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Crafting practices in the framing of sustainable buildings

Doctoral thesis

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Norwegian University of Science and Technology

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Crafting practices in the framing of sustainable buildings

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PhD programme in Interdisciplinary Studies of Culture

Summary

This doctoral thesis is an explorative study of craftspeople working in the building sector. It looks at both new and existing buildings, which are increasingly undergoing sustainable framing. It also investigates the practices of craftspeople working as agents of sustainability, who retrofit and build homes in line with climate change mitigation policies.

The thesis consists of four articles and an extended introduction (comprised of seven chapters). In the introduction, I provide a broad overview of the research context – the Norwegian building sector – and research subjects – craftspeople working in the sector. I also position the thesis within the theoretical framework of science and technology studies (STS), before introducing two theoretical concepts – *framing theory* and *social practice theory* – which I apply in a cross-cutting analysis of the four articles. The introduction also explains my methodological choices and outlines the manner in which I utilized qualitative interviews as my main empirical material.

The first article explores why energy retrofitting in private dwellings is difficult, and looks at the building sector's governance by numbers, which is carried out by craftspeople working as energy consultants. These craftspeople are analyzed as intermediaries between an unruly building sector and a political governing body that seeks to frame sustainable buildings in a particular way.

The second article looks at how environmental policies have given craftspeople new jobs and roles, inviting them to retrofit old homes to meet energy reduction standards. These new practices are shown to have transformed the craftspeople into sustainable, green-collar workers.

The third article investigates and critically analyzes the tools that these new workers use, placing particular focus on energy saving calculators. The craftspeople working with this must learn how to use these tools and fit them into existing routines. However, the script of energy calculators does not necessarily facilitate professional domestication of the tools.

The fourth and final article discusses craftsmanship within technologized building projects, focusing on the relation between sustainability and craftsmanship on the construction site. It shows how the craftspeople negotiate their role as planning agents at major construction sites and how their hands-on knowledge is transferred to actual buildings, through different production philosophies.

In the conclusion, I argue for the concrete involvement of craftspeople in the policies and activities that shape their professions. As one key informant told us: “We know how to do this. We are the ones who build the houses!” As this thesis shows, the development of hands-on knowledge is crucial for undertaking the sustainable transformation to a more energy efficient building sector, which will affect society as a whole.

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Acknowledgments

This thesis comprises part of a larger research project called "Crafting climate transitions from below," which is financed by the Norwegian Research Council under grant number 235514, through the climate research program KLIMAFORSK. I would like to thank all of the informants for their valuable opinions, and I would also like to thank my supervisors Jøran Solli, Håkon Fyhn, and Margrethe Aune. The project team's clear goals and responsibilities greatly benefited the research process, and my supervisors' mentorship was invaluable.

I would also like to thank the department in which I work, KULT, and my amazing colleagues there. A special thanks goes to Lina and the other doctoral candidates in my department. The thorough discussions in our biweekly writing group greatly developed my writing and provided me with many fun moments along the way. To the others in this group: good luck when it's your turn!

Another thanks goes to Trine – and our KULT basketball team – for arranging weekly basketball training, which was always a highlight of my week. At KULT we are also very lucky to have great administrators – Lotte, Kari, and Jan – who know how to fix everything. Also, Professor 2s Wiebe Bijker and Nelly Oudshoorn, who were guest professors at our department during my doctoral studies, gave me valuable advice and deserve thanks.

The scholarly relevance of my research became clear after we held a "Crafting Sustainability" workshop in June 2017 in Trondheim, and I would like to thank our participants there. Many of these participants have contributed to the special issue in which my fourth article is featured. Discussing craft and sustainability with these participants helped to increase my understanding of both topics.

Of course, doing a PhD is not possible without good social frames outside of work. My family and friends deserve a big thank you for making my life interesting when I was not working. Lastly, I would like to dedicate this doctoral thesis to my grandparents: my grandfather, who brought me to the workshop where he worked as a carpenter when I was a kid; and my grandmother, who delights our family with paintings, sewing, and crafts of all forms. You both have made me appreciate hands-on labor, making, and crafting.

Roger Andre Søraa Trondheim 10.January.2018

1. Introduction

This doctoral dissertation in science and technology studies (STS) explores the practices of craftspeople in the Norwegian building sector – a sector that is undergoing major energy transformations. In the past, craftspeople were not considered a significant group in terms of their contribution to sustainability in the building sector. However, education initiatives, including energy consultant courses, have attempted to remedy this situation by recruiting and employing craftspeople to work more actively towards sustainability goals in the building sector. This thesis will analyze how craftspeople in the building sector do their jobs, investigating their practices, roles and tools. The aim is to contribute to a wider understanding of effective implementation of the "green-shift"[1] in the building sector. The main research question is:

> *How do the practices of craftspeople contribute to sustainable transformations in the Norwegian building sector?*

Several sectors of society are undergoing sustainable transitions to meet the demands of a wilder and less predictable climate (Smeets & Weterings 1999). Climate problems, accelerated by our carbon-based contemporary lifestyles, call for a thorough discussion of both how we live and how we dwell. There is broad understanding that the building sector holds tremendous potential for climate change mitigation measures (Yeatts, Auden, Cooksey & Chen 2017).

David Orr (2013: 279) calls the accumulation of climate-related problems a "crisis of crises," wherein different social, economic, and technological problems give rise to a dystopian environmental future. This process can be mitigated by energy efficiency measures, such as standards for passive house levels and houses that produce renewable energy (Andresen & Hegli 2016; Berardi 2013; Hestnes & Gustavsen 2016).

Through the "Crafting climate transitions from below"[2] (henceforth "Crafting climate") research project, we have attempted to establish the notion of *crafting*

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[1]The green-shift, implying the transition from a society based on fossil fuel and polluting energy sources to one based on sustainable, clean energy features prominently on the political agenda. "Green-shift" was named "word of the year" by the Norwegian language council in 2015.

[2] The "Crafting climate transitions from below" project is financed by the Norwegian Research Council under the KLIMAFORSK program. The project is based at NTNU: Norwegian University of Science and Technology, in the Department of Interdisciplinary Studies of Culture. The project leader is currently Dr. Håkon Fyhn, who works on the project alongside Dr. Jøran Solli and myself. The project investigates

sustainability as an academic focus area that should be taken into account when planning for the green future. As a subproject of the "Crafting climate" project, this thesis focuses specifically on energy consultants and their emerging practices and tools. In this introduction, I will first set the frame for the context in which craftspeople were studied – the Norwegian building sector – and explain the context of craft in more depth.

1.1 The Norwegian building sector

The building sector accounts for approximately 40% of global energy consumption[3] and 40% of global CO_2 emissions (Gram-Hanssen 2014). Norwegian energy consumption in the building sector follows this average closely, with an onshore percentage of approximately 40%,[4] which has been relatively stable since 2005.[5] However, heating of Norwegian buildings accounts for only 1.2% of CO_2 emissions, primarily due to the high level of hydropower in the national energy chain.[6] Construction and building activity generates 15% of CO_2 emissions,[7] but this figure could be reduced if heating systems were to be installed in buildings prior to their initial use.[8]

The building sector is – both globally (Janda & Parag 2013; Shove & Walker 2007) and locally (Aune 2007, Ryghaug & Sørensen 2009) – considered one of the most promising sectors for energy reduction. It is thus an important arena for climate policy adaptation; but, according to Ryghaug & Sørensen (2009), energy efficiency policies for the building sector have not been particularly effective.

The sociotechnical problems caused by climate crises are unequally distributed throughout the world. Norway, for instance, is relatively free of extreme weather, besides its quite cold winters. Also, due to a "culture of coziness" (Wilhite et al. 1996) and high-

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craftspeople in a broad sense, in relation to energy reduction and climate change. More information about the project can be found here: https://www.ntnu.no/kult/energi-klima-miljo.

[3] As described by the UN Sustainable Buildings and Construction Programme (SBC 2017), http://web.unep.org/10yfp/programmes/sustainable-buildings-and-construction-programme.

[4] The report, *Energieffektivisering i bygninger – mye miljø for pengene!* (SINTEF 2009), gives a good account of this: https://www.sintef.no/globalassets/upload/sb-prrapp-40_sammendrag.pdf. An onshore number is used due to massive offshore CO_2 emission from the petroleum sector, Norway's largest industry.

[5] For an overview of energy consumption in households, see: http://www.ssb.no/en/energi-og-industri/statistikker/husenergi/hvert-3-aar/2014-07-14?fane=tabell&sort=nummer&tabell=187679.

[6] For a breakdown of CO_2 emissions in Norway, see: http://www.miljostatus.no/tema/klima/norske-klimagassutslipp/klimagassutslipp-bygg/.

[7] Construction CO_2 emissions can be found here: https://bygg.tekna.no/wp-content/uploads/2017/01/CO2-utslipp-og-reduksjonsmuligheter-i-BA.pdf.

[8] For more information on energy waste in construction, see: https://www.energinorge.no/fagomrader/energibruk-og-klima/nyheter/2017/utslippsfrie-byggeplasser/.

quality building stock, Norwegian houses are well insulated and improve on their energy efficiency with each new iteration of technical building laws. Norway has some of the highest per-capita spending on retrofitting in Europe[9] (70 billion NOK [8.3 billion USD] in 2016, or 13,400 NOK [1,600 USD] per person).[10] Norway also has a tradition of actively pursuing climate policies; for example, the *Our Common Future* report (Bruntland 1987) defined sustainability as an interlinkage of environmental, social, and economic sustainability. Unless otherwise stated, in this thesis I will primarily use the term *sustainability* to refer to "environmental sustainability." Social sustainability is an important topic, but it will be discussed in its own terms.

Traditionally, Norwegian climate change mitigation solutions have been top-down energy-economic policies and large-scale research and development (R&D) projects. These financial instruments have been criticized for their limited effectiveness in reaching key sustainability implementers (Sørensen 2007).

Norway is, however, an energy conundrum. The country is torn between seemingly intending to undertake a green-shift and simultaneously maintaining a massive oil (as the world's 14th largest producer) and gas (as the world's 7th largest producer) industry.[11] On the other hand, Norway ranks 9th globally in renewable electricity production, primarily from hydropower, making it the 12th largest energy producer in the world. Comparatively, Norway is the 39th largest energy *consumer* in the world, but has a population of barely 5.2 million (117th globally). In Norway's "energy-focused nation," how does the population dwell, and how is energy used in buildings? As Gram-Hanssen (2014: 393) points out, building retrofitting and climate change mitigation issues differ between countries, but a localized context such as Norway can provide valuable insight into the global issue. Although the commercial building sector is quite substantial, I will focus on

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[9] Throughout this thesis I explicitly choose the word *retrofit* over other words that are often used interchangeably, such as *renovation* ("the process of returning something to a good state of repair") or *refurbishment* ("a process of improvement by cleaning, decorating, and re-equipping"). The definition of *retrofit* that I have chosen implies: "providing something with a component or feature not fitted during manufacture or adding something that it did not have when first constructed." I base these definitions on The Designing Buildings Wiki – The Construction Industry Knowledge Base, retrieved from https://www.designingbuildings.co.uk/wiki/Retrofit.

[10] As reported by the Prognose Center, an independent market analysis company: https://prognosesenteret.no/event/gjett-hvem-som-er-europamestere-i-oppussing/.

[11] See this 2017 report from the International Energy Agency on Norway's energy production: http://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf, with additional data on oil and total energy production from the EIA: https://www.eia.gov/beta/international/index.cfm?view=production.

the private building sector in this thesis,[12] as it is in this sector that craftspeople meet homeowners, rather than corporate owners.

