16-056">https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-E--16-056</a></p> <p>Stake, R. E. (2005). Qualitative case studies. In N. K. Denzin &amp; Y. S. Lincoln (Eds.), <i>The SAGE handbook of qualitative research</i> (3rd ed., pp. 443–466). SAGE.</p> <p>Stil, H. (2022, August 10). Doek valt voor duizenden kantoren: geen energielabel, geen kantoor. AD.nl. <a href="https://www.ad.nl/economie/doek-valt-voor-duizenden-kantoren-geen-energielabel-geen-kantoor-ac8318955/">https://www.ad.nl/economie/doek-valt-voor-duizenden-kantoren-geen-energielabel-geen-kantoor-ac8318955/</a></p> <p>Sunderland, L., &amp; Santini, M. (2020). Case studies: Minimum energy performance standards for European buildings. In Raponline. RAP. <a href="https://www.raponline.org/wp-content/uploads/2020/07/rap-ls-ms-meps-case-studies-2020-july-28.pdf">https://www.raponline.org/wp-content/uploads/2020/07/rap-ls-ms-meps-case-studies-2020-july-28.pdf</a></p> <p>Volt, J., Zuhair, S., Schmatzberger, S., &amp; Toth, Z. (2020). Energy performance certificates: Assessing their status and potential. In BPiE.</p> <p>VO-raad. (2021, June 30). Nieuw Programma van Eisen voor Frisse Scholen. <a href="https://www.vo-raad.nl/nieuws/nieuw-programma-van-eisen-voor-frisse-scholen">https://www.vo-raad.nl/nieuws/nieuw-programma-van-eisen-voor-frisse-scholen</a></p> <p>Wang, Y., &amp; Ruhe, G. (2007). The Cognitive Process of Decision Making. <i>International Journal of Cognitive Informatics and Natural Intelligence</i>, 1(2), 73–85. <a href="https://doi.org/10.4018/jcini.2007040105">https://doi.org/10.4018/jcini.2007040105</a></p> <p>Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J. W., da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., . . . Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. <i>Scientific Data</i>, 3(1). <a href="https://doi.org/10.1038/sdata.2016.18">https://doi.org/10.1038/sdata.2016.18</a></p> <p>Zakir, F. (2022, April 28). BREEAM Certification: Everything You Need to Know. Alpin Limited. <a href="https://www.alpinme.com/guide-to-breeam/">https://www.alpinme.com/guide-to-breeam/</a></p> <p>Zhang, F., Liu, S., Hu, W., &amp; Yadav, M. (2022). Editorial: Effects of indoor environmental quality on human performance and productivity. <i>Frontiers in Built Environment</i>, 8. <a href="https://doi.org/10.3389/fbuil.2022.1095443">https://doi.org/10.3389/fbuil.2022.1095443</a></p> <p>Zuhair, S., Schmatzberger, S., Volt, J., Toth, Z., Kranzl, L., Eugenio Noronha Maia, I., Verheyen, J., Borragán, G., Monteiro, C. S., Mateus, N., Fragoso, R., &amp; Kwiatkowski, J. (2022). Next-generation energy performance certificates: End-user needs and expectations. <i>Energy Policy</i>, 161, 112723. <a href="https://doi.org/10.1016/j.enpol.2021.112723">https://doi.org/10.1016/j.enpol.2021.112723</a></p>
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## Reflection

<p>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)?</p>	<p>My topic is related to the graduation theme (energy transition in the existing building stock) since it covers the renovation of existing offices towards better energy-efficiency (together with a focus on IEQ). Besides, the master track MBE has a focus on, among others, managing the processes that are related to new construction or renovation. The past years of following this track, I have learned a lot about the construction process and legal procedures which are concerned with this. When implementing a methodology or process manual like this, the managers should be familiar with the know-how of these products and should become confident enough to implement it in their daily work activities. The master program combines the field of architecture, urbanism, building sciences, and management. All of these fields are extremely valuable and necessary in the process of energy transition in the existing building stock. Also, in my research these different fields come together.</p>
<p>2. What is the relevance of your graduation work in the larger social, professional and scientific framework?</p>	<p>It is important to keep emphasising the opportunities that are concerned with energy transition in the existing building stock. These buildings will still stand decades from now and have a huge share in the current emissions. Since studies showed that energy-efficiency renovations can lead to a decrease of the IEQ, and therefore a decrease in occupant's satisfaction and productivity, there comes a need to guide renovations into a direction where IEQ is not some 'side-effect' but related to the main task of renovating. This methodology and process manual can show policy makers how it possibly should work and it can create awareness concerning the importance of IEQ post-renovation.</p>