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AN EXPLORATION OF NORWAY'S CONSTRUCTION SECTOR TRANSITION TOWARDS NEARLY ZERO ENERGY BUILDINGS

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Foreword

During the Fall semester of 2019, I attended a class on "New Technologies and Ideas for Sustainable Cities" which sparked my curiosity in smart building designs and Nearly Zero Energy Buildings (nZEBs). I learned that there is a high demand for technologies that can help mitigate climate change and it led me to believe that studying environmentally-oriented concepts, like nZEBs, is worthwhile. This topic is also relevant because the Norwegian Parliament has recently set ambitious climate goals, like lowering the energy use of existing buildings by 10TWh by 2030 (compared to current levels).

I give special thanks to my advisor, Oluf Langhelle, for providing guidance throughout the semester, which helped greatly.

Interview subjects also deserve special thanks, too. Geir Sandsmark from Jadarhus, Lars Myhre from Boligprodusentenes Forening, Torstein Fjogstad from Fjogstad-Hus, Gord Rostøl from ØsterHus and Kristi Sveindal from Start Micro Housing.

Summary

This master thesis explores Nearly Zero Energy Buildings (nZEBs), with a special focus on Rogaland, Norway, looking at if - and how - the transition to nZEBs is unfolding. This research was inspired by the publication of the Energy Performance of Buildings Directive (EPBD) which is a mandate requiring new buildings in the European Union (EU) to be nZEBs by 2021. It was initially published by the European Parliament in 2002, and then recast in 2010 and 2018. Although not a member of the EU, Norway is part of the European Economic Area (EEA) and generally follows the EU's climate policies. The Norwegian Parliament has announced that new buildings are to have nearly zero energy levels by 2020, and a modified Norwegian definition of nZEBs is being developed by the Directorate of Building Acts and Regulations (DiBK), but it has not yet been published. This thesis aims to shed light on how local construction companies in Norway and the Rogaland region are perceiving the concept of nZEBs, and to what degree adoption of new practices are starting to take place. In sum, research for this thesis discovered that since nZEBs regulations have not yet been published, construction companies are generally not explicitly preparing for a transition towards nearly zero energy buildings. However, efforts are being made to make the construction sector more sustainable.

The European Union's definition of nZEBs specifies that the low energy requirements should be met to a large degree from renewable energy generated on site or closeby. Solar energy fits these characteristics, but in the Norwegian context abundant hydropower and low electricity prices might influence the nZEB definition.

Through the analysis of discourse in this thesis, it became clear that the general attitude among construction industry leaders towards renewable energy is somewhat negative (with the exception of hydropower). Still, solar energy has large potential in Norway and is becoming less costly and more widespread. Norway exports electricity from hydropower to the European continent, and imports non-renewable power. Gross energy use in Norway is roughly 50% renewable, meaning that more renewable capacity is still needed in order to reach national and international climate goals. Phasing out use of fossil fuels in all sectors by 2050 is Norway's goal, which implies increased electrification, and that the future will demand more renewable energy.

Another area this thesis explores is the niche of tiny houses. Tiny house construction is a growing industry that centers on the building of small homes that are inherently energy efficient due to their size. Building smaller homes frees up capital and time, and simultaneously decreases the environmental impact compared to larger houses. This thesis investigates attitudes towards tiny homes in Norway as part of the transition towards low energy, and environmentally friendly buildings.

In sum, through the discourse analysis, several key themes emerged from the interviews with construction industry representatives in Rogaland. Those themes include the acknowledgment that the new nZEB regulations may be complicated and difficult to implement, that all companies interviewed were making small steps towards energy efficiency, there is some resistance to change, that actors recommended incentives and subsidies for nZEB implementation, and recognition that the solar energy debate and niche market of tiny houses will continue on. Overall, a successful transition towards renewable energy and energy efficient technologies like Nearly Zero Energy Buildings is imperative in order to attain sustainable development.

LIST OF ACRONYMS

- Artificial Intelligence (AI)
- BREEAM (Building Research Establishment Environmental Assessment Method)
- Carbon Capture Utilization & Storage (CCUS)
- Carbon dioxide (CO_2)
- Direktoratet for byggteknisk forskrift (DiBK)
- Energy Performance of Buildings Directive (EPBD)
- Greenhouse Gasses (GHGs)
- Light emitting diode (LED)
- Ministry of Local Government and Modernisation (KMD)
- Nearly Zero Energy Buildings (nZEBs)
- Norwegian Water Resources and Energy Directorate (NVE)
- Regulations on Technical Requirements for Construction Works (TEK17)
- United Arab Emirates (UAE)
- Solar Photovoltaics (PV)
- The European Economic Area (EEA)
- The European Union (EU)
- The Intergovernmental Panel on Climate Change (IPCC)
- ZEB-COM-level (Zero Emission Buildings - Construction, Operation and Materials)

1. Introduction

With ever-increasing carbon dioxide concentrations in the atmosphere, and corresponding average temperature rises, the Earth is starting to experience more negative climate-related issues. These issues include heavy storms, droughts, floods, food insecurity and other consequences that impact societies and economies around the world. There is scientific consensus that these climatic changes are indeed a result of human-made greenhouse gas (GHG) emissions (Oreskes, 2004).

When searching for the origins of greenhouse gas emissions in the modern world, there are numerous pollutant sources to consider including transportation, food production and the building stock. For instance, building stock represents roughly 30-40% of Europe's energy consumption (European Parliament, 2010). Decreasing energy use (and the corresponding emissions of GHGs) from buildings can therefore be an effective strategy to mitigate climate change. The Paris Agreement, signed by 195 members of the United Nations, states that the global community agrees to limit global warming by 1.5°C, and no more than 2°C by 2100. In order to achieve the goals set in the Paris Agreement the world needs to reach net zero levels by 2050 (UNFCCC, 2015). Certainly there are changes ahead that need to incorporate energy efficient, environmentally friendly technologies and solutions, like nZEBs. The EU's Roadmap 2050 indicates that the power production goal in Europe is to be close to emission free by 2050. This means that a host of renewable energies will have to be implemented by then (roadmap2050.eu, 2020). From the Roadmap 2050, it is clear that an array of changes - in policy, innovation and practice - will need to occur in the next thirty years in order to meet this aggressive metric.

The rise of fossil fuels has formed the modern world in multiple ways, including changes in architecture and building designs. Historically, buildings were created to adapt to local climate and characteristics of a specific area; this stands in contrast to most buildings constructed in the fossil fuel era which are more of a "one-size-fits-all" approach. Modern building practices have become more uniform throughout the world, and in some cases whole cities have been built in locations that require substantial amounts of energy to operate. Not surprisingly, most of the energy used is in the form of fossil fuels. Perhaps one of the most extreme examples of this trend is the city of Dubai in the United Arab Emirates (UAE). which is amongst the countries in the world with the largest oil reserves. One notable activity in the UAE is indoor skiing (Ski Dubai, n.d.) which naturally is energy intensive, and alludes to why the carbon footprint per capita in the UAE was 22.94 tonnes in 2014, compared to 7.31 tonnes in Europe ("Energy consumption in the United Arab Emirates", 2015).

In Norway, the annual use of electricity from buildings is approximately 80TWh. In response to the growing use of energy, the Parliament has set a goal of decreasing the energy use in existing buildings by 10TWh by 2030 compared to current levels (Statsbudsjettet, 2020). This is an ambitious goal, yet arguably achievable, if stricter regulations and better subsidies are implemented (Borge, 2020).

Furthermore, the Norwegian Parliament created a national Climate Agreement (Klimaforliket) in 2012. This Climate Agreement focuses on ways to aid the shift to "green" sustainable practices, and it states that "nearly zero energy levels" will be implemented in Norwegian building code by 2020 (Energi- og miljøkomiteen, 2012), but what exactly this constitutes has not yet been declared.

In order to align with Norway's Climate Agreement, the Directorate of Building Acts and Regulations (DiBK), which lies under the Ministry of Local Government and Modernisation (KMD), is working on the new specifications for the Norwegian building code. However, at the time of writing, the code had not yet been published. KMD was contacted in the research process for this thesis, and the agency confirmed that they were working on updating the building code to implement nearly zero energy levels, but that the guidelines had not been finalized. KMD officials provided the following statement which can also be viewed in Norwegian in Attachment section 9.1 as "Response Letter from Ministry of Local Government and Modernisation": "*The Ministry of Local Government and Modernisation resolves, by law, to transition towards zero energy buildings. Norway has not yet implemented requirements of nearly zero energy buildings. Last year the Directorate for Buildings Act and Regulations (DiBK) received the order of the following task in the letter of allocation: "The government wants to develop and mandate energy requirements in alignment with the Climate Agreement. DiBK shall develop a proposal to a definition of nearly zero energy levels which are to be reviewed. In this work the Directorate must consider if other aspects than solely energy requirements in operation will be included in the further development of energy requirements. This means considering the possibility and sensibility of looking at energy use in operation as well as other environment requirements* *for buildings." The Department is currently working on this. We cannot provide information on internal, ongoing processes or deliveries of the directorate."*

Arguably, KMD is lagging behind in the development of nZEB requirements in Norway. Politically, it might also be poor timing to impose stricter regulations on the construction sector, since it is likely to come with increased costs. The construction sector in Norway has slowed down significantly in 2020 due to the pandemic, putting a break on construction activity, illustrated by commissioning of new projects being down 32% in April 2020, compared to the same time in 2019 (Boligprodusentenes Forening, 2020).

Despite the pause on regulatory processes in 2020, it is clear that the Norwegian government views the large consumption of energy in buildings as a problem that needs to be addressed. This goal certainly also has implications for new buildings, meaning they will have to be constructed and adapted to be energy efficient. This is where nZEBs enter the picture: as a concept that can contribute to lower energy use and help Norway reach its ambitious climate goals.

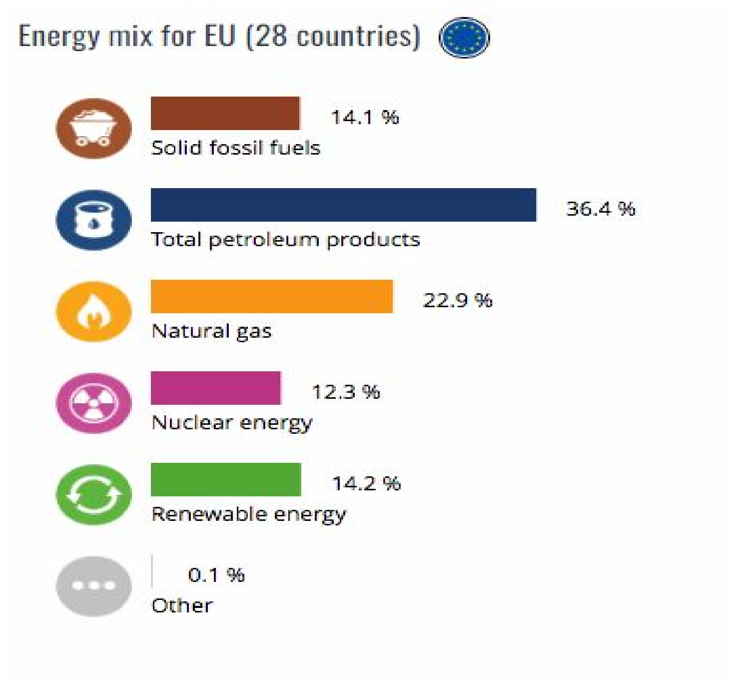
This thesis aims to identify if the local construction industry is prepared to take on the tough goals set by the Norwegian Parliament. In order to tie this research to policy goals, I chose to study the Rogaland building construction industry because it is most relevant to where I live and attend graduate school at the University of Stavanger. As context, Rogaland has a large construction sector, with roughly 5,000 firms, employing around 20,000 workers in 2019 (SSB, 2020). Also in 2019, 2,360 residential building projects were commissioned, and the annual turnover was approximately 51 million NOK (SSB, 2020).

I interviewed individual employees from local companies in order to better understand the contemporary discourse within the local construction sector regarding the shift to more sustainable practices, including the transition towards nZEBs, the use of solar power and the tiny house movement. Though these interviews may not capture all the perspectives of the building construction industry across Norway, they can provide a glimpse into the general impressions about nZEBs regarding awareness and the feasibility of implementation efforts. The overarching questions I explore in this thesis are therefore, *"Is the construction sector in Rogaland, Norway, preparing for the nearly zero energy buildings concept? If so, how? If not, why not?"*

1.2 Pollution from Buildings

Buildings use energy predominantly for four key purposes: 1) To keep a comfortable inside temperature, 2) to heat water, 3) for cooking purposes, and 4) for electric appliances, including lighting and running elevators in tall buildings. The total energy use of a building is affected by many variables including those that are socio-economic and technological in nature. These variables include location, income level, consumer habits, size of population, mean size of homes, and the energy efficiency of appliances and devices. Naturally, climatic circumstances also affect the energy use and energy demand from a building (Bhattacharyya, 2011).

As mentioned earlier, In the EU, buildings account for roughly 30-40% of total energy use and the building sector is expanding. This expansion suggests that there will be more of a demand for energy in the future. At the present time, the European energy mix consists mostly of non-renewable energy. As illustrated in the graph below, of the 28 member states, 73.4% of energy consumption was non-renewable in 2018 (Eurostat, 2020). This means that the building stock accounts for a significant portion of European GHG emissions.



Source: Eurostat (2020) "Where does our energy come from?" Retrieved July 16, 2020

Considering the fact that 50% of the EU's final energy use goes to heating and cooling, 80% of which is consumed in buildings (European Parliament, 2010), successfully achieving the climate goals and lowering the energy consumption in buildings, both new and old, can contribute to the EU reaching its climate goals. In 2009, the Norwegian government stated that it was possible for the energy use in buildings nationwide to be lowered 20 percent in ten years (Olje- og Energidepartementet, 2009). Looking back at the last decade it is clear that this did not happen. Yet, energy use seems to have flattened, despite population growth. In Norway, furnaces that run on fossil fuels in buildings were banned in 2020, exemplifying that efforts to transition buildings to become low energy and more climate friendly are being implemented (Regjeringen, 2020). Decreasing energy use from buildings, while simultaneously increasing the building stock is a challenge, and improvements in energy efficiency is a crucial aspect needed to achieve this. Enhanced energy efficiency is also more environmentally friendly and cost-effective than expanding the energy supply system to meet demand from a growing building stock (Enkvist et al., 2010).