In 2015, the Norwegian building sector consisted of 4,085,834 buildings (Statistics Norway 2015). Each year, there are increases of 1.33% in private dwellings and 1.91% in corporate buildings,[13] the building demolition rate is approximately 0.6%, and the average lifespan of a Norwegian building is 167 years.[14] Marszal and colleagues (2011) found, in their literature review of building lifespans across 7 countries, an average lifespan of 50 years in non-passive houses[15] and an estimated lifespan of 80 years in passive houses; Gram-Hanssen (2014 gives 50 to 100 years as a general estimate. Although estimates of building lifespans are problematic, it is safe to say that the majority of the buildings that will be standing for the next 50 years have already been built (Power 2008). Consequently, retrofitting existing buildings is imperative for achieving energy reduction goals.

Norway's *Technical Building Regulations* (TEK), which regulate the type of new buildings that can be built, are some of the most important regulations for the building sector. Since 2010, regulation TEK10 has been the mandatory building standard. Ambitious building standards and regulations are seen by professionals, consulting engineers (Hojem & Lagesen 2011), and other climate change mitigation and adaptation practitioners as central tools for achieving sustainability. Studies of climate adaptation in Norway have indicated that updated standards and codes are perceived by practitioners as the main tools for translating climate knowledge into practice (Næss, Solli, & Sørensen 2011).

Norway is (as of July 1st, 2017) abiding by the building regulation of TEK17, which imposes an energy and insulation demand similar to that of passive house standards on all new buildings.[16] There is a political focus on not only employing technical demands on new buildings, but also renovating existing buildings to the favored sustainable

[12] Private buildings are defined in this thesis as "buildings where people dwell" (e.g. detached houses, apartment blocks, etc.), in contrast to commercial buildings (e.g. stores, offices, etc.).
[13] Kalhagen, K. O. (2011). *Konsekvensanalyse av å innføre nye forskriftskrav til energieffektivisering av bygg*. Retrieved from: https://www.regjeringen.no/no/dokumenter/konsekvensanalyse-av-a-innfore-nye-forsk/id644086/.
[14] There is some uncertainty in this figure; Kalhagen (2011) states that it is probably lower.
[15] Passive houses in Norway have employed measures to reduce energy consumption to about 25% of that of standard buildings, through effectively insulating roofs, walls, and windows. Passive private houses follow the Norwegian Standard NS 3700. For a thorough introduction to Norwegian standards, see: https://www.byggforsk.no/dokument/4109/dokumentasjon_av_passivhus_og_lavenergibygninger_i_henhold_til_ns_3700_og_ns_3701#i1.
[16] My empirical studies were conducted under the older TEK10 regime.

standard. These existing buildings have the highest potential for reducing Norway's energy use (Gram-Hanssen 2014). Ryghaug and Sørensen, in their article "How energy efficiency fails in the building industry" (2009), identified three specific barriers that are preventing the building industry from achieving higher energy efficiency: (1) deficiencies in public policy, (2) limited governmental efforts at regulation, and (3) conservatism in the building industry. As an integral part of the construction industry, craftspeople are particularly relevant to the third point.

Energy reduction efforts have featured prominently in the Norwegian political agenda, from its signing of the United Nations Framework Convention on Climate Change in 1992 to its early adoption of the Kyoto Protocol in 1997 and the Paris Agreement in 2015. One of the most important national milestones was manifested in White Paper 34 (2006–2007) on Norwegian climate policy – popularly called the "Climate Settlement" (*Klimaforliket*) – which was enacted in 2008. In the Climate Settlement, the Norwegian government committed to cutting greenhouse gas emissions (GHG) by the equivalent of 15 to 17 million tons of CO_2 by 2020, in order to reach a GHG emission milestone of 48.6 million tons.

White Paper 21 (2011–2012) on Norwegian climate policy, popularly called the "Climate Report" (*Klimameldingen*), continued this trajectory, stating that two-thirds of all GHG emission cuts must be made in Norway (in order to prevent quota outsourcing). This year, in 2017, the government announced that these goals would not be met. Recently, White Paper 41 (2016–2017) announced the goal of reducing CO_2 emissions 40% (from 1990; the equivalent of 30 million tons) by 2030 and 80% by 2050. Common across all of these white papers is a focus on the building sector as one of the most important targets for energy reduction.

In 2009, the Norwegian Ministry of Local Government and Modernization created a working group to study the energy efficiency of buildings. The result of their investigation was the *Arnstad Report*[17]. The report summarized international research on energy efficiency and concluded that the easiest and cheapest climate change mitigation efforts could be made in the building sector, and that this sector should therefore be

[17] See Arnstad, E. (2010) *Energieffektivisering av bygg*. From: https://www.regjeringen.no/globalassets/upload/KRD/Vedlegg/BOBY/rapporter/energieffektivisering_av_bygg_rapport_2010.pdf.

prioritized. The mitigation efforts cited in the report reached beyond the buildings, themselves:

> *There is a broad political and scientific consensus that energy efficiency must be prioritized. Energy efficiency in buildings helps to replace polluting energy sources in other sectors and reduce the need for new power generation. The greenest energy is the one never produced.*

A year later, the same ministry ordered a report from Multiconsult (2011). Multiconsult mapped the Norwegian building sector and found it to consist of 385 million square meters, of which private dwellings accounted for 66% (256 million square meters). Of all buildings, 17% had been built prior to 1945 and 85% were heated. The average Norwegian citizen had an average of 52 square meters for themselves, and with the private dwelling lifetime of 167 years, homes could be quite old (but well retrofitted). The new building rate was between 1.33% and 1.91%, the rehabilitation rate was 1.51%, and the (highly questionable) demolition rate was 0.6% for private dwellings.

Another report, ordered by the Ministry of Petroleum and Energy and conducted by the Low Energy Committee[18] in 2009, pointed to the need for national action plans for the building sector as an integral part of a healthy energy policy – seeing ambitious and clear goals as key. However, the report showed that a normal craft enterprise had 8 to 10 employees and that R&D was thus limited (ibid., 37; Ryghaug & Sørensen 2009). The Low Energy Committee also cooperated with SINTEF[19] Building and Infrastructure to co-produce several reports on the topic of energy efficiency. One of these, *Energy Efficiency in Building – Lots of Environment for the Money*,[20] focused on the economic benefits of energy efficiency. They described the full saving potential for energy efficient buildings to be 80 billion NOK (9.8 billion USD) and claimed that transitioning to energy efficient buildings would create 20,000 jobs in the building sector between 2009 and 2020. To fulfill such a scenario, the report estimated that the Norwegian state would need to invest

[18] The Low Energy Committee (Lavenergiutvalget) was created by the Norwegian Ministry of Petroleum and Energy. They prepared their report between February and June 2009. The report can be found here: https://www.regjeringen.no/globalassets/upload/OED/Rapporter/OED_Energieffektivisering_Lavopp.pdf.

[19] SINTEF is the largest independent research organization in Scandinavia, headquartered in Trondheim, with more than 2,000 employees.

[20] The report, in Norwegian, is called *Energieffektivisering i bygninger – Mye miljø for pengene*, and can be found here: https://www.sintef.no/globalassets/upload/sb-prrapp-40.pdf.

1.6 to 2.6 billion NOK (200,000 to 320,000 USD) annually, between 2010 and 2020. The committee also recognized the possibility of halving the building sector's energy usage within 30 years, from 80 TWh1 in 2009 to 40 TWh1 in 2040.

Recommended instruments for this included strict building codes for new builds – as we saw with the aforementioned TEK17 – and a massive commitment to energy efficiency in rehabilitation projects, as well as energy efficiency measures in the general building sector. Another important aspect was enabling the industry to provide the technological solutions and expertise that was and would be needed. They further wrote that "[a] large-scale and long-term plan to transform the market for energy efficient solutions, and [making] the industry able to supply the necessary solutions is required."

There has also been extensive research on barriers to implementing energy efficiency measures in Norwegian buildings. A report from Enova in 2012 showed that upgrading a household to the current technical standard would save the household 6,300 kWh annually.[21] Craftspeople, themselves, are not hostile to the goal of increased energy efficiency. However, when this goal comes up against competing demands, it often loses. Competing demands can include the desire for cost efficiency, interaction with a public that may not be knowledgeable of the importance of energy efficiency or the steps necessary to get there, and the "general hassle" of gathering information and organizing work in a new way. Taken together with White Paper 28 (2011–2012, part 3), this suggests that craftspeople's increased competence – through education, training, and craftspeople buy-in – is necessary for achieving this building policy goal.

Ryghaug and Sørensen (2009: 989) studied how energy efficiency measures had failed to be implemented in the building industry, focusing on issues such as "[t]he focus on short-term costs, lack of research and development, contract practices, [and] the communication challenges of interdisciplinary coordination of building projects." They concluded that there were potentially many "conflicting interests in the building industry because of a diversity of professional traditions, epistemic paradigms, and competences" (ibid.: 989). Although the data for their study was limited to architects and engineers, they recognized that those working on the building site were also important actors.

Risholt and Berker (2013) called for research into the way in which craftspeople can increase energy efficiency in dwellings. Ryghaug and Sørensen (2009) stated that there

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[21] Please find the Enova report in the following link: https://www.enova.no/download/?objectPath=upload_images/7260B28F559045159FD9213FA7AB989E.pdf&filename=Underlagsrapport%20Potensial-%20og%20barrierestudien%20Bolig%20Prognosesenteret.pdf.

is a "general lack of interest in buildings' lives after they have been built," tied to low innovation in the sector. Similarly, Barrett and Sexton (2006) showed that small construction firms do not prioritize innovation. Lack of innovation was also emphasized in Bresnen, Goussevskaia, and Swan's (2005) study of construction project companies' responses to organizational change.

In Norway, Enova holds the official responsibility for sustainable transformations in the building sector. Enova was established by the Ministry of Petroleum and Energy in 2001 as a public enterprise, specifically to enhance the efficacy of transitions to more environmentally friendly energy use and production. In its effort to facilitate energy performance upgrading in existing homes, Enova has developed a number of tools and also provides financial support. Enova's incentives for homeowners include full renovation support as well as support for smaller energy saving measures (e.g. installation of heat pumps, solar energy, and balanced ventilation) and financial support for energy consultation and renovation. Of these measures, the energy consulting support (worth up to 7,500 NOK [1,000 USD]) and full renovation support (worth up to 150,000 NOK [20,000 USD]) will be discussed most thoroughly in this thesis. However, these programs comprise only a fraction of Enova's portfolio of energy transition services.

Whilst Enova is the only state sanctioned energy consulting and renovating enterprise, several private companies work towards some of the same goals.[22] Enova has cooperated with the building sector through the "Low energy program" (2007–2017), which has trained and certified energy consultants.[23] This program has improved craft practices in multiple ways – for instance, by collaborating with several EU projects, including the "Build up skills" program, which seeks to upgrade the skills of European craftspeople.[24]

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[22] Examples are Jadarhus Rehab, as described by Tommerup and colleagues (2010), and EL-sjekken, a commercial service offered by Sikringen. EL-sjekken has a discount deal with Huseiernes landsforbund (providing members with a 500 NOK discount on the 1500 NOK price), and provides checks on electrical systems. Jadarhus Rehab is a daughter company of Jadarhus, and focuses on walking homeowners through the renovation process, from "A to Z," in order to ensure that buildings satisfy regulatory demands.

[23] Specific actors in this program include: Enova, the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Directorate of Public Construction and Property (Statsbygg), the Directorate for Building Quality (previously Statens bygningstekniske etat), the National Building Association, the Architect Industry, and the Housing Bank. All of these are important actors in the Norwegian building sector, but they have entangled roles and responsibilities. Statsbygg, the Housing Bank, and the Directorate for Building Quality all operate under the Ministry of Local Government and Regional Development, whilst Enova and NVE operate under the Ministry of Petroleum and Energy.

[24] See http://www.lavenergiprogrammet.no/lavenergi-i-eu/build-up-skills/.

The Housing Bank manages many of the tools relating to home retrofitting, and offers preferential loans for home construction and retrofitting. These loans are used as a policy tool, as one of their conditions is a higher energy standard than that stipulated by the building code.[25] In addition to providing loans, the Housing Bank also offers support for innovative projects and research. Both the Housing Bank and Enova also deliver information campaigns and offer counseling services.