Another challenge is the fact that the current building codes only apply to new buildings, and extensive renovation projects. This leaves out a large portion of the buildings that are being upgraded on a smaller scale. This means that there still is significant potential for improvements in regards to energy efficiency in the existing Norwegian building stock.

Another area of relevance is the increased use of Artificial Intelligence (AI) as a strategy to lower energy use in the construction sector. Machines used in construction typically idles 40-60% of the time, thus using unnecessary energy and accounting for roughly 20% of emissions from construction sites. Research projects have started using AI to lower emissions, and better, faster and more cost effective outcomes are the goal. If all machines at a construction site "knew" which other machines were in use, and which ones were not, more effective outcomes could likely occur saving both energy and money. Skanska, a major actor in the Norwegian construction sector, has stated that beginning in 2020, they aim to cut GHG emissions by utilizing AI. (S*kanska vil kutte utslipp med kunstig intelligens*, 2019).

A case study of the dwelling stock in Norway estimated an optimistic scenario of energy usage across the country: it projected that the total energy delivered to buildings will decrease by 52% by 2050 (compared to 2016 levels) (Sandberg et al., 2017). Decreased energy consumption from buildings on this scale arguably implies a clear directional transition towards nearly zero energy buildings.

1.3 Overview of Nearly Zero Energy Buildings (nZEBs)

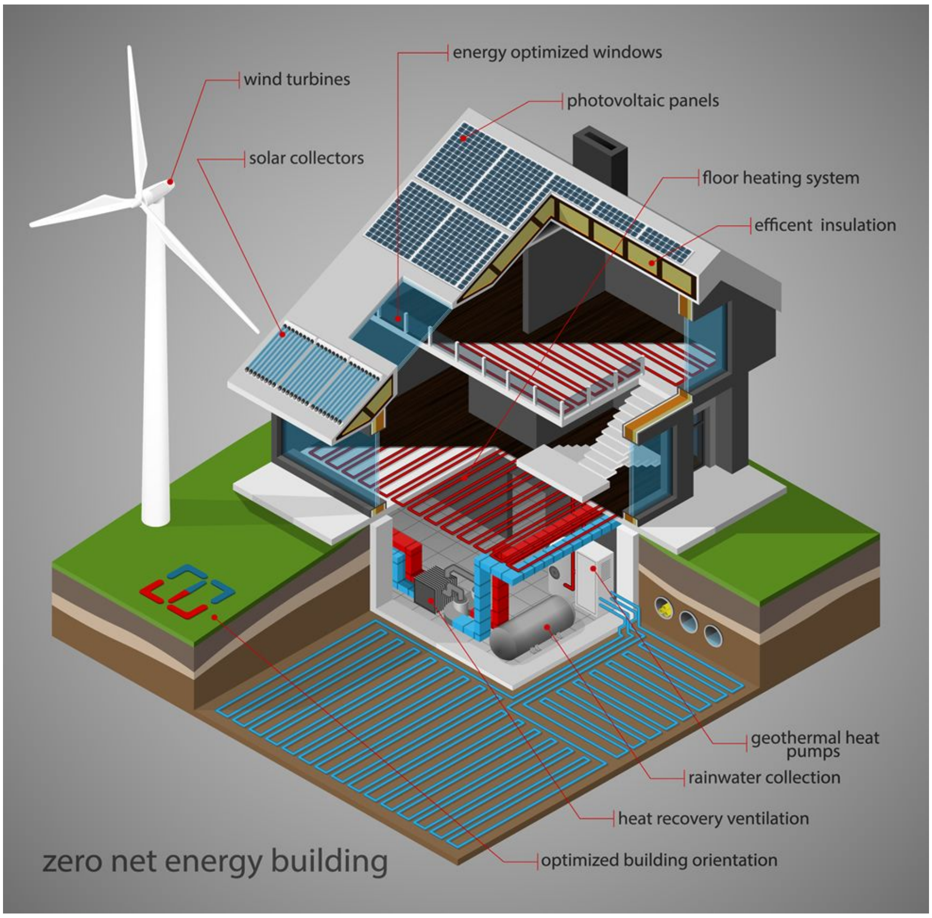
Overview of nZEBs

What exactly is a nearly zero energy building? There are various ways to answer this question and various ways of defining what nZEBs constitute. According to the EPBD, nZEBs are buildings with high energy performance, which is accomplished by designing the building to have a low demand of energy, and to meet the energy demand from renewable energy, generated on-site or nearby (The European Parliament, 2010).

Development of low energy buildings have led to increased use of solar energy, in the form of solar panels and passive solar heating. Proper insulation thickness, geothermal heat, and energy from renewable energy sources, like hydro and wind power can also be used in nZEBs. Some other technologies and measures that can contribute to energy reductions in new and old buildings include:

1) *Retrofitting existing buildings* to become energy efficient; an important aspect of reducing the carbon footprint of the building stock. Retrofitting buildings can include various elements, including but not limited to: water saving features, optimization of heating, ventilation and air conditioning (HVAC) systems, shade technology, renewable energy usage, and indoor environment enhancement for occupants (Shen et al., 2015). Policy that supports retrofitting through the implementation of subsidies has been shown to be effective (Røstvik, 2012).
2) Light emitting diodes (LED) are nearly 90% more energy efficient compared to conventional light bulbs. Adopting LEDs is a simple example of energy saving technologies that can lower energy use (Environment, 2016).
3) Dry processing of cement, which uses less energy than conventional wet processing. (Bhattacharyya, 2011).
4) Rainwater reuse measures such as rain gardens, detention ponds, and the reduction of impervious surfaces in order to absorb, retain and filter water (Thiagarajan et al., 2018).
5) Green roofs which are a cooling technique to prevent solar radiation from reaching the building beneath the roof through the use of soil and layer(s) of plant vegetation (Castleton et al., 2010).

The illustration here shows an nZEB and various technologies that can be employed.



Source: Energy Intime, 2020. Retrieved 06.04.2020

Nearly Zero Energy Building Policy

The European Parliament postulated in the recast of “The Energy Performance of Buildings Directive” (EPBD) from 2010 that by December 31, 2020, all new buildings in the European Union will have to be nearly zero energy in order to meet climate goals (The European Parliament, 2010). The EPBD, (2010) stated that a review was to be carried out by January 1, 2017, to determine how the implementation process had progressed in the Member States, investigating which initiatives had worked and which had room for improvement. In 2018, a third recast of the EPBD was published and it reiterated the requirement for new buildings to be nZEBs (Official Journal of the European Union, 2018).

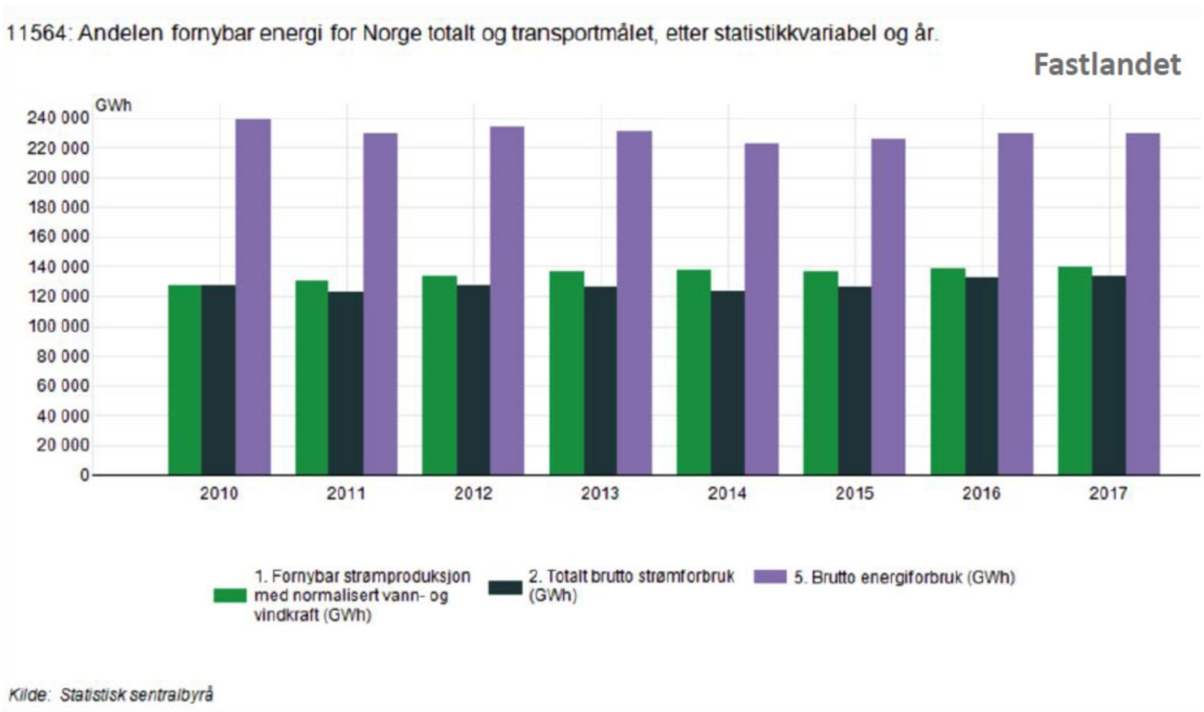
The EEA Agreement, of which Norway is a participant, incorporates Norway into the EU's quota trade system on emissions (ETS). This means that Norway follows the same goals as the EU regarding climate change mitigation, renewable energy, enhancing energy efficiency and energy saving measures (Regjeringen, 2018). The recast of the EPBD has not yet been implemented in the EEA Agreement nor in Norwegian law, but it is thought that it will be implemented without significant change (THEMA Consulting Group, 2017).

In Norway, there are roughly 2.6 million buildings (SSB, 2020), meaning that vast amounts of domestic energy use stems from buildings. Implementing nZEB building code should therefore positively affect the Norwegian climate footprint, however it is not necessarily given that the climate footprint will be significantly improved. Since the Norwegian definition of nZEBs is not published yet, it remains uncertain as to which changes the construction sector must adapt. For instance, Norway has vast hydropower resources, which begs the question; to what degree is it sensible to require buildings to utilize energy produced solely onsite (or locally) if hydropower resources are readily accessible across the country? The EPBD (2018) specifies that the energy use in nZEBs should be produced onsite or locally, but in Norway such requirements might not make sense. One might also question if it really is important to lower energy use in buildings in Norway, considering that Norway produces almost enough renewable hydropower to meet domestic demand. Yet, by looking at total energy consumption in Norway, with roughly 50% being renewable (NVE, 2015), it becomes clear that lowering energy consumption in buildings does make sense to continue to strive to meet climate goals.

The fact that Norway is connected to the European power market, importing and exporting power to and from Europe, can help answer these questions. Since Norway imports European non-renewable power, it means that the Norwegian power mix is more dependent on non-renewable energy than one might think (nordpoolgroup, 2020). Keeping this in mind, growth of domestic solar power capacity seems more sensible. For instance, more solar power in Norway would likely mean that the amount of renewable hydropower that could be exported to Europe would go up too. This would be beneficial, seeing that, if we are to reach our climate goals, we need to think and act globally. Another important aspect to consider is the fact that the Parliament aims to reduce emissions of climate gasses by 90-95% by 2050, but the current energy mix in Norway is hovering at ~50% fossil fuels (Klima- og Miljødepartementet, 2020). The goal is to actively phase out fossil fuels in all sectors, meaning that society is going to demand more electricity. For example, the electrification of the transportation sector is unfolding rapidly; in 2019, 9.31% of the personal vehicle fleet was electric vehicles (Norsk elbilforening, 2020). Electrification of onshore industries and offshore petroleum production (which has started to take place in the North Sea)

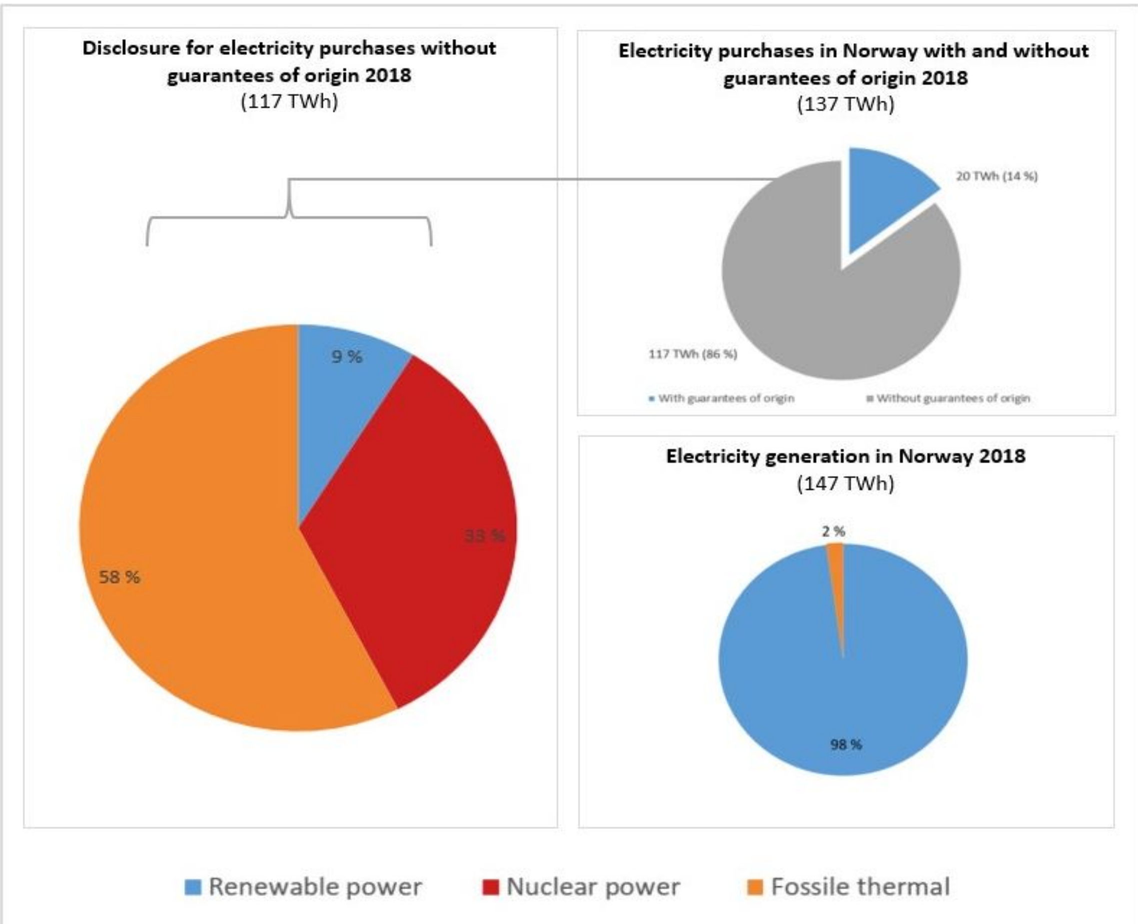
(Elektrifisering i Equinor, 2020) means that more renewable electricity is going to be needed in order to reach the climate goals set by the Parliament. NVE has estimated that electricity consumption in Norway could increase from 136 TWh in 2018 to 159 TWh in 2040 (NVE, 2019). Upgrading hydroelectric power plants, onshore and offshore wind power and solar power will all likely be a part of a successful low carbon transition.