Regulation of the building sector is primarily facilitated through massive, complex energy calculations. From a top-down perspective, calculation tools are regarded as effective enablers of climate change mitigation policies, partly because they allow for control from a distance. This perspective can be seen in the contract between Enova and the Ministry of Petroleum and Energy for 2017 to 2020, wherein "good goal achievement" is defined as: "climate results of 0,75 million ton CO_2 equivalents in non-quota sectors; energy results of 4 TWh; energy results of 400 MW; Innovation results corresponding triggered innovation capital of 4 billion Norwegian Kroner (476 million USD)."[26,27]

Enova is required to report specific cases in order to document their results. Thus, a house's energy consumption must be measurable, so that Enova can perform calculations and report them to the government. Craftspeople who work to upgrade houses serve as agents of this documentation, reporting their work in calculations. But the calculated vision of a low emission society does not necessarily translate into the hands of the workers who enable it in practice. Putting climate policies into action requires translation and implementation of existing work practices (Næss & Solli 2013), and the end users – those who dwell in the finished homes – might not see the same energy benefit as the government policies predict (Solli 2013). How, then, do craftspeople implement these policies? In order to further understand this, we must first understand what a craftsperson is, how a community of craftspeople is built, and what craftspeople's roles are in enacting sustainability policy.

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25 These loans were discontinued in 2017, when the National Office of Building Technology and Administration assumed management.

26 The full contract can be viewed here: https://www.energinorge.no/contentassets/aba852b258fb4f49a4130daab7c94d3d/avtale-om-enovas-mandat-2017-2020.pdf.

27 The 2012–2016 contract, which was in operation when we conducted our studies, had the goal of 7 TWh, which was achieved. It can be read here: https://www.regjeringen.no/contentassets/98bccb1372ab47c99cc0a08e25752066/oppdragsbrev-til-enova-sf-for-2015.pdf.

1.2 What is a craftsperson?

In order to understand how craftspeople deal with climate adaptation and energy reduction issues hands-on, one must first understand what a craftsperson is. A precise definition of a craftsperson is not necessarily straightforward. I will therefore examine some definitions that have previously been put forth by other scholars.

Sennett (2008: 20) writes that craftspeople are "dedicated to good work for its own sake", a quite a broad definition. Pye (1968: 25) looks at the difference between workmanship and craftsmanship. He argues that it is not possible to divide work done by hands and work done with machinery, and he uses the term *workmanship of risk* – in contrast to *workmanship of certainty* – to emphasize how craftspeople must be alert and present in their work in order to determine (based on experience) how to best solve difficult situations that arise.

Another craft scholar, Adamson (2007: 3), defines craft as "making something well through hand skill," whilst Hofverberg, Kronlid, and Östman (2017) define it as: "skilled hands making products (together) with materials." Taking these definitions into account, I have chosen to add my own definition of a craftsperson as a professional skilled worker who makes and repairs physical things through the transformation of materials, often with his/her hands. Ingold (2013) sees craft through the perspective of phenomenological anthropology, focusing on making as correspondence (i.e. seeing the interconnections of craft).

In the Norwegian language, craftspeople are denoted as *håndverkere* (literally "hand workers"), which emphasizes the importance of hand-object manipulation. In order to become a certified craftsperson in Norway, one must obtain a journeyman certificate at higher secondary school. Examples of craftspeople at contemporary Norwegian construction sites include carpenters, plumbers, electricians, and masons. Throughout this thesis, I will use the term *craftsperson* over craftsman, and *craftspeople* over craftsmen, in order to present non-discriminatory research in regards to craftswomen, who were present in the data material (albeit modestly, due to the heavily gendered aspect of craftsmanship, especially carpentry, in the building sector).

But who are these Norwegian craftspeople? At the beginning of 2015, 2,746,000 of Norway's 5 million people (70.8%) were employed, according to the Norwegian Statistics

Bureau[28], and in the total Norwegian workforce, craftspeople made up 9.2%. They comprised the third largest workforce group after academic professionals (26.5%) and sales and service professionals (20.9%). In 2014, the average annual salary for a Norwegian employee was 507,600 NOK (about 61,000 USD). Building sector employees had an average salary of 470,200 NOK. Apart from non-educated employment, craftspeople had the second lowest income (after operators/transporters) (ibid.).

The experience of a craftsperson in the 21st century – and in this case, the building sector – is vastly different than it was in the past. What was once regarded as a role with a well defined career trajectory, from apprentice to master, now has multiple trajectories, as well as common pitfalls such as unemployment and redundancy. Both academic scholars and observers from within the profession have sounded the alarm on the contemporary decline of craftspeople's professional knowledge (Sennett 2008; Tesfaye 2013). However, there might be a tendency to romanticize the past, which undoubtedly raises its own challenges.[29] Another concern voiced relates to the effect of the ever increasing bureaucratization, digitization, and automation of society on people who work with their hands (e.g. craftspeople). This is discussed by Tesfaye (2013), who argues that bureaucratic systems downgrade professional know-how.

1.3 What is an energy consultant?

This thesis focuses on carpenters[30] – especially those working on energy consulting, energy retrofitting, and sustainable building projects. These carpenters have many roles: on the one hand, they are hands-on practitioners who hammer nails into the walls of people's homes; on the other hand, they are often involved in advising on home energy savings (Risholt & Berker 2013) and providing practices and practical knowledge that lead to retrofitting solutions for greater energy efficiency. In addition, a large number of craftspeople are present at construction sites for new sustainable buildings. Craftspeople

[28] For the statistics, see: https://www.ssb.no/arbeid-og-lonn/statistikker/aku/kvartal/2015-04-30?fane=tabell.

[29] This is not a history thesis, but I would like to point out that there is a vast amount of craft literature. One field in which crafted items have been especially important is archeology, as artifacts provide important insights into how historical items were made, who made them, and why they were made (see Adamson 2013; Green 2007; Sennett 2008).

[30] In the Norwegian language, there is a divide between *tømrer*, referring predominantly to carpenters who work outside on larger structures, such as walls and roofs (normally on construction sites), and *snekker*, referring predominantly to carpenters who work inside on smaller items such as furniture, stairways, and doors (normally in workshops). However, the terms are sometimes used interchangeably.

are thus a highly important component in the construction of contemporary sustainable buildings.

As mentioned previously, one approach to energy efficiency retrofitting involves the education of state certified energy consultants. Professionals who wish to gain this expertise must take a course and pass a test administered by the Low Energy Program and Enova. They are then listed in a public database, which homeowners can use to find local energy advisors and hire them to conduct energy consultations. An energy consultation costs approximately 10,000 NOK (1,120 USD), of which Enova sponsors up to 50% (if thermography is also done, the total cost is approximately 15,000 NOK). The consultation leads to an energy efficiency upgrading plan; should a homeowner decide to retrofit his or her house to Enova's energy standards, Enova contributes a certain amount of money per square meter.

Energy consultants can come from a wide variety of backgrounds, from architecture and engineering to craftsmanship. However, the energy consulting program was initially intended to accelerate the knowledge of craftspeople.[31] As engineers and architects have already received broad research interest, this thesis focuses on the understudied professionals of craftspeople in this setting.

How can craftspeople contribute to energy savings and sustainable transformations in the building sector? The manner in which craftspeople contribute to climate adaptations – successfully or not – works in concert with the role and status they are given by society at large. Tesfaye's (2013) book about craftspeople in Denmark paints a gloomy picture of crafting professions. From his bricklayer background, looking at the new roles of craftspeople in contemporary Scandinavian society, Tesfaye (ibid.: 18) argues that craft is the answer to Scandinavia's challenge of maintaining an innovative workforce that will secure patents and export goods – key ingredients in developing the northern welfare states and keeping them afloat. I will investigate this idea in the more pragmatic context of the Norwegian building site whilst keeping in mind the wider sociocultural implications of how craftspeople can contribute to sustainable transformations in the building sector.

[31] This was confirmed in an interview with Enova employees in autumn 2015.

1.4 Thesis structure

This first chapter introduced the topic at hand (Chapter 1). The proceeding chapters will summarize the four articles (Chapter 2); outline previous research (Chapter 3); describe the theoretical perspectives used (Chapter 4); present a cross-cutting analysis of the articles and the relationship between them (Chapter 5); describe the methodology used (Chapter 6); and, finally, present the four full articles in full, followed by a conclusion.

2. Summary of articles

In this chapter, I will describe the four articles of this thesis and the way in which they connect. In short, the first article studies energy retrofitting in private dwellings, by analysing the way in which retrofitting is framed by different actors. It sees how craftspeople work as intermediaries between governing policies concerning up to 2.2 million Norwegian homes. Through their work as intermediaries, craftspeople document and register the energy use of Norwegian buildings and exhibit increasing control over these structures.

The second article investigates the effect on craftspeople's practices of their increased energy consciousness, which is gained as a result of their engagement with policy instruments such as energy consultant courses. The third article investigates the new digital tools used by craftspeople and traces the development of these tools. The fourth article shows how the craft practices of building are changing with the technologization of building sites. I recommend reading the full articles after these summaries.

2.1 Article 1: Why energy retrofitting in private dwellings is difficult: Coordinating the framing practices of government, craftspeople and homeowners [32]

The first article looks at how governance in the building sector attempts to use craftspeople, working as energy consultants, as intermediaries between governmental bodies and houses and dwellers, themselves, in energy retrofitting. Such attempts are made not only to help homeowners energy upgrade their building in a holistic manner, but also to enroll houses in the sphere of government control by making their energy performance calculable and thus visible in governmental audit systems.

Intermediaries such as craftspeople working as energy consultants are required for this documentation. As they already have a foot inside homes as consultants for other forms of renovation, they are ideal intermediaries for governmental energy efficiency schemes. The article finds, however, that the knowledge of these professionals was not seriously taken into account when the programs were constructed.

The article discusses how household energy consumption is discussed in relation to energy efficiency and looks at energy consulting and holistic renovation incentives. Key to

[32] This paper was submitted to *Energy Research and Social Sciences* in February 2018. The authors are Fyhn, Solli, and Søraa (equal authorship).

the article is the concept of intermediation between levels, and how the framing of sustainability is enacted through policies and data.

Because policy makers and house dwellers seem to frame energy efficiency differently, there is distance and tension between them. Using theories of *framing* (Callon 1998), the article problematizes this difference. The framing gap is attempted bridged by documenting the energy qualities of the 2.2 million homes in a standardised and calculable format; conceptualising the 2.2 million homes as a market; and also by relying on intermediaries. By looking at how the sustainability of houses is governed by policies and how energy consultants act as intermediaries in this governance, the article shows how the framing of this system is initially perceived by key actors. It argues that energy consultants enter as important intermediaries between the policies that govern buildings and the people who live in those buildings.

2.2 Article 2: Crafting environmental policies into action: Energy consulting practices of craftspeople[33]

The political aim to make buildings more sustainable and energy efficient by reducing 40% of the energy used in the building sector provides new challenges for craftspeople that are tasked with bringing about these changes. Based on qualitative interviews and observations at Norwegian building sites, this article discusses the new role of craftspeople working as energy consultants, with a special focus on their new identity as "green-collar workers." It argues that green-collar workers include a variety of highly skilled professionals and emphasizes the new tasks that these professionals must undertake in the new "green economy."

The article explains how a person becomes an energy consultant and describes the practical effect of the acquisition of skill and certification of expertise. It also describes how energy retrofitting is done, exploring the socio-interactions between energy consultants, building owners, and policy makers and showing how policy concepts are translated into physical buildings. The article analyzes four different roles that craftspeople working in energy consulting can inhabit, as derived from the data material analysis: (1) economizer – one who is responsible for making homeowners understand the economic aspects of renovating their house in a more sustainable manner; (2) controller – one who

[33] This paper was submitted to *Craft Research* in October 2017, and has been accepted for publication with revisions in volume 9.2, September 2018. I am the sole author.

acts as an intermediary between governmental bodies and the house, itself (relating to the first article); (3) coordinator – one who coordinates other actors involved in upgrading the house (craftspeople have the best oversight over what needs to be implemented and at what point on a project); and (4) seller – one who sells his or her own energy upgrade services whilst simultaneously advising on the necessary upgrades (an issue that many craftspeople feel is quite pressing).