The graph below shows the share of renewable energy in mainland Norway (green column) from 2010 to 2017 along with gross electricity consumption (dark green) and gross energy use (purple). We can see that roughly 50% is renewable, and that gross energy use hovers about 50% above the domestic energy use from renewables.



Source: Statistisk Sentralbyrå. "11564: Andelen Fornybar Energi for Norge totalt og Transportmålet, etter Statistikkvariabel og år." SSB.no, 2018.

This graph suggests that more decentralised production of electricity in Norway indeed will be needed in the years to come. However, the need to transition towards use of more renewable energy from other sources than hydropower, is being downplayed by some actors in Norway. Electricity generation in Norway was 98% renewable in 2018 (Norwegian Energy Regulatory Authority, 2019), and this fact is regularly employed as an argument to proceed with business as usual. What is being omitted from the argument is that not all 98% is used locally - much of it is exported to neighboring countries. Why bother transitioning towards nearly zero energy buildings, solar power and other more climate friendly technologies when basically all electricity generated in Norway stems from renewable hydropower? This is a compelling argument, and is widely used in the discourse surrounding topics like these. The rationale used is that lowering energy use contributes little to climate change mitigation, when said energy stems from hydropower. Another argument employed is that the price of electricity in Norway is low, so more solar power (for instance) has minimal economic benefit. However, even if Norway produces almost entirely renewable power, it does not mean that only renewable power is utilized domestically. As the diagram from the Norwegian Energy Regulatory Authority shows below, of the electricity purchased without guarantees of origin, which was 86% in 2018, only 9% was renewable, 33% came from nuclear power and 58% stemmed from fossil thermal energy (Norwegian Energy Regulatory Authority, 2019).



Source: Norwegian Energy Regulatory Authority. (2019, June 21). Electricity disclosure 2018.

When looking ahead, it is important that the Norwegian nZEB definition takes into account the fact that the Norwegian power mix is not purely renewable. Discourse that boasts about the domestic electricity production being virtually 100% renewable in Norway, and therefore no more renewable energy is needed, is merely a logical fallacy. There certainly is a need for more renewable energy, from sources like solar and wind power, due to the interconnectedness of Norway and the European power market. The electrification transition that is starting to take place means that Norway will be needing more renewable energy into the future. Increased renewable energy production in Norway leaves more clean, renewable energy available for domestic use and for exporting, which promotes sustainability, helping to reach national and international climate goals.

Climatic conditions vary a lot throughout Norway, which makes different types of energy more or less economic in the various regions. Local renewable energy in Norway, like hydropower, should suffice as "renewable energy, produced nearby" like the EU's Energy Performance of Buildings Directive dictates (*Norsk definisjon av nesten nullenergibygg, 2017*). Modifying the nZEB concept, to fit into the local conditions will be key, to achieve nearly zero energy levels in a cost effective manner (DiBK, 2013). However, considering the falling cost of solar power, it does not seem far fetched to assume that it will increasingly become more adopted as a renewable energy source for buildings into the future.

1.4 Tiny Houses

Naturally, larger buildings tend to use more energy than smaller buildings, which is why decreasing the average size of homes can contribute to lower the energy use from buildings. The tiny house movement is a niche trend that is spreading throughout the western world, emphasizing minimalism, affordability and sustainability. In 2018, 7% of Norwegian households were smaller than 40 square meters in size, as opposed to 24% of households being 160 square meters or larger (SSB, 2018). With more people living in cities, the average size of homes naturally tends to become smaller. This is exemplified by the Norwegian capital, Oslo, where the average size of new homes decreased by approximately 30% between 2001 to 2008 (Mikalsen, 2008).

Living in a smaller house frees up capital and time, and simultaneously decreases the environmental impact compared to larger houses. Living smaller and more densely is a logical strategy to enhance the sustainability of housing, which a growing number of people are coming to realize. Perhaps the most alluring aspect of small homes is the decreased costs, not necessarily per square meter but in maintenance, construction costs and mortgages. With less available space the amount of items accumulated and consumption goes down. This leaves more time to prioritize other non-materialistic and important aspects of life. These are some of the reasons as to why I chose to look into the tiny house concept as a niche in the move towards more sustainable building and housing practices.

Source: Norske Mikrohus, 2020. Retrieved 08.03.2020

Tiny houses tend to be between $15m^2$ and $30m^2$ which significantly reduces the total energy consumption compared to conventional larger houses. Interestingly, tiny houses are oftentimes built on a trailer bed, because it makes it less complicated to adhere to local zoning codes and other restrictions. Typically, tiny homes have a main room with an open floor plan that combines the living space with the kitchen in order to effectively use the area. The interior design of a tiny house regularly uses modifiable couches, foldaway tables, and smart shelving for effective storage solutions. Sleeping lofts, often accompanied by ladders, are another relatively normal feature in tiny houses, since they convert unused vertical space into livable space. The bathroom tends to be small, but many tiny houses do have full-sized showers and toilets. In general, both multi-purpose design and high quality craftsmanship appears to be the norm in tiny houses (Kilman, 2016). Since the tiny house movement is in its early stages, the definition of exactly what a tiny house is varies from different sources. Some claim that a tiny house is between $10\text{-}40m^2$, while international building codes require homes to have at least $20m^2$ of interior space for it to be legal (Kilman, 2016). The ambiguity surrounding the definition of a tiny house becomes more clouded since the size criteria varies, and much is dependent on local building codes, climate, and so forth but the tiny house concept aims to embody energy efficiency and sustainability. The International Code Council specifies that any dwelling unit needs to have at a minimum one room with no less than $11m^2$ of net floor area, and that other rooms require a net floor area of at least $6.5m^2$. Additionally, tiny homes are oftentimes off the grid, which means they tend to utilize renewable energy produced onsite, like solar power.

The EPBD puts emphasis on how improving energy efficiency is the most effective way to reach the Union's climate goals (Official Journal of the European Union, 2018). Since they are inherently energy efficient, tiny houses should be welcomed by policymakers who are serious about climate change mitigation. The thesis also tries to identify the prospects for tiny homes in Norway based on the perspectives from individuals who work in the building construction industry.

Due to the small size, the price of a tiny home is more affordable than a larger apartment or conventional house on the market. A tiny home can thus be an attractive option for first time home buyers. Norway is home to several tiny house manufacturers, including Norske Mikrohus, whose model house is pictured above. StartMicroHousing is another

Norwegian tiny home provider, located in Haugesund, which states, loosely paraphrased, on their website that by “living in a smaller house you will be able to live a larger life”. On their website you can also read that historically low energy prices in Norway and good access to land led to development of large homes with high energy demands, which is an unsustainable path to continue down (startmicrohousing.no, 2020). In cities the limited area makes tiny houses a possible solution to housing shortages while at the same time decreasing the climate footprint compared to conventional buildings.

Source: norskemikrohus.no (2020)

1.5 Takeaway Points

The construction sector is entering an era of transition, meaning more opportunities and new challenges**.** Climate change is threatening the modern way of life, and there is a need for an energy shift toward renewable energy sources. Changing practices to promote sustainability is starting to spread throughout the world, and the Energy Performance of Buildings Directive from the European Union and the Climate Agreement in Norway exemplifies these efforts made to mitigate climate change.

Even though the majority of electricity that is produced in Norway comes from renewable hydroelectric power, it does not mean that all electricity that is consumed domestically is also renewable. The import and export of electricity within the Europe market means that a significant portion of electricity use in Norway stems from non-renewable sources, meaning that Norway must increase its renewable energy capacity if we are to reach our climate goals.

The Norwegian government has stated that buildings are to adhere to nearly zero energy levels in 2020, but the regulations regarding nZEBs are not yet published. I learned in my research that this is the reason why it is difficult to identify how the nZEB transition is unfolding. The Directorate of Building Acts and Regulations (DiBK) are working on a Norwegian nZEB definition, and were contacted in the research process for the thesis, but since the definition is still being developed, a formal interview could not be conducted. Please see Attachment section 9.2 to view the DiBK Interview Response letter in Norwegian.

1.6 Research Questions

In sum, this thesis will 1) investigate how the construction industry is preparing for this transition, 2) determine if there are already measures being taken, and 3) explore possible explanations as to why the transition is unfolding quickly or slowly. After much thought and planning, this thesis will attempt to answer the following overarching question:

Is the construction sector in Rogaland, Norway, preparing for the Nearly Zero Energy Buildings concept? If so, how? If not, why not?

Additional questions, listed below, will supplement the main research question and will attempt a clearer glimpse into the reality of the nZEB transition locally. The interviews with construction industry experts will illuminate how nZEBs are perceived by the industry and how the transition may be incorporated into laws, regulations and policies.

Supplemental questions are:

1. *What are the views of Nearly Zero Energy Buildings in the industry?*
2. *Will new buildings in Rogaland all be nZEBs starting 2021?*
3. *Is there a place for tiny homes as part of the shift towards nearly zero energy buildings?*
4. *To which extent will solar energy in Norway be implemented in the foreseeable future?*

2. Background

Since the Industrial Revolution during the 18th century, far reaching repercussions on humanity and on the environment have manifested. Since then, a radically transformed interconnected global economy has developed, with intricate social systems, extensive bureaucratic structures of nation states, global economic trade systems, innovative technologies, and enhanced methods of communication (Burke et al., 2009).

Energy utilization was greatly enhanced with the invention of the steam engine, which mainly used coal as its fuel source. The steam engine, and other innovations that used fossil fuels, helped economies grow in an unprecedented manner. The world's preferred energy source quickly became fossil fuels, due to its unique characteristics (i.e., high energy density, reliability, storage abilities and large reservoir discoveries). However, the increased rate of burning fossil fuels would come to have negative effects on the environment, which are now threatening the modern way of life.

The greenhouse effect is crucial for our existence, and for life on earth as we know it. However, releasing excess greenhouse gasses (GHGs) into the atmosphere enhances the greenhouse effect. This creates global warming, which throws off the fine balance of the climatic systems on Earth. Additionally, there are mechanisms that exacerbate global warming, like heightened albedo effect, released GHGs from melting tundra, less sunlight reflecting from progressively smaller ice caps, and larger oceans absorbing more heat. Various mechanisms like these will undoubtedly enhance global warming; this has been referred to as a "hot-house" scenario, where rampant global warming causes detrimental consequences for life on earth (Steffen et at. 2018).

In the two decades between 1980 and the new millenium, global energy use grew by 49%, along with a 43% rise of carbon dioxide (CO_2) emissions over the same period (Pérez-Lombard, et al., 2008). The majority of the energy used to meet growing demand has come from fossil fuels, and the atmospheric concentration of CO_2, has risen from 280 parts per million (ppm) during pre-industrial times to 414 ppm in 2020, which is the highest recorded levels in the preceding 650,000 years (energiogklima, 2020).

With this as a background it becomes clear that the world needs to transition towards more environmentally friendly practices, including enhanced energy efficiency, and renewable energy. Since buildings account for a significant part of emissions, implementation of low energy buildings, like nZEBs, can play a central part of the transition, often referred to as the green shift.

2.1 Defining Nearly Zero Energy Buildings

nZEB Definitions in Policy

There are a host of different low energy building concepts that have been developed, some of which will be discussed in the following section.

The construction sector contributes to global GHG emissions in multiple ways, including through manufacturing industries and from transportation. The emissions of climate gasses and other pollutants stemming from buildings becomes significantly larger if the production of materials, demolitions and transport related to the construction phase is included in the calculation. The EU definition of nZEBs estimates energy use of the building post construction. This overlooks the energy consumption during the construction phase, not accounting for aspects like deliveries made to the built site. The notion of 'net zero energy' on the other hand does account for the energy use during the production phase, and is often used in renewable energy assessments (Hernandez et al., 2010). Some low energy buildings aim to compensate for the greenhouse gas emissions during the construction phase by producing local, renewable energy once the building is finished (Selvig et al., 2017).

The EPBD (2010) has left room for each member state to define what an nZEB constitutes in the given state. What defines an nZEB will thus vary from country to country. Some countries have been quick at making definitions, while others have been lagging behind. Looking across Europe, the Brussels capital region stands out, when it comes to rapidly defining nZEBs. Their nZEB requirements were defined in 2011 and implemented from 2015. There, the construction sector has little by little adapted to nZEB requirements and currently it is obligatory for every new building to have nearly zero energy levels (BPIE, 2015). Some other member states of the EU have announced guidelines that exceed nZEB levels. For example; zero energy buildings in Holland, climate neutral buildings in Germany, positive energy buildings in France and Denmark, and in the UK they have zero carbon buildings. Other EU countries use carbon emissions, instead of primary energy use as the indicator of most importance (BPIE, 2015).

The EU has created 50 standards of use to adhere to in the EPBD that are extensive and complicated, to such a degree that DiBK has decided to not use them. TEK17, which refers to the Norwegian Regulations on Technical Requirements for Construction Works (i.e. building code), require new buildings to have low energy consumption and an environmentally friendly energy supply (DiBK, 2017). Energy needs of buildings are referred to in terms of primary energy in the EPBD, whereas the building code in Norway currently sets its energy guidelines in terms of net energy use. Additionally, TEK17 does not consider the sources of energy, like the EPBD does. The construction sector is once again going to have to adapt to stricter standards, once the updated building code is published.

nZEB Definitions in Literature and Practice

Torcellini et al. (2006) provide discussion on the varying definitions of zero energy buildings, and talk about four commonly used definitions found in the literature. Torcellini et al. (2006) suggests that the appropriate nZEB definition needs to predominantly be concerned with energy efficiency, rather than renewable energy, because energy efficiency is the most effective way to lower energy use and mitigate GHG emissions. The four nZEB definitions highlighted are; 1) net-zero source energy, 2) net-zero site energy, 3) net-zero energy emissions and 4) net-zero energy costs.

Net Zero Source Energy: The building generates at minimum the same amount of energy that it uses annually. Source energy alludes to the primary energy consumed in order to produce and provide energy at the given location.

Net Zero Site Energy: The building generates at least the same amount of energy as it uses in a year. This definition does not specify what type of energy to use. The building can thus use propane, natural gas, or other fuels besides electricity.

Net Zero Energy Emissions: The building generates as much (or more) non-emission renewable energy as it's annual use of emission-generating energy.

Net Zero Energy Costs: Utility providers buy excess renewable energy from the given building, which annually adds up to at least equaling the amount of the annual utility costs of the building (Torcellini et al., 2006).

Other low energy buildings that are worth mentioning include the Passive House, the ZEB-COM-level (Zero Emission Buildings - Construction, Operation and Materials), and BREEAM (Building Research Establishment Environmental Assessment Method).

Passive House

The Passive House is a type of building that utilizes passive measures in order to minimize its energy needs. Some of these measures are optimized insulation for outer walls, floors, roofs and windows, preventing air leakages, and utilizing passive solar heat. A Passive House that is larger than 250 square meters in Norway generally uses no more than 15kWh/m² for heating per annum (Lavenergiprogrammet, 2018).

In Norway, the Climate Agreement (Klimaforliket) from 2012 states that "nearly zero energy levels" will be implemented in building code by 2020 (Energi- og miljøkomiteen, 2012). Additionally, the Climate Agreement stated that passive house levels would be implemented by 2015. However, it is interesting to note that passive house levels are not the same as passive house standards. Standard Norge has defined what constitutes a passive house in Norway (Norsk Standard NS 3700:2013), which differs from other passive house definitions (Standard Norge, 2020). It can therefore be assumed that the "nearly zero energy levels" as referred to in the Climate Agreement, will be different from the other definitions of nearly zero energy buildings.

ZEB-COM Buildings (Zero Emission Buildings - Construction, Operation and Materials)

ZEB-COM-level buildings are where the total amount of emissions from construction, operation and materials all equal zero. This is achieved by compensating for the emissions by producing renewable energy on it once the building is completed (Statsbygg.no, 2017). In December 2016, the Norwegian College (Høgskolen I Innlandet studiested Evenstad) started using the first ever ZEB-COM building in Norway (Statsbygg, 2017). Part of the ZEB-COM building is pictured here.

Source: Statsbygg, 2017. retrieved 9/5/2020

BREEAM-NOR 2016 New Construction

Another energy efficiency concept used in constructing buildings that was identified during the research for this thesis is the *BREEAM Scheme*. It was originally developed by BRE Global Limited and was adjusted by *Grønn Byggallianse* to make it applicable in Norway (BRE Group, 2020).

BREEAM (Building Research Establishment Environmental Assessment Method) is internationally acknowledged as a measure of a building's sustainability. Since 1990, over 530,000 buildings have been certified as BREEAM across the world. These buildings have been planned, designed, and constructed to promote environmentally friendly solutions (Nesteby et al., 2016). BREEAM disputes the common belief that high quality sustainable buildings are notably more expensive to build than those adhering to conventional requirements. Research has found that sustainable solutions regularly create very little extra cost, if any at all, to a project. The extra costs that occasionally occur can often be paid back through achieving decreased costs of operation (Nesteby et al., 2016).

All these low energy house concepts have commonalities, ultimately making them more energy efficient. They are all designed to have proper amounts of insulation in floors, ceilings and walls, and air-sealment is emphasized which assures minimal amounts of air leakage from the building. Additionally, double or triple pane windows with a special coating is utilized, helping to capture and/or reject solar heat. All in all, these measures contribute to the improved energy performance of the building and make it possible to cover the energy demand exclusively from renewables.

Recommendations from the Green Sector

THEMA Consulting group is a Norwegian consultant firm that focuses on the “green shift” in the energy and transportation sector. The purpose statement of the firm calls attention to the importance of green growth in regards to economic and sustainable development into the future (THEMA, 2020). THEMA made a report for Energi Norge, *Norsk definisjon av nesten nullenergibygg (2017)*, where it is also stated that since Norway is not part of the EU and the EPBD (2010) is not incorporated into the EEA agreement, Norway should not be required to adopt the same nZEB definition as the member states of the EU.

THEMA recommends that Norway should focus on low energy buildings, but with some adjustments from the EPBD that are better adapted to Norwegian conditions (*Norsk definisjon av nesten nullenergibygg, 2017)*. The report states that building structure should be the top priority topic to take into account when the government writes the Norwegian nZEB definition. This is because a structure that is designed to be low energy and energy efficient will enhance the energy performance of the building, helping to reach nearly zero energy levels.

2.2 Energy Transition

The Paris Agreement (2015) states that mitigating the global temperature rise by well below 2°C, and aiming at 1.5°C by 2100, relative to pre-industrial levels, will be needed to prevent detrimental ramifications on Earth's natural systems. The Intergovernmental Panel on Climate Change (IPCC) postulates that man-made CO_2 emissions needs to be lowered by roughly 45% from 2010 levels by 2030 in order to reach international climate goals (IPCC, 2018). Additionally, the International Energy Agency predicts that worldwide energy demand will rise by approximately 25% by 2040 from 2018 levels (IEA, 2018). These international goals imply a rapid transition in the energy sector and makes it clear that the global community is facing unprecedented challenges.

To reach the 1.5°C target will require the world to reach net zero emission levels by 2050, and if the 1. 5°C degree target is not met, the risk of unforeseen consequences increases exponentially (UNFCCC, 2015). The impacts are much worse if global warming reaches 2°C degrees compared to 1.5°C degrees. Global warming of 2°C likely would lead to irreversible tipping points, yet the present trajectory of greenhouse gas emissions suggests global temperature rise of 3–4.5°C (IPCC, 2012).

Promisingly, the IPCC has announced that energy transitions are starting to take place throughout the world, with increased electrification and more implementation of renewable energy (IPCC, 2018). Considering that the world is facing these challenges in regards to rising energy demand and global warming, it becomes natural to look towards innovative technologies, like nZEBs, that can help lower our energy use. The socio-technical landscape is changing in the form of climate policies, which has spurred innovative niche technologies to emerge, like tiny houses. The incumbent actors who constitute the regime level in society will have to contribute towards this change and adapt new, sustainable practices. This can be difficult and resistance to change is normal.

For instance, fossil fuel producers with vested interests in the petroleum industry often consider climate policies and energy transitions as risks. If renewable energy comes to meet more of global energy demand, fossil fuel providers risk experiencing lower demand.

Usually this is regarded as long-term risk, because energy transitions are slow and the effects will not be felt for years to come. However, this perception is inexact. That is, even though finalization of an energy transition can last for decades, the heightened unpredictability surrounding the transition affects the energy market and geopolitical landscape much quicker than the energy transition itself (Fattouh et al., 2019). In some cases, this can lead to horizontal diversification for forward-looking oil producers - including investments in renewables.

For instance, the Norwegian energy company, Equinor, states on its website that its strategy is to increasingly incorporate renewable energy, Carbon Capture Utilization & Storage (CCUS) and hydrogen (Equinor, 2020). Such jargon of diversification and societal responsibility can be interpreted as their way of reassuring their shareholders that it is a company to invest in, into the future. Even with its diversification strategy, Equinor's production of oil and natural gas has continued to steadily increase since 2014 (Jortveit, 2020). This can be seen in the following graph.

Equinor's oil production has increased since 2019

Equinor's production of oil and gas, in thousand barrel oil equivalents per day, 2014-2019

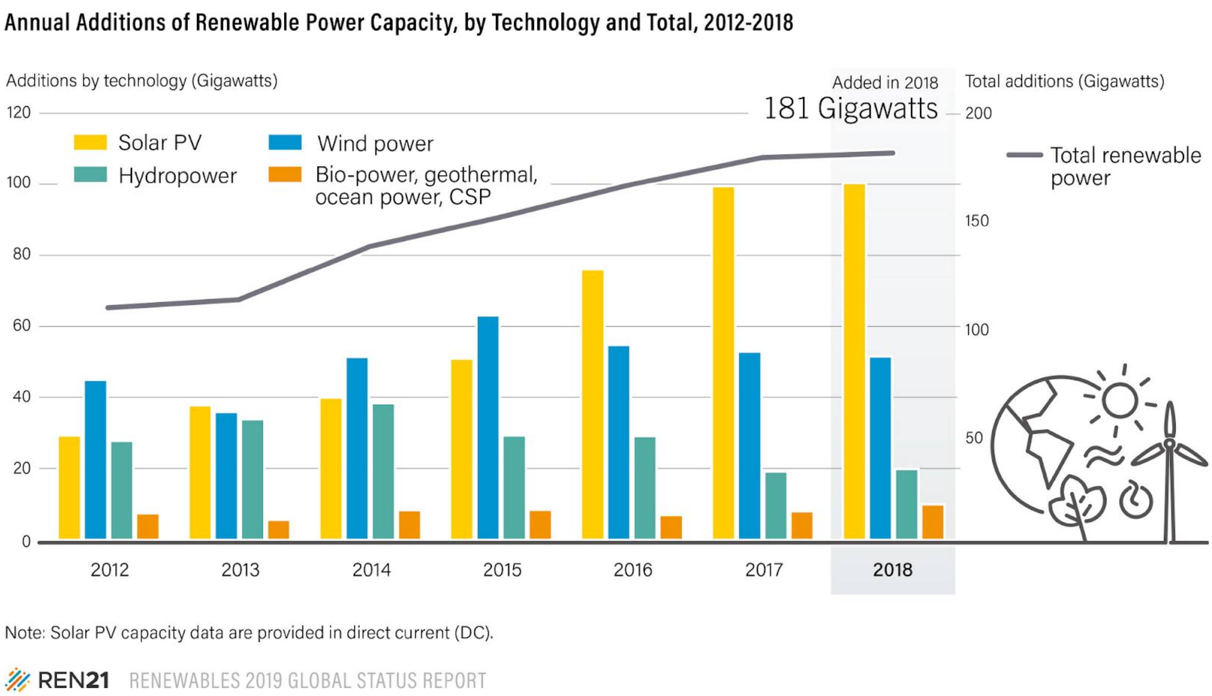
Source: Jortveit, A. (2020, March 12). Hvor fornybart er Equinor? Retrieved August 13, 2020, from energiogklima.no

2.3 Renewable Energy

Renewable energy sources, or alternative energy sources, are defined as resources that can be utilized to produce energy repeatedly; they include wind, solar, hydropower, geothermal, biomass, and marine energies (Panwar et al., 2011). Renewable energy capacity is growing globally, and in 2019, installed capacity went up with over 200 GW, mostly in the form of solar photovoltaics (PV). The renewable power capacity of the world then reached 2,588 GW in 2019 (REN21, 2020).

Government policy is one of the most important drivers for both growth and decline of renewable energy markets, according to *The Renewables Global Status Report* (2020). The report emphasized how in 2019 the private sector signed power purchase agreements for the highest amount of renewable power capacity ever, and that this was driven largely by cost of certain technologies continuing to drop.

The graph beneath shows the annual additions of renewable power capacity, by technology, as well as the total amount of renewable power from 2012 to 2018.



Source: REN21. (2019). Renewables 2019: Global status report. *Retrieved 09.04.2020*

The Renewables Global Status Report, (2020) put emphasis on improvements in efficiency and price, which again exacerbates the rate of adoption. This can also be seen in the Norwegian Water Resources and Energy Directorate (NVE) estimations of European wind power production. NVE estimates that wind power capacity in Europe will increase from 330 TWh in 2018 to around 754 TWh by 2030 (NVE, 2019). This would make wind power one of the main sources of power in the European electricity market.

2.4 Solar Power and Photovoltaics (PV)

The sun emits enormous amounts of energy, and a lot of it reaches Earth's surface (Panwar et al., 2011). In fact, every ten minutes we receive enough energy from the sun to cover our annual primary use (Coley, 2008). Facts like this are certainly reasons for optimism. By utilizing enough of the received energy from the sun, the looming climate crisis could be avoided, by decreasing the CO_2 emissions stemming from electricity production.

Multiple aspects, like local weather and latitude, determine the efficacy of solar power in any given location on the planet. In general, the closer to Earth's equator, the more energy is received from the sun, and moving north and south from the equator, decreases the amount of received solar energy (Coley, 2008). Solar energy is advantageous in that sun irradiation can be transformed into electricity in remote parts of the world where electricity is often unavailable, thus enhancing energy security for many communities (Panwar et al., 2011).

Solar panels can be catered to small-scale operations for villages and households, making it an especially good option in the developing world, where received sunshine tends to be high, and many households are not connected to the grid. In order to convert sun energy into electricity, solar cells, or photovoltaic cells, are typically used. (Coley, 2008). The photoelectric effect refers to the capability of matter to discharge electrons upon receiving light. When the sunlight reaches the solar cell, the photons present in sunlight react with silicon atoms, creating free electrons that are separated from the atoms which move in the same direction due to the cell having an electric imbalance (Coley, 2008). This process creates electricity.

Source: Energi og klima, 2020. Retrieved 05.05.2020

Other positive aspects of solar power include how it can be incorporated into the building structure, and excess electricity produced can in many cases be sold back to the grid, which the owner then gets paid for by the utility company. Investing in solar energy can therefore be lucrative for homeowners. Solar power is a low maintenance technology since there are no moving mechanical parts, and is thus likely to last for a long time. Furthermore, selling excess power back to the grid can not only stabilize the grid, but also increase the share of renewable power in the grid. Technological advancements in renewable energy also tends to produce possibilities for employment and local development (European Parliament, 2010).