The article's analysis utilizes *sustainable transition theory* and *practice theory.* Studies using sustainable transition theory (Jackson 2009; Loorbach 2007; Schot & Geels 2008) often focus on systems or larger societal transitions of technologies; my article sees such transitions on a much smaller scale, relating to a group of workers transitioning to more sustainable practices. Specifically, the article investigates how energy consultants are forming new practices.

Craftspeople are part of a complex, sustainable transition that is taking place in the building sector. It is necessary to understand their profession in order to further reduce energy usage in buildings, as identification of their practices enables a deeper understanding of their relationship to sustainable buildings.

2.3 Article 3: Energy consultants calculating sustainability in the built environment[34]

The third article investigates one of the key tools that energy consultants use in their work: an energy calculator for energy marking buildings. The article studies how the energy calculator is used to measure Norwegian buildings and investigates whether there is synergy between the users and developers of the calculator. Additionally, it looks at the collaboration between users and developers in shaping the technology. As a computer program, the energy calculator is scripted to achieve sustainable transformations in the building sector. But how do craftspeople domesticate this technology? How can we describe the collaboration between the users and developers in shaping this technology?

The article highlights many of the difficulties involved in utilizing the calculator and shows weak user involvement in the design process, both before and after its release. This particular sustainable transition tool does not account for the expertise of those who

[34] This paper was submitted to *Facilities* in October 2017. As of January 2018, it was under its second review. The authors are Søraa, Fyhn, and Solli.

use it. Thus, the tool could be further developed and improved by considering its users' views and utilizing their expertise.

Through interviews, we discovered that the calculator developers intended to involve craftspeople in the creative process. However, the ambitious deadline for completing the calculator (due to it being scripted into a scheduled television program) prevented this collaboration from happening. Our interviewees were aware that many energy consultants had strong opinions about the calculator, especially concerning its shortcomings and how it could potentially be improved.

The article uses domestication theory – specifically, the *Trondheim model of domestication* (Lie & Sørensen 1996) – and draws inspiration from sustainable transitions (Shove & Walker 2007; Smith, Stirling, & Berkhout 2005; Tukker & Butter 2007) in its analysis. It investigates the domestication of the energy calculator by examining the practical, symbolic, and cognitive dimensions of the process. The article also uses *script theory* (Ainamo & Pantzar 1999; Akrich 1992) to analyze how the technology was originally intended for use. Domestication theory enables a focus on the correlation between the technology and its users (i.e. how the technology changes users, and how users change the technology in return).

The article shows that, due to bureaucratic obstacles, energy consultant user feedback has not reached the calculator's developers. Between these parties exist strong governmental bodies that, for various reasons, do not pass along the information. The article questions why this is so, given that energy consultants are required to use the tool despite their overwhelming dissatisfaction regarding its usability and shortcomings. The article is part of a special issue on *Realising Sustainability Potentials in the Built Environment*, which focuses on the way in which energy practices contribute to a building's lifetime performance and day-to-day use. The special issue has a particular focus on the tools used to increase energy efficiency in buildings, including the energy calculation tools we investigated.

2.4 Article 4: Craftsmanship in the machine – Sustainability through new roles in the crafts of building at a technologized building site[35]

The final article is a case study from a contemporary building site, following the construction of the prestigious student housing project Moholt 50-50, which consisted of five wooden tower blocks. The paper considers whether craftspeople have a sustainable future in a building industry that is increasingly characterized by automated production. The study follows a team of carpenters building a set of tower blocks at a high-tech building site using "lean" construction[36] techniques and robot production technology.

The paper explores how contemporary craftspeople interact with various kinds of automation and technologized production systems and how this interaction affects their practices as craftspeople. It explores three ways in which craftspeople are seen as something more than assembly workers (i.e. persons who craft, rather than merely put together elements), relating to robot technology, prefabrication, and organization of lean production systems.

In the case, craftspeople develop and follow a strictly regulated plan of work tasks. They must be at exact locations at precise times and put together exact elements in order to maintain the flow of the building process. This shows how parts of the building sector are shedding their conservative reputation by employing new ways of building. However, these new methods are affecting the kinds of persons who can be employed on site, as a high level of independence, teamwork, and skill are needed to maintain the flow of the building work. Furthermore, craftspeople on site must be very professional and knowledgeable of the practices needed for that particular construction project, and they must know each other well in order to work together in a fine-tuned manner. Casual laborers, who are frequently used throughout the building industry, are not well suited to these building sites, as they lack experience in the finer details of their practice, which only comes from long-term experience on a site.

Thus, being a builder on such a site implies more than being merely a part in a machine; a builder's crafting skills are needed in planning, problem solving, improvising,

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[35] The paper was published in *Nordic Journal of Science and Technology Studie*s in December 2017. The authors are Fyhn and Søraa.

[36] Lean construction, as we explain in the article, was developed by Womack, Jones, and Roos (1990), by combining the Japanese *kaizen* (JP: 改善) business principle of continuous improvement with the *Toyota production system* (TPS) – or "just-in-time manufacturing" (JIT) – a demand flow manufacturing system.

and fettling, in order to make the building machine run smoothly in a world characterized by uncertainty. Thus, the builders take on a dual role as "machinists" and "cogwheels," in what we call *craftsmanship of uncertainty*, drawing on the theoretical tradition of Pye (1968), who discussed workmanship of risk and workmanship of certainty. We define craftsmanship of uncertainty as craftsmanship that produces reliable results in an uncertain context. This type of craftsmanship is specialized for the technologized building site and a novel way of practicing craft.

Whilst critically discussing several theories of craft, the article is primarily empirical, using the case study to introduce the topic of craft in a technologized setting. Similar to the second article, the case study provides an example of the changing nature of craft practices.

Additionally, planning – and not merely implementation – at the construction site is quite important and involves multiple craftspeople. They are required to attend meetings in order to plan forthcoming work and provide insights into their current problems. In this way, the craftspeople are enrolled as actors in the building process in a much more thorough manner, utilizing their skills more than they would otherwise, if they were just to be handed orders.

The article relates to the other articles, showing that craftspeople have a unique competence and skillset that, if correctly employed, greatly benefits the entire building process. As craftspeople are normally the persons called when a building has problems after completion, it is imperative that they are involved in construction prior to completion, and even prior to the building work starting.

2.5 Questions raised by the articles

What do these articles have in common and why are their common trajectories interesting to follow? All of the articles point to ways of understanding craft professions in transition: whilst buildings are undergoing an energy efficient sustainable transformation, craftspeople themselves are also changing in accordance with – or in reaction to – the green policies that they are tasked to implement. How can this be understood? Before I attempt to do so in the cross-cutting analysis, I will explore previous research on aligned subjects and theoretical frameworks that can help us understand craftspeople's practices.

3. Previous research

This thesis focuses specifically on the practices of craftspeople working on energy transitions from a social scientific humanities (SSH) tradition. Only a limited amount of prior research on this precise topic exists. Although there is a wide variety of STEM[37] literature on how buildings can be made sustainable (e.g. chemical formulas and mathematical algorithms for achieving acceptable insulation values), this topic is not my focus.

This is a social scientific thesis, and as Gram-Hanssen (2014: 393) points out: “The understanding that houses are owned, occupied and retrofitted by (the same) people implies a need to focus on the human dimensions of the retrofitting process.” Thus, there is a need to understand how social processes relating to sustainable dwelling are co-constructed with craftspeople’s practices of retrofitting. I will first give an account of research literature on craftspeople and then provide an overview of sustainable building research. I will then move on to my main investigatory subject of craftspeople working as energy consultants.

3.1 Craft and craftspeople

Craftspeople are professionals who work with their hands to create things. Some professionals use simple tools, and their products are usually made one at a time (in contrast to the norms of industrial production). Sennett’s (2008) book *The Craftsman* is regarded by many craft scholars as the epitome of sociologic craft research. In this book, Sennett provides a thorough introduction to a quite broad definition of craftspeople, comprising a variety of professionals, from potters to those who raise children. In this way, Sennett posits that the will to do something well resides in all of us. Sennett’s concept of a craftsperson is a perfectionist – someone who excels by honing skills, striving for continuous improvement, and showing dedicated learning – someone who is dedicated to good work for its own sake.

[37] STEM stands for “Science, technology, engineering, and mathematics,” also known as the “hard sciences.”

A re-examination of the term *craft* is suggested by Frayling (2011), who argues that craft is a combined effort of head and hand thinking. This interrelation between head knowledge and hand knowledge is also emphasized by Hofverberg and colleagues (2017), who define craft as "skilled hands making products (together) with materials," and Owen, (2017) who defines craft as "deploying skilled labour to shape physical materials to create a unique item." The notion of craft is being challenged and added to by do-it-yourself (DIY) culture, the maker movement (Hatch 2013), and art, as exhibited by Adamson (2013), who argues that craft is a parallel and "break out thing" of industrial processes. Adamson (2007) connects art to craft, arguing for a nuanced view of craft by showing how craft has contributed to contemporary art practice.

Luckman (2015) writes about craft and the creative economy, noting the rise of online craft entrepreneurship, especially through online sites such as Etsy.[38] She challenges craft's relation to feminism, cultural settings, social media, digitization, and technology, demonstrating new ways of crafting. Ingold (2013) elaborates on the concept of thinking through making by describing what it might mean to create things and how the intricate interrelation between design, material, and form constitutes "making."

3.2 Energy retrofitting in Europe

Many European countries have prioritized the goal of reducing energy consumption in their building sector. Additionally, while EU regulatory goals for achieving energy emission targets exist in the European Climate Change Program (ECCP) – and, more specifically, in the Energy Performance in Buildings Directive (EPBD, recast 2010) – energy advising in the building sector seems bound to national contexts. Given language barriers and differing laws and policies, one would suspect that energy consulting for building retrofits would be difficult to conduct across countries.[39]

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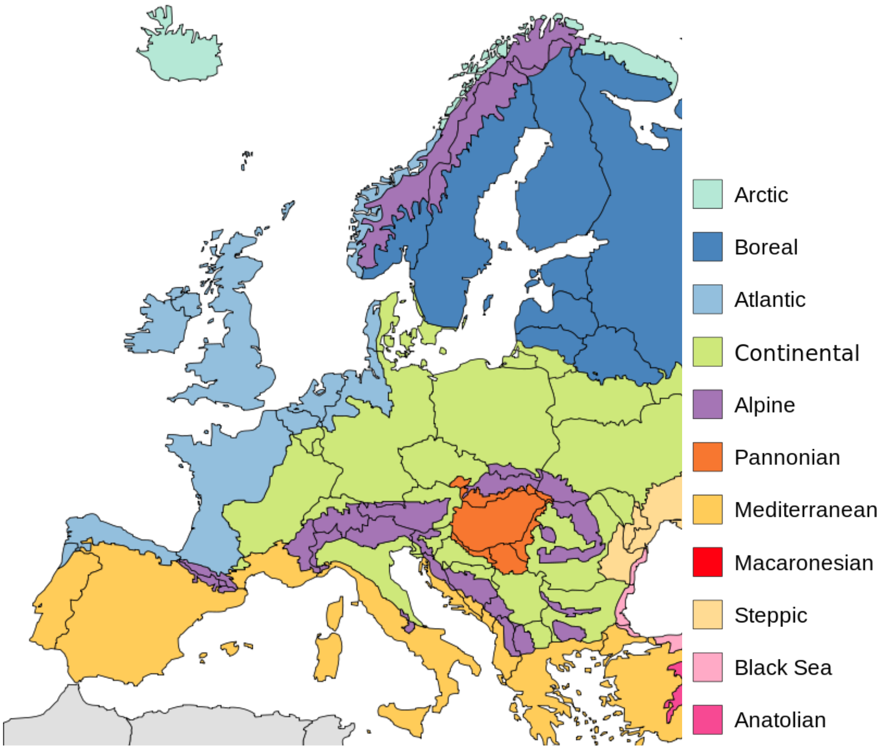
[38] Etsy is an online marketplace similar to Amazon or eBay, specializing in handmade objects (i.e. crafted things) that are made by the seller. Challenging mass-produced items sold on other online marketplaces, Etsy vends mostly unique handmade items.