2.5 Solar Power in Norway

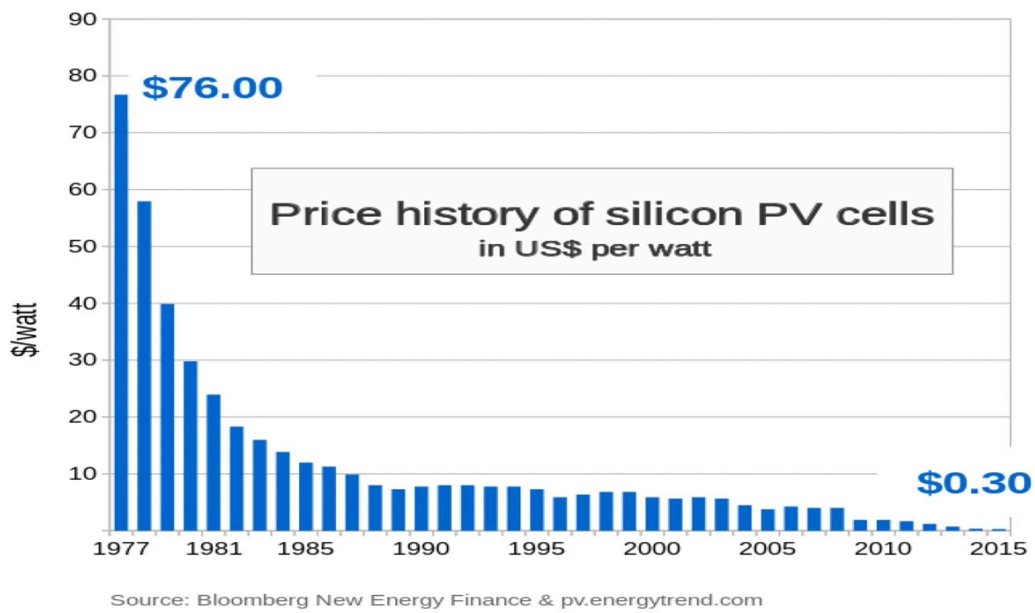
One might assume that the potential for solar power in places like Norway is low, due to the high latitude, but this is not necessarily the case. The Earth receives 15,000 times more sun energy than the annual energy use, and in Norway the rate is 1,500 more (Solenergi, 2018). The potential for solar energy in places like Norway, which receives relatively less sunshine than regions closer to the equator, is certainly still significant. In Norway, solar power is in its niche phase, but growing fast. The growth of Norwegian households with solar power increased by 99% from 2018 to 2019 (Thorsheim, 2020).

Annually, the average home in the southern part of Norway receives 60,000-70,000 kWh on the south facing side of the house. This is more than three times the annual energy consumption of the average household (Enøk Bolig AS, 2017). It has also been estimated that the passive solar energy received could cover more than 10% of the energy needed for heating during the winters (Enøk Bolig AS, 2017). It is also noteworthy that the cold climate in locations like Norway, makes the solar panels work more effectively (Solhaug, 2015). Furthermore, even though Norway has plenty of hydropower capacity, the price of electricity goes up when reservoirs are low, which generally happens during the summer. During the summertime, solar power could help stabilize electricity prices, and indirectly save more of the water reservoirs for later. It is pointed out by the OED (2016) that there is potential for improved energy efficiency in the current building stock. By, for instance, implementing technologies that produce electricity onsite, both in new and existing buildings. The OED (2016) also states that the goal is not to decentralize the power supply in Norway, because that would not be cost effective. This puts government and renewable energy actors in a difficult position because utilizing solar power will inherently decentralize some of the power supply.

During hours of peak electricity demand in winter, it has been estimated that the price of solar power in Norway could climb to levels 40% higher than hydropower (THEMA Consulting Group, 2017). This is why policies that support solar power can effectively be incentivized for adoption of solar power. Subsidies are indeed offered; Enova SF, is an enterprise owned by The Norwegian Ministry of Climate and Environment, that offers subsidies to homeowners who install solar power. For the installment, 10,000 NOK is subsidized, and then 1,250 NOK per kW installed, up to 15 kW. The total amount comes out to 28,750 NOK (Enova, 2020).

Swanson's Law

Solar cells are a relatively young technology compared to other sources of renewables, like wind and hydropower, which generally means that it has more potential for efficiency improvements. Advancements of solar power technology will bring the price down, and thus increasing the rate of adoption. Swanson's Law is described as the "learning curve plot of solar cells production cost performance (adjusted for inflation) versus cumulative installed capacity experience" which projects that the cost of solar cells will drop enough to become competitive with fossil fuels used to derive electricity (Partain et al., 2016). The hypothesis of Swanson's law illustrates this, by suggesting that a seven percent yearly growth of solar energy capacity will double every ten years. This also means that the cost would fall by 20% during the same time period (The Economist, 2012). Beneath is a graph that shows how the price of silicon PV cells has drastically decreased over the last few decades. The graph clearly shows how the price of PV cells are dropping, becoming more competitive with other sources of power. This means that solar power is arguably one of the major energy sources of the future.

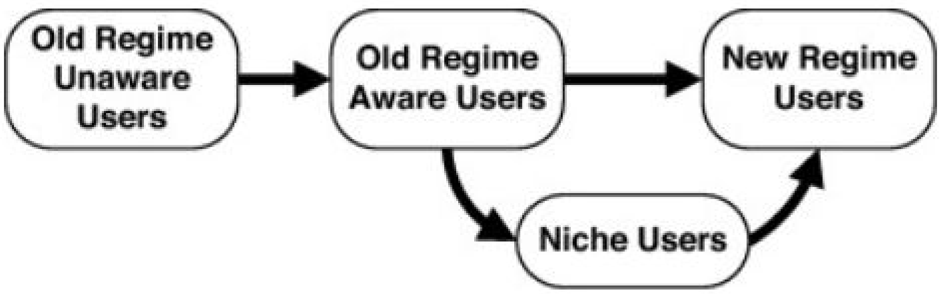


Source: The Economist Newspaper. (2012, November 21). Sunny uplands. Retrieved April 20, 2020

3. Theory

The Multi Level Perspective (MLP) will be applied in this thesis as an abductive framework to analyze the transition toward nZEBs. The MLP framework emphasizes the interplay that takes place between various transition paths at three levels. These levels include: 1) the socio-technical landscape; 2) socio-technical regimes; and 3) technological niches (Grin et al., 2010). The MLP highlights that, from a socio-technical perspective, transitions depend on technological changes in areas like cultural practices, markets, infrastructure, and institutions regulations among others. The multi level perspective brings attention to various ways these configurations change to fulfil societal functions.

The niche level consists of entrepreneurs and startups, which take risks in efforts to introduce their technologies to the market (Geels, 2011: 27). The entrance of niche innovators can often alter the dominant regimes. If the socio-technical regime (which is usually "dynamically stable") or the socio-technical landscape is changed, transitions can take place more rapidly. The MLP framework refers to this as a window of opportunity for new technologies (Geels, 2002). Still, there are various ongoing processes taking place in different dimensions. Examples of elements in the social-technical regime include market user preferences, industry, science, culture, technology and policy. Exogenous development in the socio-technical landscape influences the existing regime, which adapts and creates windows of opportunity for novelties. Eventually a new regime is re-adjusted and reformed. The illustration below demonstrates how a regime user can come to incorporate niche technologies.

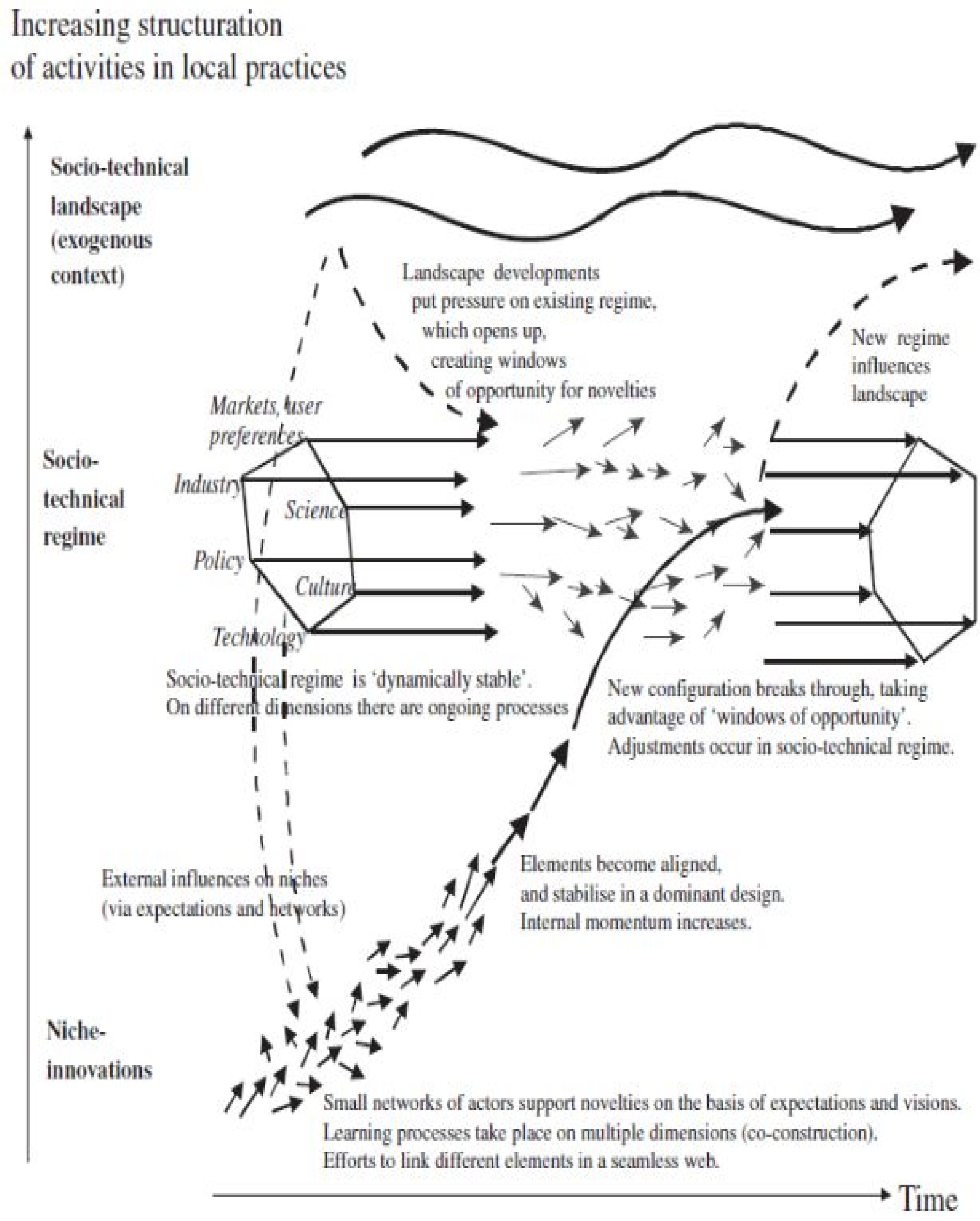


Source: Chang et al. (2015). Transition to a sustainability-oriented construction industry in China: a critical analysis from the multi-level perspective. (pp. 361-368).

In the context of this research, the EPBD from the EU is regarded as a change in the socio-technical landscape, requiring new buildings to be nearly zero energy by 2021. The regime level consists of the construction companies in Rogaland, and the niche level consists of tiny, and micro house providers, who might offer an alternative way of adhering to nZEBs standards.

Beneath is a visual representation of the MLP, demonstrating the interplay between the three levels. Like mentioned above, the niche level consists of small networks of actors that support novelties on the basis of expectations and visions. In time, details become aligned, moving the niche phase towards the social-technical regime. New configurations start to break through, and take advantage of windows of opportunities. Eventually, adjustments take place and niche technologies transition to become part of the social-technical regime.

As a result of socio-technical landscape changes coming in the form of changes in laws from the EU, incumbent actors on the regime level who are affected by law changes, have to adapt to these changes. Regulations of the regime have substantial implications for the incumbent actors, meaning that incumbents need to follow any new policy that is mandated. Socio-technical landscape change in the form of new building code will put pressure on and come to affect how the socio-technical regime level operates. Still, mindsets, and attitudes amongst the incumbents on the regime level are not easily changed; Geels & Schot (2010) highlight how low-carbon transitions tend to be long-term multi-faceted processes due to aspects like resistance from incumbents. These perspectives are the core of what I am exploring through the interviews with building construction representatives in this thesis.



Source: Multi-level perspective on transformations (Geels 2002: 1263).

Transitions can shift between different pathways, influenced by struggles between technology utilization and institutions. Geels & Schot (2010) developed a theory of four such transition pathways: transformation, reconfiguration, technological substitution, and dealignment and realignment. They talk about how the development of niche technologies are less important than their relationship to the incumbent regime. Different types of relationships between the incumbent regime actors and niche technologies come to affect which type of transition pathway ensues (Geels & Schot, 2010). The timing of socio-technical landscape change is emphasized as important in regards to the effects it will have on transitions. For instance, if a niche technology is developed fully, then socio-technical landscape pressure on the existing regime will likely lead to incorporation of the given niche technology.

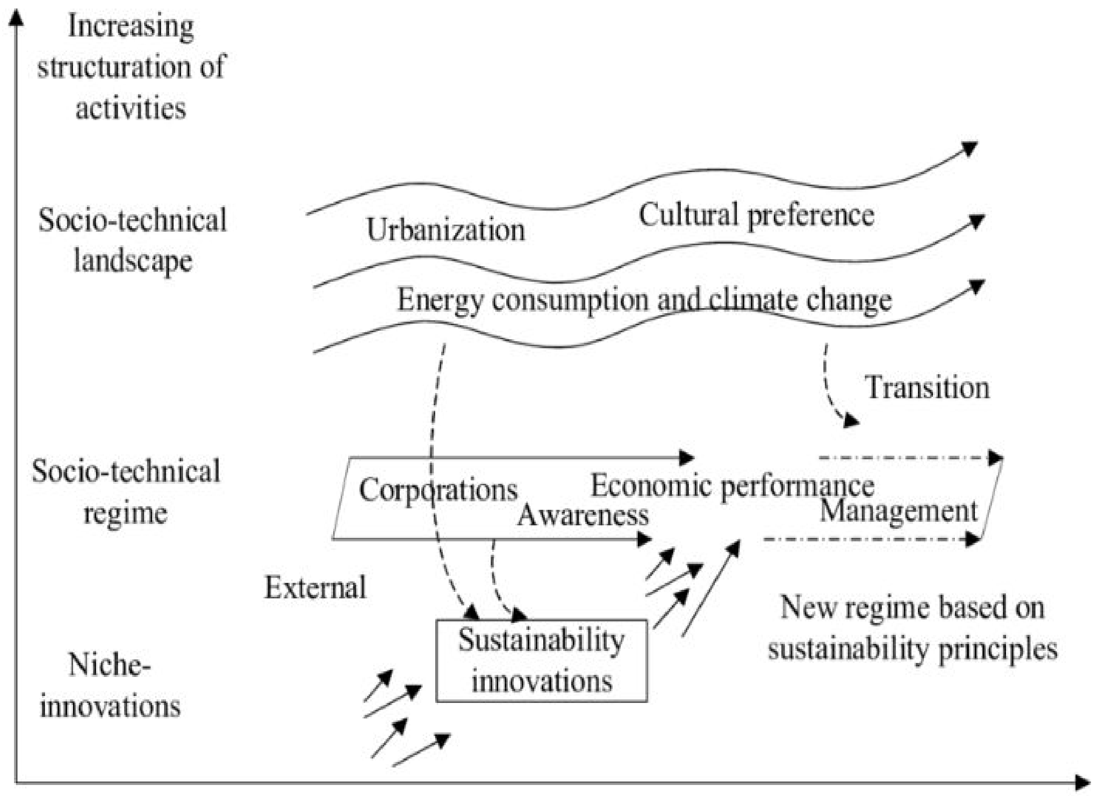
The transformation pathway tends to follow moderate landscape pressure, at a point in time when niche-innovations are not quite developed enough to have a major effect on the regime. Therefore the regime actors will change their practices and develop their own innovations (Geels & Schot, 2010). Incumbent regime actors in the Norwegian construction sector are experiencing moderate pressure to innovate and adapt to nZEBs, thus following a transformation pathway. However, the pressure would increase if new requirements come to mandate stricter building regulations in terms of energy efficiency and nZEBs.