[39] However, some private enterprises facilitate such efforts, including cleanenergysolutions.org (which provides advice to countries and government representatives) and energyadvice.com (which provides advice to commercial actors).

Another issue is the various climate zones across Europe, which makes governing common energy standards for sustainable buildings difficult. The map[40] below shows, for example, that Norway is part of four different biogeographical zones:



Different European countries offer different support for reaching energy goals. For instance, depending on the country, homeowners may need to access consulting on a local or a national level (see Tommerup et al. 2010 for examples). In Germany, KfW Förderbank is a bank that provides energy saving support, originally funded through the Marshall Plan. The support is directly tied to how close a homeowner can bring his or her home to the standard of new German houses, and in 2012, it supported the renovation of 200,000 German houses (ibid.), contributing to many jobs in the German building sector.

[40] The map (from https://www.eea.europa.eu/) illustrates how Norway is located in four distinct biogeographical zones: arctic, boreal, Atlantic, and alpine. These zones have implications for the implementation of house regulations. A strength of the Norwegian system is that it attempts to regulate all of these zones on an equivalent basis. For example, initially, passive houses had different standards in northern and southern Norway. However, they now have the same standard (which makes passive houses harder to achieve in the north, due to less sun in the winter months).

Austria has similar programs that provide a free energy consultant home visit prior to support seeking.

In the UK, the "Green Deal" is three-part program involving a Green Deal assessor, a Green Deal provider, and a Green deal installer (typically a craftsperson), who are each pre-approved and certified. All three can be from the same firm. The program was created in 2012 with the dual goal of helping England meet its climate goals and creating new jobs. In neighboring Ireland, the Better Energy Homes program (launched in 2009) has helped 100,000 homes become more energy efficient by providing money for each installation (ibid.). In the Netherlands, Corporate Social Responsibility has had good success; through this program, private investors put money into a fund and homeowners can apply to receive money from this fund for green projects. Since 1995, 6,000 projects have been funded through this program (ibid.).

In northern Europe, retrofitting schemes are similar to those used in Norway. Hassouri, Gundersen, and Bolwig (2014) showed that Nordic homes account for 70% of all energy used by Nordic buildings. Most of these homes are at least 30 years old and in need of general renovation. However, the authors noted that Nordic homeowners do not prioritize energy efficiency when considering renovation; that is, they do not see "quick money results" from energy renovation and find it difficult to access information on it.

Scandinavian countries aggressively pursue energy consulting and retrofitting, albeit with some striking differences between them. Tommerup and colleagues (2010) wrote a report on *Existing Sustainable Renovation Concepts* that discusses energy renovation solutions in Nordic countries. The report discusses how Nordic single family building retrofitting is dominated by craftspeople offering individual solutions, traditional warehouses, "do-it-yourself shops," and actors marketing single products. That is to say, there is a chaotic "jungle of buildings." However, there are several Scandinavian attempts to govern this jungle.

Most strikingly, in Sweden, energy consulting is municipality driven and free of charge (Matsson 2000; Westelius 2008). The Swedish Ministry of Economics created the Swedish Energy Agency (Energimyndigheten), which is responsible for installing at least one "climate and energy consultant" in each of the country's 290 municipalities (Nair, Gustavsson, & Mahapatra 2010).[41] These consultants are organized into an energy advisor union (Energirådgiverna).

The Swedish Energy Agency also commissioned the Energikalkylen – a tool that calculates homeowners' energy usage while also offering tips on how they can make their house more energy efficient. After using the tool, homeowners are advised by a consultant on the grants they are eligible to apply for; this is quite similar to the Norwegian procedure (as discussed in the second article).

Mattsson (2000) writes that the most common Swedish advising is done over the telephone, free of charge; for 500 SEK, an energy consultant will visit the home to investigate further. This is a similar process to that employed in Norway, at only one-tenth of the price. Westelius (2008) writes that the Swedish energy consulting market has a more highly organized network of advisors. Furthermore, the Swedish ROT deduction funds 30% of retrofitting costs.[42] Sweden also has an interesting comparative sector of car manufacturing, which has great similarities to house building, especially when it comes to worker involvement.[43]

Denmark has been the site of some of the most extensive research on energy consulting. Hassouri and colleagues (2014) and Jensen (2004) focused on barriers to energy efficiency gains, and Strandgaard (2012) showcased some Danish cases (e.g. a highly networked group of advisors included in many decision making processes). The Danish energy advising landscape is much wider than the Norwegian one.

The Danish Energy Authorities (Energistyrelsen), founded in 1976 under the Danish Ministry of Energy, Utilities and Climate, runs a service called BedreBolig (EN: "better homes"). In addition to advising, BedreBolig can also manage the renovation process. It has 211 consultants listed in its database, comparable to its Norwegian counterpart. The service is primarily geared towards creating a link between homeowners and craftspeople. A homeowner using BedreBolig can be referred to up to three energy consultants, free of charge.

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[41] However, studies by Mahapatra, Nair, and Gustavsson (2009) indicate that this free service is not often used.

[42] In Scandinavia ROT stands for the "rehabiliterings-, ombyggings og tilbyggsmarkedet" (EN: "rehabilitation, reconstruction, and additions market"). In Sweden, it provides a 30% tax deduction on these services, leading to 19.9 billion SEK worth of tax deductions in 2015: https://byggmesteren.as/2016/01/25/rekordmange-brukte-rot-i-sverige/.

[43] For a deeper dive into the Swedish car industry and how workers' competence and expertise was developed, see (e.g.) Ellegård, Nilsson, Engström, and Hedin (1991).

BedreBolig also collaborates with several programs, such as SpareEnergi and Energitjenesten, which support energy efficiency renovations in homes more broadly. SpareEnergi is an informational service (also under the Danish Energy Authorities) that provides tools for homeowners to self-calculate energy use in their homes and a list of craftspeople that homeowners can contact. Energitjenesten is a service that trains energy advisors and makes informative presentations about energy usage at schools.

In Denmark, most energy advising seems closely knit with other actors, such as municipal craftspeople networks (as described by Strandgaard 2012). One example of such a network is ZERObolig, based in the Sønderborg municipality. ZERObolig promotes a three-step model for energy advising: "check, fix and save."[44] This model is similar to the Norwegian model, which can be summarized as "consult, retrofit, save."

Another example of a Danish network with many actors in energy advising is the Network of Energy Advising,[45] which consists of 50+ actors working together to provide energy advice. In their report (Energirådgivning 2013), they describe their focus areas: better information, education and greater competence, research, enrollment of energy companies, financing of energy renovations, data for energy renovation, and demands.

Additionally, in Denmark, energy marking of houses must be done by energy consultants, whereas in Norway, homeowners can do it themselves (a prerequisite for renting out or selling a home). This suggests a much higher earning potential in Denmark for energy consulting companies.[46] As this section has shown, there is a wide variety of solutions for energy retrofitting. In the next section, I will explore its innovation potential.

3.3 Innovation in the building sector

As mentioned in the Introduction, the building sector has a reputation for being conservative and unadaptable. This can be tied to a lack of interest in existing buildings (Ryghaug & Sørensen 2009). In Norway, the building sector is primarily composed of many small- and medium-sized companies with limited capacity for innovation. Barrett

[44] Vanhoutteghem & Rode (2014) pointed out a problem with ZERObolig, in that homeowners do not receive specific guidance on the renovation process, but are left to communicate directly with the craftspeople, which puts more pressure on the craftspeople. Another weakness is that ZERObolig does not guarantee that the craftsmanship will be of a certain standard (though they will remove craftspeople who perform inadequately from the list).

[45] In Danish, this network is called the Netværk for Energirådgivning.

[46] Energy retrofitting is not only a European focus, but also extends, for example, to the United States (see Liang et al. 2017). In order to keep this section focused, I will limit my investigation to the more localized context of Norway and its neighboring countries.

and Sexton (2006) showed that small construction firms do not prioritize innovation. However, small companies are not *incapable* of innovation; Manley (2008), for instance, gives an account of successful innovations made by small construction companies.

Prior research has focused on barriers to innovation in the construction industry – in particular those concerning management and organization. Bresnen, Goussevskaia, and Swan (2005) found, when studying construction firms that implemented change, that management of the change process was key. Gann and Salter (2000) argued that a better conceptual understanding of management practices in construction is needed in order to link projects with business processes.

Additionally, the construction sector is often affected by a high degree of uncertainty. Demaid and Quintas (2006) describe how rigid markets, uncertainty, and changes to legal and ethical imperatives make sustainable buildings a messy affair. Such conditions can be tied to regulatory regimes, as Dewick and Miozzo (2002) argue, showing how the building sector is – on the one hand – supposed to be heavily regulated to, among other things, ensure the safety of buildings, and – on the other hand – criticized for being too regulated, and thus not innovative.

Innovation is tied to taking risks, and for many small construction companies, risk taking is difficult, as the companies need to be perceived as stable and reliable by their customers. The way in which craftspeople manage the green-shift so that it does not jeopardize a company's reputation as stable and reliable is thus important. As Heerwagen (2000: 2) argues, it is not about "how green you make it – it's how you make it green."

A study of craft in Norway touches on the subject of foreign laborers (who, e.g., comprise a large percentage of carpenters), who have received much research attention as of late. In his doctoral thesis, Friberg (2012) discusses the perception of Polish immigrants working in the building sector and highlights the lack of permanent employment for these workers. In Friberg's analysis, there is a divide between Norwegians, who are able to obtain permanent employment, and immigrants, who cannot. This, combined with the difficulties immigrants face in obtaining Norwegian language skills, creates an employment situation fraught with complexity.

Dyrlid's (2017) doctoral thesis also examines Polish immigrants working in Norway. The majority of her Polish male informants worked in the construction industry, and she emphasizes the Norwegian language programs and learning processes that Polish workers immigrating to Norway could engage with. Dyrlid shows how the workers were not labelled as solely Polish immigrant workers; rather, through their hard work, they were identified with industriousness more than foreignness, and viewed as attractive employees.

My thesis is not focused on immigrant workers, specifically, as such workers have already been extensively studied. Additionally, as the work of energy consulting is rather complex, few immigrant workers hold this role, e.g. due to language barriers.

3.4 Energy consulting in Norway

The Norwegian energy retrofitting and consulting sectors share some similarities with the European cases described above. From the 1970s through the 1990s, Norwegian energy and environmental policies were dominated by "energy economizing,"[47] wherein "local energy-suppliers were left to inform the energy users on energy economizing actions that they should do and what gain those might bring them" (Sørensen 2007). Sørensen describes "energy economizing" as a discussion primarily between engineers, who saw energy efficiency as a technological phenomenon, and economists, who saw it in terms of cost efficiency; environmental issues were given less focus. According to Ryghaug and Sørensen (2009), "policy-makers seem to have believed that ENØK policies would translate themselves"; of course, as several studies have shown, this was not the case (Hubak 1998; Moe 2006; Ryghaug 2003; Sørensen 2007).

There are a wide variety of energy efficiency measures that target the building sector. A variety of energy efficiency instruments have been discussed by Ibenholt (2011), who calls for increased use of energy efficiency instruments in existing buildings and the introduction of "white certificates" (i.e. outsourcing energy production/consumption by making it marketable). Hojem, Sørensen, and Lagesen (2014) found that "policy-makers should encourage initiatives to ease the transfer of new knowledge and technology to the building sector by facilitating transition activities." I will explore this further in the cross-cutting analysis, examining whether craftspeople can serve as facilitating agents.

In a recent CenSES report[48], Sørensen gives an overview of energy policy tools, emphasizing action-oriented social instruments that supplement more traditional economic

[47] In Norway, energy economization is known as ENØK, which is widely understood by the public as an energy saving policy.
[48] The report, *Virker de? Virkemidler for energieffektivisering med vekt på bygninger* (EN: "Do they work? Instruments for energy efficiency with an emphasis on buildings"), can be found here: https://www.ntnu.no/documents/7414984/1275356549/VirkerDe.pdf/5347ca1c-824b-4d6c-b553-8e344281e437.

and technological instruments. He mentions a wide variety of instruments, such as networks of knowledge for energy-focused buildings, energy markets, climate and energy plans for municipalities, and Enova's information material and advisory activity. Enova was criticized by Fyhn and Baron (2016) for having too high of a threshold for subsidies due to a "must retrofit everything at once" policy (i.e. a policy that prohibits one from retrofitting one room at a time). Enova's goals were also scrutinized by Solli (2004), who discussed the goal of being cost-effective in the context of actual implementation.

In regards to craftspeople working as agents of sustainability, the Arnstad report[49] state that there should be increased strategic investment in craft education in order for energy reduction goals to be met. Risholt and Berker (2013) note that "the craftsman has no gains from energy efficiency. What should be looked into is if the craftsman could be the one assessing the dwelling and preparing the plan for energy saving renovation." A report by MMI (2014) shows that craft businesses are reluctant to invest in their employees' skills when doing so does not directly lead to increased profit. Additionally, the report finds that increased skills in individual employees can be negative, as the specific employee might become "too attractive" on the job market and leave to pursue higher paid work. The report also concludes that its informants did not strongly identify with the energy consultant role.

Jensen (2004) produced a report tackling the "barrier issue," primarily focusing on the barriers met by homeowners seeking to make their home more energy efficient. One potential barrier cited in the report was homeowners' skepticism towards craftspeople (real or perceived), which related to their having various professional traits that homeowners disliked (e.g. "craftspeople are messy") (ibid.: 13). The report also described how energy efficiency was not "in," insinuating that one would not brag about one's attic in everyday conversation. Our study found a more complex situation, in that our informants mentioned that some wealthy homeowners might want to show off their "monetary ability to retrofit." In this context, retrofitting was considered more of a form of conspicuous consumption than something truly driven by energy efficiency concerns; our informants regarded this as quite pompous.

[49] See Arnstad, E. (2010) *Energieffektivisering av bygg*. From: https://www.regjeringen.no/globalassets/upload/KRD/Vedlegg/BOBY/rapporter/energieffektivisering_av_bygg_rapport_2010.pdf

A Danish study, also by Jensen (2013), presented energy advising as a tool to primarily "break barriers." The result of these broken barriers, together with information, regulation, and economic support, was thought to be energy savings. The paper primarily considered craftspeople in relation to *håndverkerfradrag* (EN: "craftsperson deduction"), or the economic savings that result from the use of certain craftspeople.

Energy consultants come from a wide variety of professional backgrounds, many of which have received considerable research focus. For example, architects have been much studied as agents of sustainability. Kjølle, Blakstad, and Haugen (2005) focused on boundary objects between architects and end users – especially briefings as processes, not products – whereas Kongsli, Ryghaug, and Sørensen (2008) found that architects might lack the authority to enroll other actors in sustainable action plans. Another profession that closely relates to craftsmanship is engineering, and the actor-group of engineers has also received considerable research attention (Amdahl & Sørensen 2008; Hubak 1998; Sørensen 2009). Hojem's doctoral thesis (2012) focused on the role of consulting engineers in sustainable building, examining how "consulting engineers engage with new environmental knowledge," whilst Hojem and Lagesen (2011) investigated the way in which engineers constitute different assemblages in their work on environmental concerns. Solli's (2013) article, "Navigating standards–constituting engineering practices – How do engineers in consulting environments deal with standards?" also examined engineers, exploring their uncertainty when attempting to comply with standards.

When it comes to construction laws (including the aforementioned TEK), Müller and Berker (2013) and Müller (2015) extensively researched engineers' domestication of regulations. Müller (2015: 96) found that research engineers perceive laws "differently" than the law prescribes. Pries and Janszen (1995) give an account of how engineer paradigms in the construction industry can make it difficult for craftspeople to innovate. Taking the different professions involved into account, Reichstein, Salter, and Gann (2005) show how craftspeople trying to innovate in the construction sector are seen as the "last among equals," as they are perceived to only be interested in fast cash and to lack a deeper commitment to the profession

Building operators – often in close collaboration with craftspeople – are also increasingly relevant for climate change mitigation activities. Bye's (2008) doctoral thesis was an extensive study of building operators' role in managing the energy usage of buildings, finding that their knowledge of building operation should be used in the design and construction phase and not only in the operation phase. Aune, Berker, and Bye (2009) define this actor-group as "the missing link that was already there."

Perhaps the most important actor-group that craftspeople must work with in home retrofitting is that of homeowners. Aune (2007) found, in a study of energy consumption and everyday life, that energy consumption practices are closely connected to the way in which homes are domesticated. Homes have different images and practical constructions, and energy efficient retrofitting projects must take these into account. According to Aune, Godbolt, Sørensen, Ryghaug, Karlstrøn & Næss (2016), people have become increasingly aware of the environmental issues regarding energy use and will likely respond positively to energy saving measures such as retrofitting, as long as such measures fit into their everyday routines.

With so many actors involved, how do craftspeople navigate this field? How do craftspeople – especially working as energy consultants – contribute to sustainable transformations in Norwegian buildings? How can buildings be affected by the detailed work of practitioners? In order to further understand this, I will utilize the theoretical concepts described in the following chapter in a cross-cutting analysis of the issue.

4. Theoretical framing and practices

This project is grounded in *science and technology studies* (STS) (Bijker & Pinch 1987; Callon 1986; Latour, 1988; Law 1986), which takes a non-deterministic, constructivist, and practice-oriented approach. STS critically investigates knowledge production, technological development, and the interrelations between science, technology, and society (Jasanoff, Markle, Peterson, & Pinch 2001). Exploring the expertise of different actors is also a key focus, e.g. through laboratory studies (Knorr-Cetina 1981; Latour & Woolgar 1979).

Stemming from a wide array of backgrounds, STS has important theoretical roots in *social construction of technology* (SCOT) (Pinch & Bijker 1984), *actor-network theory* (ANT) (Law & Lodge 1984), and *large technological systems* (LTS) (Hughes 1987). Whereas LTS is derived from technological history, focusing on huge and complex systems such as the electricity grid, SCOT focuses on the interrelation between humans and technology and identifies the influence of relevant social groups in technological development. ANT emphasizes the continuously evolving networks of actors and actants (human and non-human actors) whilst examining how "things" are also important parts of the same networks.

The term *black box* is important in STS, referring to the "obscuring" of social, scientific and technological processes (Latour 1999). Black boxing means that we only understand the input and output of these processes, with little knowledge of the processes, themselves. One example of a black box is the sustainable building, which is often discussed in terms of its input (in terms of, e.g., materials and energy used) and output (in terms of, e.g., energy performance and the sense of well being it promotes for those who dwell within it). A sustainable building is a result of technical and behavioral aspects, and it is a political construct as shown in the previous chapter. My thesis does not investigate the political, technical or behavioral as such, but analyses the practical craft in transforming a building. What skills and practices are relevant in constructing and retrofitting homes for sustainability?

In this chapter, I will introduce the concept of *framing* (Callon 1998; Goffman 1974) to examine how sustainable building retrofits are shaped and reshaped. I will primarily use Callon's theoretical framework for the analysis, as this framework provides important insight into the sociotechnical side of the issue. As the four articles show, the framing process consists of tying together heterogeneous elements: calculations, technologies, policies, and practices.

As the topic heavily concerns practitioners, I will also use *social practice theory* (SPT) (Shove 2010) to investigate the practices of craftspeople. Practitioners have been widely studied in STS. For example, researchers have studied the practices of engineers (Hojem & Lagensen 2011), architects (Kongsli et al. 2008), and building operators (Bye 2008). However, while these works have all focused on the practices of practitioners, they have not all, strictly speaking, employed SPT to do so. This illustrates that practice research is a broadly interdisciplinary field. Using SPT, I will go a bit deeper into the practice aspect of these practitioners and examine the practices of builders, adding to theories of framing. These two core theories will be explained in the following chapters.

4.1 Framing and reframing

In his book *Frame Analysis: An Essay on the Organization of Experience*, Goffman (1974) introduced an interdisciplinary research methodology that was designed for examining the way in which individuals organize their experiences. Frame analysis provides insight into how people's actions, norms, and habits create frames over time. Goffman's framing concept can thus be understood as one that delimits the experiences and meaning making attached to specific social settings and interactions. It has made a strong contribution to interaction analysis.

Goffman (1974: 21) introduced the term *primary framework* as "a schemata of interpretation," or the core frame reference point from which all who adhere to the frame base their definition. He divided this further into natural frames (the "purely physical," or the ground on which a house is built) and social frames (e.g. the morning routines of people who live in the house) – both of which affect the general framing of what it means to live in a particular house.

4.2 Externalities and overflows

Callon (1998) redeveloped the concept of framing to better understand economic markets through a social scientific lens. He promoted an STS perspective in the field of economics in order to expand both "pure" economics and economic sociology. Specifically, Callon (ibid.) redefined the economic concept of externalities. In economic theory, one is meant to avoid externalities in order to prevent the system or calculation from becoming suboptimal. Externalities are, in other words, unwanted variables that do not fit – or are forgotten in – a framing. However, externalities are often perceived as problems that must be addressed. According to Callon, they can be described as "overflows."

One example of an overflow relates to the biofuel. Biofuel was initially framed as a sustainable fuel source. However, this framing did not consider how crops used for fuel became unavailable as food sources, and that this was especially detrimental for poor communities. This reduction of food resources was an overflow, and when this overflow was recognized, biofuel was reframed to account for it.

A problem with overflows, according to Callon, is that they need to be both detectable and measurable; this is easier said than done. Overflows in the energy performance of buildings can be seen as both expected and prepared for and a disaster that threatens the frame. Only when overflows are properly identified can one deal with them and open up the possibility of reframing them. This process, Callon wrote, involves internalizing the externalities, allowing the frame to contain the overflow.

Callon (1998: 260) further described situations as either "hot" or "cold." Cold situations are easy to manage, as their overflows are easily detectable and measurable (e.g. a broken window frame). Hot situations, in contrast – which are increasingly replacing cold situations – have a complex and heavily contested nature, so it is nearly impossible to contain their overflows (e.g. the Norwegian custom of sleeping with one's bedroom windows open, which heavily inhibits balanced ventilation). In the following analysis, I will explore this hot and cold typology.

Examples of energy studies using framing include those conducted by Aune and colleagues (2016), which gave an account of the framing of the electricity market in Norway, and Aune (2012), which examined how energy was framed in domestic property market advertisements.

Callon's notion of framing strongly relates to his other work on social economy, such as that pertaining to *calculative collective devices* in markets (Callon & Muniesa

2005) and *qualculations* (Callon & Law 2005), through which he introduced judgement into the act of calculating, as exemplified by *agapè* (selfless love) – first described by Cochoy (2002). In their study, Aune and colleagues (2016: 347) found that "consumers appeared to be qualculative rather than just calculative agents." Additionally, when discussing the framing of economization, Çalışkan and Callon (2009, 2010) suggested considering *processes of economization*, through which social scientists' and market actors' assembly of actions and descriptions are made economic. Such energy economic processes can also be used to frame sustainable buildings.

As Callon (1998) emphasized, all framings are incomplete and imperfect, as they always externalize some aspects and entities in order to keep the frame tight. Nevertheless, framing theory can be used to understand how houses are shaped and reshaped. In order to further understand how sustainable buildings are framed and overflows are mitigated, I will look at how craftspeople contribute to sustainable transformations of Norwegian buildings. Examining the craftsperson's profession through a practice perspective can help to clarify this.