According to Sovacool et al. (2020), transitions intermediaries—actors that link various groups involved in transitions, are becoming more highlighted in research on low-carbon transitions. Grønn Byggallianse, a non-profit membership organisation established in 2010, is an example of such a transition intermediary. It is owned by members across the Norwegian construction and real estate field, including actors like Stavanger Municipality, Statsbygg, Bate Boligbyggelag and Sintef. Grønn Byggallianse's mission is to enhance sustainability and quality of the building stock by promoting use of environmental assessment tools that can transform planning, construction, design, maintenance and operation practices (Grønn Byggallianse, n.d.). The organisation has stated that they endorse the awaited new building code (TEK20) which implements nZEBs and requires entities to show total climate gas emissions (including emissions from building materials and those stemming from buildings themselves) (Grønn Byggallianse & Norsk Eiendom, 2019).

Another example of such an intermediary is Bygg21, which is a collaboration between the construction sector, the real estate industry and the government, initiated by The Ministry of Local Government and Modernisation. It aims to promote solutions that can help solve challenges in regards to sustainability, productivity and costs ("Om Bygg21", n.d.). Bygg21 has identified ten encompassing propositions of what constitutes sustainable buildings, and they recommend that all new construction projects follow these guidelines, so that national and international climate goals can be reached (Bygg21-rapport, 2018). The propositions from Bygg21 on sustainable buildings states that buildings should: 1) Stimulate contact, activity and experiences, 2) Provide good natural lighting and views, 3) Provide good air quality and little noise disturbances, 4) Promote safety, 5) Have good accessibility for users of all functionality levels (e.i., handicapped, elderly, children etc.) , 6) Have a long life span, 7) Utilize space efficiently, 8) Be energy efficient, 9) Be built with efficient use of resources and a low climate footprint, and 10) Produce low costs of operation and maintenance (Bygg21-rapport, 2018).

In sum, the majority of MLP literature emphasizes the importance of innovations and how they push new technologies forward. It is also important to reiterate the role of incumbent transition intermediaries and how they are critical to the collaborative work alongside interests of dominant government— and can therefore contribute to reaching sustainability goals. Following this rationale, it becomes conceivable that the incumbent regime, by working alongside transition intermediaries, can be a part of the transition towards nZEBs.

Chang et al. (2015) used the MLP to investigate how the construction industry in China impacted the environment, society, and the economy. The following MLP model was used to analyse the sustainability of the Chinese construction industry. The model can likely be a useful tool to analyse the nZEB transition in Norway, too. According to Chang et al. (2015), societal developments like urbanization, cultural preferences, energy consumption and climate change has led to more awareness of sustainability for corporations. Awareness then leads to innovation which is eventually incorporated into the socio-technical regime.



Multi-level perspective on sustainability transition of the Chinese construction industry.

Source: Chang et al. (2015). Transition to a sustainability-oriented construction industry in China: a critical analysis from the multi-level perspective. (pp. 361-368)

Because the Chinese construction industry has significant impacts on China's society, environment and economy Chang et al. (2015) wanted to identify the drivers and the barriers for sustainability of the industry. Their findings showed that different factors in the construction industry, such as policies, corporations, and culture and technology, co-develop and interact across multiple dimensions. The different barriers and drivers of sustainability in the Chinese construction industry were indeed found to be interconnected and coexistent. In the Norwegian context the development of sustainability efforts in the construction sector seems to be following a similar path, with landscape change in the form of the EPBD and the Climate Agreement (Klimaforliket) spurring a transition toward more climate friendly practices.

3.1 Discourse Analysis

Discourse is a shared way of understanding the world, rooted in language, and it allows those who believe in it to interpret bits of knowledge and put them together into systematic stories or narratives (Dryzek, 1997). Discourse encompasses conversation, argumentation and speech, and it seeks to produce a consensus of a given topic. This thesis employed discourse analysis to identify the attitudes, mindsets and practices amongst incumbent and niche actors in the construction sector in Rogaland to answer the research questions. Discourse can be analyzed using the concepts of story-lines, which is a "narrative on social reality" (Hajer, 1995:56). By creating story-lines, it can often simplify complex issues leaving out important nuances. This can be observed in the story-line that says that Norway does not need more renewable energy because of large hydropower resources. However, there are important aspects of Norway's present and future energy use that are left out of such story-lines. Discourse has also been defined the following way: "*A specific ensemble of ideas, concepts, and categorizations that are produced, reproduced, and transformed in a particular set of practices and through which meaning is given to physical and social realities"* (Hajer, 1995:44). Achieving a common understanding of a given phenomenon, simplifying the given issue, and making solutions seem more viable is the desired result of employing the story-line concept, according to (Hajer, 1995).

The story-line that conveys that since Norwegian electricity prices tend to be relatively low, and hydropower resources are vast, and therefore there is little need for more solar power is what Hajer, (1995) calls " a narrative on social reality" that some actors prescribe to. Discourse is a way of looking at the world, and it is interesting to note that environmental concerns were not a part of politics until the 1960s. Environmental challenges, often are looked at as contradicting the goal of policymakers to enhance economic growth (Dryzek, 1997). Leaving out the fact that Norway imports and exports electricity with Europe simplifies the issue, and makes innovative solutions, like more renewable power, seem less needed. Omitting the fact that roughly 50% of energy consumption in Norway is non-renewable and that more electricity is going to be needed as a result of phasing out fossil fuels, is a part of the story-line that conveys that Norway does not need solar power, nor to reduce energy use in buildings. This narrative on social reality is used by some of the interviewees, and will be illustrated in the discussion and interview part of the thesis.

4. Research Design and Methodology

In research settings, methodology alludes to the comprehension of the chosen research design. The methodology calls attention to the research design, including data gathering, data reduction, literature review, observations, case studies, analyses, and drawing conclusions (Neuman, 2011). As a result of research findings, many changes can arise including philosophical assumptions, political repercussions, effects in the social-organizational realm and ethical considerations. In this thesis, I aim to simply summarize the problem at hand, as well as the purpose and significance of my research on nZEBS:

Problem: As discussed above, global average temperatures are rising, which has negative effects on the environment. The need for utilizing cleaner energy, and low energy buildings is therefore high.

Purpose: I intend to obtain and shed light on the nZEB concept, and investigate if, and how, the transition is taking place in Rogaland and Norway.

Significance: Like discussed in the Introduction and Background chapters, climate change mitigation is a pressing issue. It is possible that nearly zero energy buildings can have a positive effect on climate change mitigation.

4.1 Data Collection

Qualitative Methods

Qualitative research is a research approach which seeks to gain understanding of phenomena in the real world settings without intervention from the researcher, who might attempt to affect the given phenomenon (Patton, 2001). Discourse, with various social constructions like story-lines of reality was employed as qualitative research strategies during this study of nZEBs.

A few qualitative methods were utilized in the analysis to help answer the research questions, including:

1.) Interviews were conducted through email and phone conversations with informants from construction companies, and other representatives from the construction industry. These interviews helped identify narratives from the people involved in nZEBs work. The interview subjects, or key informants, possess detailed, specialized knowledge in their field. These individuals are generally good sources of information for the researcher (Payne and Payne, 2004). These interviews provided insights into the discourse regarding nZEBs and renewable energy in the form of solar power. Fourteen actors were contacted for this thesis, and they include: Jadarhus, Miljøbygg, Bygg21, Statsbygg, Fjogstad/Hus, Øster Hus AS, Norske Mikrohus, Direktoratet for Byggkvalitet, Grønn Byggallianse, Rogalandshus, Ministry of Local Government and Modernisation, StartMicroHousing, Mario's Tiny Houses, Boligprodusentenes Forening. Five of the fourteen organizations completed the research interview process (Jadarhus, Boligprodusentenes Forening, Fjogstad/Hus, Øster Hus, and StartMicroHousing), and two more responded saying that they could not discuss the topic in detail due to government restrictions (KMD and DiBK). Overall seven of the fourteen (50%) responded to my initial inquiry.

2.) A literature review of nZEBs was conducted in order to discover if there are global industry tendencies and leading practices. This was relevant because a literature review can demonstrate "lessons learned" from other places that are transitioning their energy systems and implementing nZEBs.

Quantitative Methods

In terms of quantitative data gatherings, surveys were sent out via email, but no respondents filled it out. The form was intended to supplement and/or substitute the interviews. The survey was sent out in the midst of the Covid-19 pandemic which likely was a cause of the low response rate. Multiple inquiries to construction companies and other actors were made. All interviewees who responded opted for email or phone interviews. The survey was created in Google Forms, and can be accessed here: https://forms.gle/uPmyTbpgUAhGpsWN A hardcopy of the survey can be viewed in Attachments section 9.3 under Nearly Zero Energy Buildings Survey. The surveys intended to complement the in-person interviews mentioned above.

Literature Review

Accessing appropriate data for the thesis was done by utilizing databases like Google Scholar, the library of the University of Stavanger, as well as relevant websites such various construction companies, government sites and environmental organizations.

Interviews

The COVID-19 pandemic halted the in-person interview process, and remote communication, like phone and email was then used as an alternative. The interviewees were contacted, informed about the thesis project goals, my intent as the interviewer, before agreeing to be interviewed. Additionally the interview subjects were informed that they had the right to withdraw their answers. The interview phone calls took 20-40 minutes, and the respondents were given the option of appearing anonymous in the paper. The names, roles and organizations of interview subjects that gave permission, are disclosed. The personal data collected was deleted after processing was completed. The project has also been reported to the Norwegian Center for Research Data (NSD).

4.2 Data Reduction and Analysis

The intention for the thesis is to create well-rounded, valid and unbiased inferences that have a high degree of reliability. Reliability relates to if the research findings are accurate and can be trusted (Heale et al., 2015). As a researcher, I attempt to be objective, but as a human it may not always be possible to be completely objective, and the research findings might reflect this. My hope is that if another researcher conducted the same research through interviews with actors in the Rogaland construction industry, that their results would lead to the same conclusions, thus implying that my research was comprehensive and reliable.

Validity is another priority area. In the Social Science Research Methods course, we learned about validity and I am putting that knowledge to use. There are four types of validity - face validity, content validity, construct validity, and criterion-related validity (Heale et al., 2015). In this research, content validity is the most relevant and it “looks at whether the instrument adequately covers all the content that it should with respect to the variable" (Heale et al., 2015). In order to be 100% certain that my research covered *all* the current perspectives present in the Rogaland construction sector, I would have needed to interview every company within the local sector. However, since that was not possible in the given time frame, this research can serve as a starting point for further inquiry. From a Multi Level Perspective, the interview response rate appears representative of the socio-technical regime of construction actors in Rogaland. 4 of the 5 interviews (80%) were conducted with representatives from larger companies or incumbent construction actors, and 1 of the 5 interviews (20%) was conducted with a niche innovator company. Though the responses cannot be extrapolated with 100% validity, they are valid and true to the five specific actors who were interviewed.

5. Data Findings

In order to gain insights into the discourse on nZEBs, solar power, and tiny houses, a short list of questions were asked to the informants After asking interview subjects about their role, place of employment and their area of focus (and if it related to EPBD, the Climate Agreement and energy efficiency), I transitioned the conversation from the introductory questions to my specific research questions. Interviewee responses were translated from Norwegian to English and are displayed in English. Some comments are slightly paraphrased for the sake of brevity and ease of understanding for the reader.