4.3 Social practice theory

Shove (2010) describes social practice theory (SPT) as "understanding [that] social change is in essence a matter of understanding how practices evolve, how they capture and lose us, their carriers, and how systems and complexes of practice form and fragment." Shove and colleagues (2012) further denote that practices are driven by personal choice in regards to beliefs, values, lifestyles, and tastes. SPT is a theoretical tool that challenges the structure and agency dualism by understanding practice as a habitual action that links physical and physiological human action with a multitude of things in different usage areas. In this manner, SPT has a lot in common with *domestication theory* (Lie & Sørensen 1996).

Domestication theory has roots in more established practice theory, including the work of Bourdieu (1977), who introduced the concept of *habitus* (i.e. social order internalized in the body); Giddens (1979), who saw practice as a unification of structure and agency, explained as *structuration*; and Ortner (1978), who brought together anthropological studies with practice studies, seeking to fold actors into a social structure. These three scholars were branded by Bräuchler and Postill (2010) as "first wave practice theorists."

A second wave of practice theorists (ibid.) are currently building new understandings of practice into the theory. Schatzki (2001) has added the concept of a *total field of practices*, encompassing all global practices and emphasizing both the cosmopolitan stretch of practices and the situational context of practices as socially constructed. Schatzki distinguishes between *integrative* and *dispersed* practices, with the former being complex hands-on practices such as building houses through hammering nails, and the latter being more abstract processes, such as thinking about how to do that.

Shove and colleagues (2012) have developed social practice theory further, focusing more on practices, themselves, than on human agency. This is particularly relevant to an examination of craftspeople, who form meaning-bearing activities through their skilled manipulation of materials. Practice theory enables a focus on the practices of professionals, allowing us to determine how the activities they perform on a regular basis shape their profession.

SPT (Shove et al. 2012) has three specific analytical foci: materialities, competences, and meanings. Additionally, the theory examines the connections between these three over time, investigating how practices change or remain the same. Shove and colleagues (2012: 23) define materialities, the first central focus of SPT, as "objects, infrastructures, tools, hardware and the body itself"; that is, anything that can be accounted for physically. In my research, such materialities were exemplified by, for instance, buildings, craft tools, and the human bodies involved in retrofitting. Competence is described as "know-how" (ibid.), or background knowledge and understanding. As I will describe in my analysis, competence in my research referred to the know-how of hands-on knowledge and experience. Meanings are described as "mental activities, emotion and motivational knowledge […] the social and symbolic significance of participation at any one moment" (ibid.). In my study, meanings were an important component of the inquiry, as they facilitated a deeper understanding of not only *how,* but also *why* craftspeople were working with sustainable buildings.

Connections between practitioners are described in *The Nexus of Practices: Connections, Constellations, Practitioners*, edited by Hui, Schatzki, and Shove (2016). This book investigates SPT from another vantage point, aiming at understanding people as practitioners.[50] It challenges criticisms of SPT that brand it as too localized and suitable

[50] Another strand of connections research is found in the concept of *communities of practice* (Lave and Wenger, 1991), which emphasizes how communities that share similar practices, such as coworkers in an

only for smaller tasks. The book's subtitle describes the triple focus on practitioners, their connections, and the constellations they form.

SPT has some contested space with STS. SPT's main theoretical criticism of STS – and particularly ANT – has, according to Shove and colleagues (2012: 10), inspired "debates about the relation between humans and non-humans […] but has ironically done so in ways that divert attention away from more ordinary questions about what these cyborg/hybrid entities are actually *doing*." Such relations can be *better* understood through theories of practice (ibid.), which put more emphasis on the practices of configuration, rather than the configuration, itself. In this thesis, I take both a *configuration* and a *doing* approach, connecting SPT to framing theory.

4.4 Practices of framing and reframing

Having described the two main theoretical perspectives taken in this analysis, framing and social practice theory, an explanation of why these two were chosen and how I will combine them are in order. Framing theory was chosen as a means of explaining the processes involved in solidifying sustainable buildings, seeing framing as a holistic, multivocal process. Sustainable buildings are framed by different actors, and in some cases the sustainable framing can create overflows. Overflows, as mentioned above, are unwelcome, as they have the potential to break the frame and must therefore be sealed.

Overflows can be dealt with through technology, energy consulting, and the practices of craftspeople. I have therefore focused on craftspeople's methods for sealing overflows in the framing of sustainable buildings. Social practice theory enables us to understand the practices of craftspeople and how they relate to the buildings they are tasked to make sustainable. Although framing in a Callonian sense is a relational theory, SPT can complement this by seeing practices as all-encompassing. This difference between the theories allows for a comparative theoretical analysis of how the findings can be understood in one theoretical strand and not the other. According to Shove and colleagues (2012: 3), SPT thus relates more closely to Giddens' (1984) position of *structuration*, in that the theory states that practices are recursively related and not shaped by human agency.

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office environment, learn from other practitioners in their community (in SPT, the learning concept is not explicitly the main focus). Lave and Wenger see this in quite a hierarchical context; for an analysis of learning practice in a more egalitarian context, see (Søraa, Ingeborgrud, Suboticki, & Solbu 2017) which describes the concept of *communities of peer practitioners*.

SPT was previously applied to building retrofitting (specifically of domestic buildings) by Karvonen (2013). The theory enables a focus on craftspeople's practices, as it allows researchers to analyze the social practices they exhibit as members of a working professional group. Additionally, it ties to the wider framing of sustainable buildings by allowing craftspeople to be understood as meso-agents of transition between huge macro-governmental policies and individual homeowners' micro-practices of dwelling. Hence, an analysis of the meso-practices of craftspeople and how craftspeople become carriers of those social practices can provide valuable insight into their framings of sustainable buildings. In contrast, framing theory allows one to determine how sustainable buildings are framed by a variety of actors, in addition to craftspeople. By combining these theoretical strains, one can gain an understanding of how sociotechnical framings of sustainable buildings are formed through craftspeople's practices. This leads to the following theoretical inquiries, which will be investigated in the following cross-cutting analysis:

1. How are sustainable buildings framed and what overflows do these framings create?
2. How can craftspeople mitigate overflows and participate in the reframing of these buildings?
3. How do practices of craftspeople contribute to the construction of sustainable buildings and how are their practices changing?

5. Cross-cutting analysis of sustainable craft practices

By utilizing the two theoretical concepts described in the previous chapter – framing theory and social practice theory – in a cross-cutting analysis of the four articles in this thesis, this chapter will explore how sustainable buildings are framed, the overflows these framings create, and how the practices of craftspeople contribute to both mitigating these overflows and reframing sustainable buildings.

Together, the four articles tell a story about the situation of contemporary craft practices of sustainability in the Norwegian building sector. For readability, I will refer to the articles by order of appearance, with abbreviated names. They will thus be henceforth referred to as: Article 1 ("Why energy retrofitting in private dwellings is difficult: Coordinating the framing practices of government, craftspeople and homeowners"), Article 2 ("Crafting environmental policies into action: Energy consulting practices of craftspeople"), Article 3 ("Energy consultants calculating sustainability in the built environment"), and Article 4 ("Craftsmanship in the machine: sustainability through new roles in building craft at the technologized building site").

Article 1 tells a story of governance – how the rather strict rules and regulations for governing energy transition policies in the Norwegian building sector are planned on a political, governmental level, and the intentions and context of their implementation. Article 2 introduces the main characters of the story: the craftspeople working with energy issues. It also discusses the contemporary practices of these craftspeople and shows how they physically enact the policies described in Article 1.

Article 3 further explores the items and artifacts of the story – energy calculators – that are being pushed onto craftspeople by the policies and problematizes the lack of a pull mechanism for providing feedback on and co-creating these tools. In Article 4, a case in which craftspeople collaboratively face the challenge of building Norway's largest massive wood building complex, Moholt 50-50, is outlined.

As a society, we need craftspeople to create and fix things. In the case of buildings, new buildings must be built and old buildings must be retrofitted. What can these stories tell us about the framing of sustainable buildings through the practices of craftspeople?

5.1 The framing of sustainable buildings

Energy efficiency and environmental sustainability were only recently (in relation to the age of most buildings in Norway) identified as essential components of a building's framing. This was driven, to a significant degree, by government regulation, including the technological demands of TEK. Making buildings sustainable is seen as one of the most feasible ways of achieving huge energy reductions and facilitating a broader societal green-shift. The evaluation of buildings in relation to this frame requires attention to be paid to two variables: the status of the retrofitting of buildings and the manner in which new buildings are constructed

In order for a building to be "countable" within broader global energy calculations, it must adhere to the calculative framing; that is, one must know exactly where it is, what its energy performance is, and when someone does something with it. Such data is relatively straightforward to gather for new structures, such as the Moholt 50-50 project described in Article 4, as they are designed to adhere to strict sustainability regulations such as TEK17. The regulation of new buildings is not only strict and ambitious, but also feasible and governable in calculative formats, in this technologized age of counting and measuring.

The situation is much more complex with existing structures. The energy characteristics of such buildings are often uncertain, as most were built at a time when the energy efficiency of buildings was less regulated; for this reason, energy usage data would not necessarily have been collected at the time of construction. However, as Article 1 describes, in order for these buildings to be governable, they must first be made calculable. This situation is comparable to Asdal's (2011: 19) account of how numbers and counting are used to reshape nature to quantifiable, governable units. As also described in Article 1, government actors are attempting to count, measure, and upgrade the building mass of 2.2 million Norwegian homes. However, Enova and the Housing Bank have only (approximately) 10 employees devoted to tracking these 2.2 million buildings and determining how they might transition to more energy efficient performance. Thus, one Enova employee is theoretically responsible for 220,000 buildings, on average. Even with no days off, that employee would need to review 603 buildings each day in order to see them all within a year. We thus see that it is imperative that intermediaries are used; this is where energy consultants become the most prominent actors.

Sustainability measures in buildings are important because the government, in driving sustainability goals, is interested in measuring, and lowering, actual energy use. Energy use is determined by the way in which individuals interact with buildings, in addition to the buildings' construction. As Gram-Hanssen (2014: 393–394) points out, "a major gap exists between the technical calculations and the actual energy consumed […]

they keep lower temperatures in inefficient houses and higher temperatures in efficient ones." In other words, homeowners are not necessarily rational energy consumers, as described by what Sunikka-Blank and Galvin (2012) call the "rebound and prebound effect." But which types of overflows can we see in this framing?

5.2 Three examples of overflows

Making buildings sustainable has multiple challenges, and their framing is not necessarily straightforward. In this subchapter, I will elaborate on three distinct overflows that I have identified through my research. They are homeowners' "illogical" energy practices, "incalculable" houses, and the general problem of fitting both old and new buildings into the framing of sustainability. These are but three of the many challenging overflows of the framing of sustainable buildings, but this selection provides an opportunity to further understand how craftspeople can address overflows through reframing.

The framing of sustainable buildings can involve both "hot" and "cold" situations simultaneously (Callon 1998), but for different groups involved in the framing. For example, a building can be regarded as a cold case for policy makers, as they only need the numbers to be adequately registered; but for the craftspeople and homeowners who have to negotiate the building's energy performance into a livable physical retrofit, the situation can be quite hot, as the process of fitting the building into the daily life of its residents is not necessarily straightforward.

If everyone were to lower the temperature in their house (and forego dwelling in it barefoot in a T-shirt in the middle of winter when it is very cold outside), significant energy savings could be achieved (Wågø, Hauge, & Støa 2016). However, since this message has proven difficult for dwellers to implement, an alternative path has been chosen in the discourse, holding that buildings must be made sufficiently energy efficient for individual practice to have little impact on energy usage. Thus, the framing of sustainable houses, with its strict environmental recipe for living in them, attempts to externalize unwanted, energy unfriendly behaviors.

Inhabitants' behaviors thus become a sort of overflow in the framing of sustainable houses. People can make illogical choices, and their energy behaviors can be difficult to measure (Aune 2007); both of these facts are overflows in the sustainable framing of buildings. Buildings can be counted, measured, and changed (see Article 1), but they still need to be well constructed, and this makes the training and expertise development of energy consultants and energy retrofitters crucial.