1. *Is the construction sector in Rogaland, Norway, preparing for the nearly zero energy buildings concept? If so, how? If not, why not?*
2. *What are the views of nZEBs in the industry?*
3. *Will new buildings in Rogaland all be nZEBs starting 2021?*
4. *Is there a place for tiny homes as part of the shift towards nZEBs?*
5. *To what extent will solar energy in Norway be implemented in the foreseeable future?*

The following graphic, "nZEBs Interview Response Table" and sections 5.1 - 5.5 share the specific research findings that were collected through the interviews with representatives from the Rogaland construction sector.

nZEBs Interview Response Table

Name	Company	Construction Incumbent / Niche	Is the construction sector in Rogaland, Norway, preparing for the nearly zero energy buildings concept? If so, how? If not, why not?	What are construction industry perspectives of nZEBs?	Will new buildings in Norway all be nZEBs starting 2021?	Is there a place for tiny homes as part of the shift towards nearly zero energy buildings?	To what extent will solar energy in Norway be implemented in the foreseeable future?
Geir Sandsmark	Jadarhus. Among the largest construction companies in Rogaland with 80 employees.	Incumbent	No, because subsidies are not good enough. And homeowners do not want more expensive houses.	Politically, it is easier to implement than it is for the construction sector. The construction sector does not want more complicated and more costly buildings.	We follow building code and industry associations recommendations.	This niche is more of an idealist idea in my opinion. Cities are not well suited for such small homes. Also people seem to want larger homes - not smaller.	Subsidies are not good enough and our customers generally do not want to pay the extra cost even if it means lowering their climate footprint.
Lars Myhre	Boligprodusentenes forening. Industry association with close to 800 members.	Incumbent	The Climate Agreement (Klimaforliket) states that nZEB levels will be implemented, and DiBK are working on new requirements. We recommend to our members to proceed with business as usual until these requirements are published.	A general challenge is that building code is becoming more complicated. Policymakers do not understand that some of the new regulations are complicated to follow. We do not know yet what the Norwegian definition of nZEBs will be, but it should be different than the EU's nZEB definition, due to aspects like vast hydropower resources.	Since the Parliament has stated in Klimaforliket that new buildings will have nearly zero energy levels in 2020, this is going to be implemented, but we do not know what this means exactly. "nZEB levels" will not mean the same as "nZEB".	Not applicable, researcher error.	The price of electricity in Norway is already low, so it does not make sense to implement lots of solar power.
Torstein Fjogstad	Fjogstad-Hus. Rogaland based construction company with 59 employees.	Incumbent	Fjogstad-Hus focuses on energy efficiency and expects a host of changes to come, including requirements of more insulation, better heat recovery and use of materials that create lower CO2 emissions. The latter would require life cycle analysis. Fjogstad-Hus is considering establishing ourselves as a construction company that has fossil free construction sites. We will have to start using Building Information Modelling in order to adhere to the enhanced sustainability standards.	DiBK has alluded that the materials used in construction have to be transparent and show life-cycle GHG emissions. The construction sector is preparing for updated building codes and low energy buildings by developing BIM-based tools, as well as Product Data Templates. Fjogstad-Hus is also a member of Boligprodusentenes Forening, and follows their recommendations.	Fjogstad-Hus follows the official building code and recommendations of industry associations. Based on the development of updated building code in regards to nZEBs, and the various other components that are part of the green shift in the construction industry, we see a need for more digitalization and use of Product Data Templates and the Building Information Model (BIM) model.	Fjogstad-Hus has no experience with tiny houses. However, during the large stream of refugees coming to Norway in 2016, we were challenged to design and plan affordable small homes. The planning and buildings law and its regulations is the main barrier to implement such small and affordable homes.	Solar energy and/or other forms of “local energy” will only be widely adapted in a scenario where it is mandated by law/building code. In Norway, electricity is cheap and reliable, which is why it would not be profitable to invest in such technology in buildings. The exception is for idealistic reasons. There is currently little demand for solar energy in the building market.
Gord Rostøl	ØsterHus. The largest construction company in Rogaland with 110 employees.	Incumbent	Our goal is sustainable practices, meaning that we aim to meet the demands of today while at the same time not compromising future generations' ability to meet their needs. We expect the costs for new buildings to increase as a repercussion of nearly zero energy requirements.	Costs will go up if new nZEB regulations are implemented.	Not applicable, researcher error.	We do not have any experience with this concept.	We have not considered this.
Kristi Sveindal	StartMicroHousing. Producer of micro homes. 3 employees, based in Haugesund.	Niche	I think that we are far from nearly zero energy levels. I don'y think that there will be any changes to the building code in 2020. If we are to reach the goal of nZEB levels we must look at total life cycle analysis. By building smaller we reduce energy use in all building process steps. My best environment advice is to use less.	I believe we need a change in attitudes in the government, the consumers and other actors in society. The government should subsidise innovative technologies and solutions by providing incentive for adoption. If economic incentive is provided it will fuel change.	No, I do not believe that we will reach nearly zero energy levels, and I do not think that there will be any changes to the building code in 2020.	To secure sustainable development, we must change the way we live by living more closely and more compact. Smaller homes are part of the transition towards more sustainable building practices.	We have not delivered any buildings with solar power yet. I believe that electricity in Norway is green since we employ hydroelectric power (which I think is better for the environment than solar cells, if we use a life cycle analysis). I do think solar energy is part of the future.

*Interviewee responses were translated from Norwegian to English and are displayed in English. Some comments are slightly paraphrased for the sake of brevity and ease of understanding for the reader.

5.1 *Is the construction sector in Rogaland, Norway, preparing for the nearly zero energy buildings concept? If so, how? If not, why not?*

Through the interview process, it became clear that in general, that at least three of the four incumbents of the Rogaland construction sector are not actively implementing or preparing for the nearly zero energy building concept. Fjogstad-Hus was the dissenting voice among the incumbents and displayed optimism about nZEBs and identified the need for more technological resources to address the new regulations when they are published. However, as part of the conversations, interviewees openly shared that their companies are undertaking some efforts to be more sustainable. Interview comments include:

- *"For the time being, we recommend our members to not be concerned with how they will adjust to nZEBs"* -Lars Myhre, Boligprodusentenes Forening (Incumbent)

- *"Requirements of nearly zero energy levels would mean more costly buildings"* -Gord Rostøl, Øster Hus (Incumbent)

- *"The current generation is not ready, and the green shift is not being incorporated in the restoration of old buildings"* - Geir Sandsmark, Jadarhus (Incumbent)

- *"I do not believe there will be any updates to the building code in 2020"* - Kristi Sveindal, StartMicroHousing (Niche)

- *"To complete the green shift, we see that we must increase digitalization and develop use of Building information modelling (BIM"* -Torstein Fjogstad, Fjogstad-Hus (Incumbent)

Sustainability efforts that are underway

Despite initial reservations about the nZEB concept and implementation time frame, the interviewees went on to share various methods of implementing sustainable measures into their companies' work.

Pilot projects

Sandsmark mentioned that environmentally focused pilot projects were an important step in the process in order to identify best practices. Even though his company, Jadarhus, has contributed to low energy building pilot projects, he conveyed that the demand for such buildings is still low among their customers and coming up with new building concepts and conducting pilot projects is costly which is part of the reason why the concept has not taken off. Furthermore, Sandsmark remarked that lower oil prices, and the corresponding slow down of the local economy in Rogaland, has contributed to putting low energy buildings and nZEBs on "ice", figuratively speaking.

Banning fossil fuels and digital simulations

Lars Myhre from Boligprodusentenes Forening mentioned how measures like banning furnaces that use fossil fuels in buildings, exemplifies that efforts to transition buildings to become low energy are being implemented. Both Myhre and the CEO of Fjogstad-Hus, Torstein Fjogstad, also shared that they likely will adapt the use of digital simulations of buildings in the planning phase which can lower the energy use of buildings.

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5.2 *What are construction industry perspectives of nZEBs?*

For the parties involved, new regulations are often perceived as more complicated than the old regulations. This is likely one of the reasons as to why this coming change is perceived with skepticism from actors in the construction industry. Based on the interviews, attitudes and mindsets in the construction industry seem to be somewhat negative towards nZEB changes that could increase cost and require adoption of new practices.

Four of the five interviewees expressed skepticism towards nZEB implementation in Norway, with three citing cost and the lack of incentives, and one citing the likelihood of complicated regulations. The minority opinion came from Torstein Fjogstad from Fjogstad-Hus who listed a host of changes they expect in the building code, and pointed out increased market interest in the BREEAM-NOR scheme.

- *"We see that the market interest for Svanemerket and BREEAM-NOR is currently increasing. We expect a host of potential changes to be implemented in building code in the near future, like use of materials with low associated emissions of climate gasses and life cycle analysis of CO2 emissions."* -Torstein Fjogstad, Fjogstad-Hus

The other four interviewees, representing the majority opinion, helped shed light on the current state of affairs in regards to nZEBs in Norway:

- *"Costs will go up if new nZEB regulations are implemented."*
  -Gord Rostøl, Øster Hus

- *"I believe we need a change in attitudes in the government, the consumers and other actors in society. The government should subsidise innovative technologies and solutions by providing incentive for adoption. If economic incentive is provided it will fuel change. "* - Kristi Sveindal, StartMicroHousing

- "*Firstly, the EPBD from the EU applies to its member states, and Norway is not a member of the EU."* -Lars, Myrhe, Boligprodusentenes Forening

Additionally, Myhre brought up some concerns regarding the EPBD applicability in the Norwegian context (when “nZEB” is defined in Norway):

- *“A general challenge is that building code is becoming more complicated. Policymakers do not understand that some of the new regulations are complicated to follow. We do not know yet what the Norwegian definition of nZEBs will be, but it should be different than the EU's nZEB definition, due to aspects like vast hydropower resources.”* -Lars Myrhe, Boligprodusentenes Forening

Myhre also shared low energy prices in Norway makes the potential cost saving of nZEBs small, and multiple actors are involved in the construction sector, meaning that adapting to new practices can be difficult to implement.

- *“Low oil prices have caused a downturn for the construction sector in Rogaland, and our customers are not willing to pay more to get a house with a lower climate footprint. ”* -Geir Sandsmark, Jadarhus

Given that Stavanger is the oil capital of Norway, the local economy is therefore sensitive to fluctuations in the oil price. Regarding the question of whether or not the EPBD and nZEBs are a focus for Jadarhus, Sandsmark answered that explicitly it is not. He did, however, mention that Jadarhus is a member of the national organization for construction companies (Boligprodusentenes Forening) and follows their recommendations. Sandsmark conveyed that Jadarhus has estimated the cost of low energy buildings to be 7-10% higher than conventional buildings. Rather than focusing directly on nZEBs, Jadarhus has promoted energy efficiency by emphasizing to their customers the positive aspects of efficient houses, like lower electricity bills. During the interview, Sandsmark argued that *“Politically, it is easier to implement than it is for the construction sector. The construction sector does not want more complicated and more costly buildings.*” He remarked that support and subsidies are needed if nZEBs are to be successfully put into practice. He also said that commercial developers are more successful at implementing low energy buildings than private home buyers because businesses are given better incentives from policymakers to adapt to low energy buildings.

Overall, these statements point to the fact that actors in the construction sector in Rogaland are aware of the impending nZEB transition, but they are not necessarily proactively planning for implementation when Norwegian TEK17 building code regulations are updated.

5.3 *Will new buildings in Norway all be nZEBs starting 2021?*

Considering that all the interviews were conducted in the spring and summer of 2020, with the exception of Fjogstad-Hus, the general attitude from interviewees was that nZEB implementation may be slow, though none estimated a time frame. Comments include:

- *"I do not believe that we will reach nearly zero energy levels, and I do not think that there will be any changes to the building code in 2020….to secure sustainable development, we must change the way we live by living more closely and more compact. Smaller homes are part of the transition towards more sustainable building practices."* - Kristi Sveindal, StartMicrohousing

- *"The changes that are coming in Norway in regards to low energy buildings are rooted in the Climate Agreement (Klimaforliket) that the Parliament has mandated, and for the time being, the EPBD is not something the Norwegian construction sector needs to adhere to. If the government does not fulfill the measures stated in the Climate Agreement, there will likely be repercussions, which means that they are indeed very likely to implement nearly zero energy levels in 2020.*
  - Lars Myhre, Boligprodusentenes Forening

Myhre conveyed that this since multiple actors are involved in the process of constructing new buildings, implementing nZEBs can be complicated. Today, it is not the project planners that pick the materials used by the builders. He pointed out that the EU does not include material use into the EPBD, and if the Norwegian policymakers omitted this too, the construction sector would likely have less difficulties adhering to the regulations. He also conveyed that for the construction sector in Norway, the transition will likely entail that buildings will be constructed similarly to the passive house standards, but with a building body that is even more energy efficient, to minimize the energy requirements.

Furthermore, Myhre expressed concerns with the EPBD in regards to Norwegian building code, pointing out that heat losses are not part of the calculated net energy demand in TEK 17, so if the new guideline were to incorporate heat losses, the net energy demand would increase. He also said that in the EU, electricity is produced less effectively than it is in Norway, and therefore the EPBD is less applicable in Norway. This is likely one reason as to why DIBK, and KMD, is making their own, Norwegian version of nZEB building code that will have to be adjusted based on considerations like these.

Showing more optimism about nZEBs, Fjogstad from Fjogstad-Hus shared:

- *"In 2018, we thought that regulatory implementation of life cycle analysis of CO2 emissions were far into the future, but seeing that DiBK is implying nearly zero energy levels, such regulatory change might already come in 2020."*

- *"Fjogstad-Hus follows the official building code and recommendations of industry associations. Based on the development of updated building code in regards to nZEBs, and the various other components that are part of the green shift in the construction industry, we see a need for more digitalization and use of Product Data Templates and the Building Information Model (BIM) model.*
  -Torstein Fjogstad, Fjogstad-Hus

This sentiment shows that Fjogstad-Hus is actively planning for the new regulations and has identified gaps in resources in order to meet the standards of potential new regulations. This is the most proactive attitude displayed in the interviewees, especially coming from an incumbent in the construction industry in Rogaland.

5.4 *Is there a place for tiny homes as part of the shift towards nearly zero energy buildings?*

In general, the incumbent actors in the Rogaland construction sector do not perceive tiny homes as a concept that has great potential for growth in Norway. However, the niche provider of tiny houses, StartMicroHousing, disagrees. The fact that there already are tiny home producers in Norway means that they are filling a market demand. These comments convey the perspective from construction incumbents:

- *"I am aware of some local producers [in the tiny homes market], but the concept is a niche. Tiny homes, or micro homes need access to land, which is limited in urban settings. Policies are not facilitating the adoption of tiny homes. Additionally, people in Rogaland generally want larger homes, not smaller."* -Geir Sandsmark, Jadarhus

- *"Fjogstad-Hus has no experience with micro houses. Other than querying to design and develop small and affordable homes for refugees. The largest challenge we see in regards to such small homes is the current plan- and building codes."*
  -Torstein Fjogstad, Fjogstad-Hus

Niche providers of tiny homes are experiencing a window of opportunity, due to heightened demand for alternative, smaller and more eco-friendly homes. This is leading to increased popularity and adoption of tiny houses. Based on discourse analysis and interviews conducted as research for this thesis, it is the impression that the tiny house concept, indeed, is in its niche phase, and that incumbents in the construction sector in Rogaland, and Norway are not yet starting to adapt towards tiny houses.

According to Kristi Sveindal from StartMicroHousing, small homes can be a part of the transition towards sustainable, low energy buildings.

- "*Living in a micro home appeals to all ages and social classes, and our homes are fully equipped with all conveniences of a conventional home."*
  - Kristi Sveindal, StartMicroHousing

According to Sveindal, the incumbents in the construction sector are neither very supportive nor against their concept. She mentioned that during a housing convention that they participated multiple incumbent construction companies clearly expressed interest in their concept. StartMicroHousing aims to make quality architecturally-drawn micro homes available for a large part of the population, and Sveindal stated that Norwegians are ready for this transition.

5.5 *To what extent will solar energy in Norway be implemented in the foreseeable future?*

According to the CEO of Fjogstad-Hus, Torstein Fjogstad, solar power is only going to be widely used if regulatory requirements come to mandate it. This sentiment was shared by the other interviewees. Fjogstad also argued that since electricity prices in Norway are low, employing solar power would be unprofitable. None of the interviewees mentioned the trend of falling costs of solar power, nor the fact that solar power In Norwegian households grew by 99% from 2018 to 2019 (Thorsheim, 2020). Multiple interviewees cited idealistic reasons as the only incentive for utilizing solar power in buildings in Norway, leading to the likelihood the rate of adoption of solar power in Norway will be delayed:

- *"We have not installed solar power on any of our buildings yet. We have received some questions regarding solar power, but personally I believe that electricity is a rather green source of energy in Norway. Since we produce electricity via hydroelectric power I think that is more environmentally friendly than solar power."*
  -Kristi Sveindal, StartMicroHousing

- *"Perhaps some changes will be implemented in regards to the type of energy supply, like solar energy. But in the Norwegian context, one might question, if that is needed? Considering the vast amounts of hydropower in Norway, and the electricity prices in Norway are low, more solar power only makes sense when there is scarcity of renewable energy.* -Lars Myhre, Boligprodusentenes Forening

- *"The price of solar panels is relatively high, and again, our customers are not generally willing to pay more for a house that is more environmentally friendly".*
  -Geir Sandsmark, Jadarhus

ØsterHus answered that they *"have not considered"* the extent to which solar power might be implemented in the foreseeable future.

This suggests that Rostøl, like the other interviewees, follow the narrative that Norwegian electricity is cheap and reliable, and therefore it would not be profitable to invest in such technology in buildings.

Building code complications

Another theme that also surfaced from the interviews was challenge with the Norwegian building code, TEK17. Several interviewees pointed out that adding power supply sources like solar power to the building code, would make it difficult to adhere to the code. Specifically, Lars Myhre expressed concerns with how solar power would be counted. "*Will solar power produced during the summer be worth the same as electricity produced in the winter*?" He also said that by using solar cells to compensate for the energy use of the building, incentives to put lots of solar power on the ceilings are likely to be created, which does not necessarily decrease the energy use from the building, and solar power then becomes merely symbolic to install.

Interestingly, none of the interview subjects were enthusiastic about the prospects of solar power in Norway. The story-line that was adopted said that since electricity in Norway comes from hydroelectric power, more renewable energy in the form of solar power is not necessary. The interviewees cited the heightened costs of houses with solar power as a reason why it is not widely adopted and some alluded to the importance of subsidies to help offset costs.

6. Discussion

After reviewing the content from the interviews, it is growing increasingly clear that the Rogaland construction industry is aware of the pending nZEB transition, but there is little action that is being done to proactively address the likely changes. This is due in part to the lack of a Norwegian definition for "nZEB" and clear guidelines to follow. In the following sections, key themes were distilled from the interviews and are commented on below with support from the interviewees and the review of literature.

Complicated Regulations

Some of the actors that were interviewed expressed that, politically, it might be unpopular to establish new TEK17 regulations in Norway. As garnered from the interviews, new regulations, though not yet published, are already perceived as more complicated and might come with heightened costs for the construction companies. The general attitude from the construction sector in Rogaland, based on the discourse analysis and interviews, is that any change that would increase costs is not welcomed. This is mentioned in the literature on transition theory, saying that the attitude and mindsets of incumbents on the regime level are not easily changed (Geels & Schot, 2010).

Generally, the incumbent regime actors that were interviewed emphasized how any new more strict environmental regulations would likely increase costs. A general problem that was identified and pointed out by some of the incumbent regime actors, is that the new regulations are increasingly becoming more complicated. For example, in the past, thermal transmittance, known as U-value (the rate of heat transfer through a structure), of windows, walls and ceilings were the principal objective that was implemented in order to calculate energy efficiency measures. If a window had a low U-value, it could be compensated for by increasing the U-value of the walls and/or ceilings. Under this model, calculating the heat loss, and energy use was fairly simple. Currently, the annual energy demand needs to be calculated, and TEK17 specifies how much a given building can use.

Power use within the building, geometry of the building, orientation, shadowing from neighbouring buildings, volume, size, thermal bridges, lighting, thermal effect of persons, and solar radiation are examples of factors that determine the annual energy demand ("Dette trenger du for å gjøre en energiberegning", n.d.). Taking these factors into consideration when estimating annual energy demand, certainly is a complicated task, which could increase the workload for construction companies.

Small Steps towards Efficiency

Despite the general lack of enthusiasm in the interviews, the interviewees spoke positively about their respective company's efforts to focus on energy efficiency in buildings. For instance, Fjogstad-Hus pointed out that they are considering establishing themselves as a construction company that has fossil free construction sites, and also mentioned that they choose products that have been labeled with Svanemerket/EU-flower, ECOproduct-database or SINTEF Technical Approval. Other companies like Jadarhus and Øster Hus seemed to be more passive about lowering their climate footprint, but still stated that they follow building regulations and recommendations from industry associations. Construction companies are profit-minded in their practices, which means that implementing nZEB building standards before said guidelines have been published, would likely mean unnecessary costs, compared to carrying on with business as usual.

Resistance to Change

As an example of an incumbent perspective, it is helpful to highlight Jadarhus as a voice for the majority of the larger construction companies. Geir Sandsmark from Jadarhus mentioned that they have conducted a pilot project, "Isobo Aktiv", as an energy efficient home of the future, but that the demand from their customers is not yet there when it comes to these energy efficient homes. The EPBD is a socio-technical landscape change that promote transitions, whereas the low oil price, and the repercussions for Rogaland, can be interpreted as a socio-technical landscape change that ends up working against nZEB adaptation, and illustrates how socio-technical landscape change can work both for and against transitions. Negative economic repercussions on the local economy in Rogaland seems to increase resistance to change, including with the idea of nearly zero energy buildings. Sandsmark's comment: *"The current generation is not ready, and the green shift is not being incorporated in the restoration of old buildings"* highlights what Geels et al. (2014) calls resistance by incumbent regime actors towards change. Frequent changes in the construction sector is not wanted. This is especially true in the current climate, with a global pandemic, changing the socio-technical landscape, spurring a slowdown of new projects, and a construction industry that is dwindling.

Incentives and Subsidies

Another key theme that emerged from the interviewees was the need for incentives to speed up adoption of innovative technologies that promote sustainability. Three of the five interviewees cited cost and the lack of incentives and subsidies as barriers to the nZEB transition. The growth of solar power can in part be attributed to Enova SF subsidies who offer a total amount of 28,750 NOK (Enova, 2020) for homeowners who install solar panels. Government may do well to take the advice from industry leaders and offer incentives and subsidies to companies and private homeowners for nZEB implementation.

Renewables and the Solar Energy Debate

In Norway, there is an abundance of available hydropower which multiple interview subjects highlighted. Some questioned if energy saving measures would be sensible from an economic standpoint. As mentioned previously, one could point out that there still is a need for more renewable energy in Norway since we import and export electricity to Europe, and total energy use hovers around 50% non-renewable. Lowering the energy use in Norwegian buildings, would leave more renewable energy for other European countries to lower their share of non-renewable energy. Despite the fact that none of the interviewees expressed interest or acknowledged that solar may be a key player in reducing GHG emission, the notion that Norway plans to phase out use of fossil fuels in all sectors also means that more renewable energy will be needed, including solar. The discourse identified in the interviews followed a story-line that did not talk about this issue, but instead followed the rationale that since hydropower is cheap and reliable in Norway, solar power is not needed.

Niche Markets - Tiny Houses

The incumbent regime actors had short answers when it came to tiny houses. Geir Sandsmark from Jadarhus remarked that in general, people want larger homes, not smaller.

Conversely, the niche provider, StartMicroHousing, which produces high quality, small homes conveyed that they had received strong interest from conventional construction companies in their concept of small homes. Kristi Sveindal repeated their motto, which is

"Live small-live more" meaning that quality of life would go up with more sustainable and more affordable smaller homes. Since there are producers like StartMicroHousing on the market, it means that the niche is in demand, and if the socio-technical landscape puts pressure on the existing regime it likely would lead to incorporation of the given niche technology.

Looking into the Future

With roughly 800 members, Boligprodusentenes Forening recommendations has a large impact on the construction sector in Norway. For the time being, they recommend that their members not be concerned with how they will adjust to nZEBs and potential solar power requirements. This is because such regulations have not yet been announced by the authorities, and starting to prepare for nZEBs now could be regarded as unnecessary efforts. Lars Myhre, stated that when the time comes, Boligprodusentenes Forening is confident that they can provide proper guidance for its members.

The construction industry adapts to laws and regulations that are published by the authorities. And it is safe to say that the green shift is starting to take place, but, the transition towards nZEBs is arguably unfolding slower than the goals set by policymakers. The lack of clear guidelines and the lack of a Norwegian definition for nZEB are the two major reasons why the construction sector is not preparing for the nZEB concept.

7. Conclusion

The transition towards nearly zero energy buildings in Norway is indeed unfolding. However, the transition is multifaceted and based on the findings from this thesis, it is lagging behind the goals set by policymakers. There is great potential in renewable energy, with technologies quickly evolving and the increased recognition of environmental concerns from both the public and private spheres.

In order to mitigate climate change, we need a rapid transition on many levels where clean energy is a top priority. Climate change is also causing the socio-technical landscape to change on various levels, including raising demand for sustainable and more eco-friendly options. Utilizing fossil fuels more efficiently can postpone the inevitable depletion, however, it seems short sighted to continue down the current path.

Renewable energy is becoming more competitive with non-renewables in the global market, which is leading to change through shifts in attitude, preferences and policies. Due to these steady shifts in the market, renewable energy is gradually increasing its share of the power generation mix. This demonstrates the will to curb climate change, and hopefully as a result, the quality of life for future generations will not be compromised due to present day practices. A successful transition towards renewable energy and energy efficient technologies like Nearly Zero Energy Buildings is imperative in order to attain sustainable development and to indeed avoid compromising the ability of future generations to meet their needs.

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9. Attachments

The Attachment section includes the following documents:

9.1 Response Letter from Ministry of Local Government and Modernisation

9.2 DiBK Interview Response Letter

9.3 Nearly Zero Energy Buildings Survey

9.1 Response Letter From The Ministry of Local Government and Modernisation

nesten nullenergihus

Samsing Sindre <Sindre.Samsing@kmd.dep.no>
fr. 10.07.2020 15:44
Til: Amund Nordal Gismervik <an.gismervik@stud.uis.no>

Hei, viser til den e-post med intervjuforespørsel. Beklager sent svar.

Kommunal- og moderniseringsdepartementets virkemiddel for omlegging til nesten nullenergibygg er regelverket. Norge har ikke foreløpig innført noen krav om nesten nullenergibygg.

I fjor fikk Direktoratet for byggkvalitet følgende oppdrag i tildelingsbrevet:

"Regjeringen vil utvikle energikravene til bygg i tråd med klimaforliket. DiBK skal utarbeide forslag til definisjon av nesten nullenerginivå som kan sendes på høring. I dette arbeidet må direktoratet vurdere om andre forhold enn kun energibehov i drift skal inngå i videreutviklingen av energikrav. Dette innebærer å vurdere mulighet og hensiktsmessighet av å se energibruk i drift og andre miljøkrav til bygg i sammenheng."

Departementet jobber videre med dette nå. Vi kan ikke gi informasjon om de interne pågående prosessene eller direktoratets leveranse.

Dersom det fremdeles er relevant kan du sende meg en e-post med spørsmål, så skal vi se om vi har noen svar å bidra med på det nåværende tidspunkt.

Mvh

Sindre Samsing
fagdirektør

Kommunal- og moderniseringsdepartementet
bolig- og bygningsavdelingen

Telefon 22 24 71 37
E-post sindre.samsing@kmd.dep.no

www.regjeringen.no/kmd

9.2 DiBK Interview Response Letter

DIREKTORATET FOR BYGGKVALITET

Amund Nordal Gismervik

Tlf: 22 47 56 00
www.dibk.no

Postadresse:
Postboks 8742 Youngstorget,
0028 Oslo
Besøksadresse:
Mariboes gate 13, Oslo
Hunnsvegen 5, Gjøvik

Org. nr.: 974760223

Ref: 20/4199-2
Deres ref:
Dato: 26.06.2020

Svar på henvendelse om nærnull energi hus masteroppgave

Takk for henvendelsen din om masteroppgave om nærnullenergi hus.

Direktoratet for byggkvalitet har fått oppdrag i årets tildelingsbrev fra Kommunal- og moderniseringsdepartementet. Oppdraget sier at Regjeringen vil utvikle energikravene til bygg i tråd med klimaforliket. Direktoratet skal i 2020 bistå departementet med å utarbeide høringsforslaget, og sende forslag til definisjon av nesten nullenerginivå på høring. Dette oppdraget er nå under arbeid. Vi kan derfor dessverre ikke svare på spørsmålene dine.

Med hilsen

Inger Grethe England
Senioringeniør

Dokumentet er godkjent elektronisk og har derfor ikke håndskrevne signaturer.

Nearly Zero Energy Buildings Survey

Thank you for taking the time to respond to questions regarding nearly zero energy buildings in Rogaland, Norway. Your responses will help to inform my graduate thesis research paper on Nearly Zero Energy Buildings in the Master in Energy, Environment and Society program.

If you have questions, please email me at: an.gismervik@stud.uis.no.
Thank you! - Amund
*Må fylles ut

1. First and last name *

____

2. Email address *

____

3. What is the name of your organization, business or agency? *

____

4. Would you like to to remain anonymous? If used, names and organizations would be included in my thesis publication which would be publicly available through the University of Stavanger library database, Brage. *

   Markér bare én oval.

   ◯ No
   ◯ Yes
   ◯ Andre: _______________

5. What is your current role in your company? How did you end up in your current role?

____

Survey Questions

6. Does your company focus explicitly on lowering energy use in buildings? If so, how? If not, why not?

7. Is the local construction sector preparing for a transition towards nZEBs? If so, what are some measures being taken?

8. Do you believe that new buildings in Rogaland will be nZEBs starting 2021? Why or why not?

9. Can micro homes be a part of the transition toward low energy buildings in Rogaland? Please elaborate.

Thank you for taking the time to fill out this survey!