When buildings perform poorly against energy efficient targets (e.g. by being badly insulated), they become another overflow in the sustainable framing of buildings. Turning a blind eye to these buildings is ineffective, as they impact sustainability calculations whether or not they are energy efficient. This can give a positive or a negative spin to the frame, but either way, it impacts the framing.

Another overflow is caused by buildings that are difficult to count and measure (e.g. due to being built in an irregular fashion that does not fit the calculative tools described in Article 3). Dealing with the overflow of such buildings, which literally do not fit into the frames of the energy calculator, involves registering the buildings, albeit inaccurately (in order to fit a standard template). How can these three overflows of poorly constructed buildings, energy demanding dweller practices, and incalculable houses be mitigated by craftspeople?

5.3 Containing overflows in the framing of sustainable buildings

The sustainable framing of existing buildings – as well as the framing of new sustainable buildings – in a calculable format has some issues, which I have defined as overflows. Dealing with these issues is necessary for achieving the green-shift. What role can craftspeople play in these overflow situations?

Overflows can take many forms, and I will here examine how overflows such as homeowners' "illogical" energy practices, incalculable homes (according to energy calculators), and the general problem of fitting both old and new buildings into the sustainability framing can be understood. When discussing an overflow, an important question to ask is: For whom is this an overflow? Aune (2012) found that neither homeowners nor real estate agents gave building energy standards much attention, in stark contrast to the money and political attention that had gone into the framing of buildings with energy standards. This could be described as a political overflow situation, and is partly attempted mitigated on a policy level.

In Article 1, we see how governmental agencies need to be able to count the number of buildings in Norway and know the energy performance of these buildings. Instead of relying on pragmatic good-willed consumers to collect their data, the agencies rely on professional intermediaries to gather this information. For new buildings, as described in Article 4, use of such intermediaries is an integral law governing contemporary building practice. For old buildings, the process is more complex.

It has an explicit strategy of Enova to enroll craftspeople as consultants for work on older buildings, as craftspeople are used to dealing with homeowners in person and working on buildings in a hands-on fashion. As agents of sustainability, craftspeople not only contain overflows within the technical "natural framing" (as understood by Goffmann 1974) of the building, itself, but also make plans for the dwellers to implement sustainable solutions for their building. They thus mitigate the natural overflows by offering a social reframing of how the homeowners might relate to their house. Reconciling these perspectives requires social skills and technical skills, and this is why craftspeople are such key actors; they can navigate both worlds.

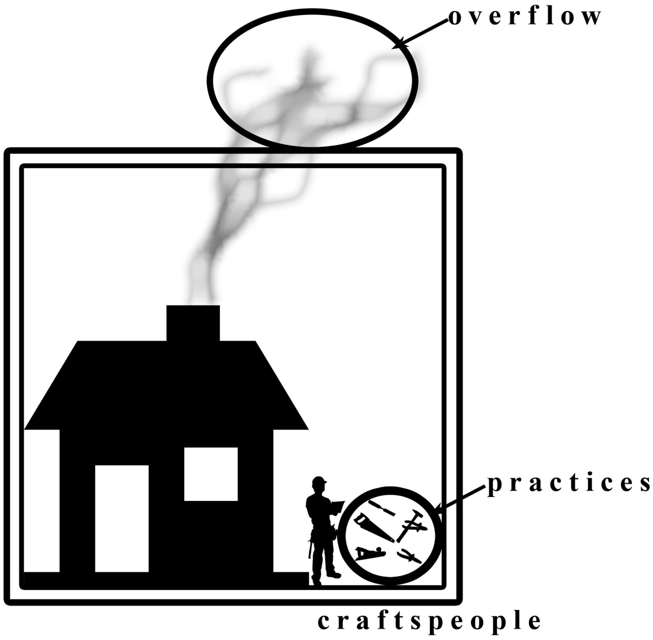
However, the concept of energy consulting is understood differently by different actor-groups. Governmental actors have an impression of what energy consulting should be (as described in Article 1), but this impression is not necessarily shared by the craftspeople who actually work as energy consultants. There seems to be a miscommunication between policy makers' wishes and reality, as one carpenter energy consultant said in an interview:

> *We have received a lot of inquiries, but to be honest, I think their campaign has been a little misguided. People interpreted their commercials as "It does not matter what they do, they will get funding for it.*

The energy upgrading schemes presented by energy consultants are interpreted by many of their customers as quick ways of getting money for upgrading to an energy efficient level. This does not resonate particularly well with the energy consultants, who often see them as quite the opposite – potentially cumbersome and quite expensive procedures (as discussed in relation to their role assignment and practices in Article 2), and not a "free lunch" of energy upgrades.

What is less communicated from the government side is the more or less "hidden agenda" of energy consulting and retrofitting, relating to the governance of having these buildings registered and accounted for in a sort of "control by calculation." As Article 3 describes, when undergoing energy consultancy, a building is transformed from a material house to a digital house, which is much easier to control, as it is countable.

As I have shown, the reframed digital house is not completely consistent with the physical manifestation of the same house. But by having more documentation on the house, the government finds it easier to contain the overflows that might occur in the sustainable framing of the house. The overflow containment process is illustrated in the figure below:



As can be seen in the figure, craftspeople are involved in containing the overflows (e.g. caused by homeowners who retrofit only parts of their buildings, despite Enova's recommendation that homeowners do a complete retrofit, as retrofits do not occur often). If homeowners disregard highly effective retrofit measures such as insulating walls and roofs or installing thicker windows, they create an overflow in the framing of buildings as sustainable, which needs to be sealed. This is where craftspeople, who visit the homes as energy consultants (as described in Articles 2 and 3), come in.

By generating energy reports of the buildings and readying them for retrofit, the consultants attempt to contain the overflow. Knowledge of houses is thus imperative for overflows to be mitigated. One of the reasons behind the political agenda to replace the Norwegian "energy economization" scheme of the 1990s was that there was little reason for homeowners to follow the advice given by the scheme, except for utilitarian and economic reasons.

The new energy consulting policy has changed this by having energy consultants give plans, rather than advice**.** These plans are concrete, and they show how retrofitting can be practically achieved, what it will cost, and what funding homeowners can receive by following the plan. Through this policy, the monetary gains for homeowners of energy retrofitting have grown from small cost savings to significant financial support.

Another way of dealing with overflows in the framing of sustainable buildings is to deal with them before anyone moves in. Article 4 describes how Moholt 50-50 was thoroughly conceptualized through planning tools, involving a wide variety of actors at the construction site. As an example (provided by the informants on site), when a bathroom was fitted in reverse, creating a potentially disastrous overflow (imagine installing a shower and realizing that the pipes that are supposed to provide water are directly opposite you in the room), professionals realized the mistake and quickly contained the overflow by refitting bathroom in the correct direction. Generally speaking, on a building site, things must be done in the order in which they are planned; but if they are not, craftspeople's expertise and improvisation are key.

By dealing with the overflows of the natural framing of buildings hands-on, and dealing with the social framing of dwelling in person, craftspeople occupy the unique position of mitigating energy issues in the green-shift. As Article 2 describes, craftspeople tie this to what I label "green-collar work," or work in which energy is a dominant factor in the rationale behind the practices.

Since what constitutes the framing of sustainable buildings is a relatively recent phenomenon, the substantial work craftspeople are tasked to do in containing the overflows of the frame represents a novel component of their work. This introduction of a new variable into the nature of their craft has, consequently, changed what it means to be a craftsperson in the building sector. Understanding the nature of these changes through this cross-cutting analysis will not only allow for a better understanding of the experiences of this population; they are also necessary for ensuring the success of the new tasks. These changes, explored in the following sub-chapters, involve the *materialities, competences, meanings,* and *connections* of these practices.

However, even when looking at these discrete elements, an overall pattern emerges. The government is the driving actor in many of these interactions: they define the overall goal (limited global temperature increase, limited emissions from building energy use, specific reductions on specific projects, etc.). They define how data must be recorded and counted towards documenting progress towards that goal. They also mandate what tools must be used to gather that data (e.g. energy calculators). Because of the nature of this top-down approach, craftspeople, even as they are called upon to do much more work, could feel like they are a cog in a larger machine without much individual and creative agency.

Yet their improvisatory skill is essential for these schemes to be successful. The calculators and other tools used to collect data necessary to record buildings in these schemes are often not perfectly suited to accounting for the idiosyncrasies of older buildings; they must therefore use their skills to make the data as accurate as possible. These examples indicate that the specialized knowledge and skill of a craftsperson is not obsolete; it is essential, and there are training programs that can be developed that draw on a reservoir of skill to equip craftspeople for the new tasks of sustainable building. This can not only advance the goal of equipping the building stock for a sustainable future but include craftspeople – who are essential for carrying out the project – as more equal partners. Craftspeople can thus play active roles in these overflow situations. Next, I will investigate how their practices are developing and changing in relation to this.

5.4 Materialities of craft practices

Craft practices are crucial when building new houses and retrofitting old ones. As Article 2 showed, four distinct practices were identified for energy consulting: the practice of economizing; the practice of controlling; the practice of coordinating: and the practice of selling. In Article 4 we further described craft practices in relation to new forms of building sustainably.

As mentioned in the previous subchapter, the framing of sustainable buildings has challenges attached to it. I will here explore how craft practices can mitigate these overflow challenges – starting with the materialities of practice – before looking at the meaning and then competencies of practice, concluding with an exploration of how these are interconnected.

What are the materialities of craftspeople's practices of containing overflows in the framing of sustainable buildings? Materialities, according to Shove (2010), are the physical manifestations of practice. In classical STS (e.g. ANT), materialities can be described in terms of an actor network, with different materialities present that shape the network. But in the case of SPT, it is possible to further build on this idea by describing the competences and meanings involved in practice. This framework enables a focus on how materialities of practice reframe sustainable buildings.

The physical entities that make up the network of practices is highly relevant. The people involved – craftspeople, engineers, architects, policy makers, homeowners – make up an important human material factor. Other important materialities include the buildings, their contents, the cost – as I saw in Article 2 when exploring the practice of economizing – and of course, their energy performance. Further, whether building new or retrofitting old buildings, craftspeople's material tools are of great importance. It is through these tools – which were often described by our informants as part of their body – that the craftspeople conduct their hands-on work, physically hammering, sawing, tearing down, putting up, and changing the physical buildings.

The building sector, although physical manifested through the actual buildings of which it is comprised, also takes a digital form. Through the energy calculator tools described in Article 3, buildings are translated into a world of numbers and subsequently controlled. As Article 1 describes, complex calculations enable policy makers to manage and control the building sector. Digitization and craft, as described by Luckman (2015), enables new ways of crafting (see Article 2), especially through the digitized tools described in Article 3.

Although Luckman sees craft more in relation to online marketplaces, the sociotechnical practices of the craftspeople in my studies, which made houses calculable, co-created a digital marketplace. As I described in Article 1, this translation was encouraged from a governmental level; and as we see in Article 4, digitized planning tools became imperative for the workers at Moholt 50-50. In this way practices that were developed to account for existing structures within the sustainable building frame resulted in the development of techniques used in the design and construction of brand new structures.

The question of how materialities relate to craft can be understood by looking at Ingold's (2013) description of thinking through making, in that the creative process of design and craft is deeply interwoven with the materials used. In Ingold's terms, materials can actively engage with sentient practitioners and, together, co-create craft. As discussed in Article 2, material practices can be exemplified with finding the "correct timber," with some craftspeople diligently searching for the appropriate use, even getting up close and smelling different planks to find the best suited ones for a particular wall.

Sennett (2008) similarly describes the craftsperson's relation to her or his tools and materials as an embodied practice, honed over many hours, until it meets perfection. This is similar to what we see in Article 4, wherein continuous drilling through various production management practices enables craftspeople hired on a permanent basis to hone their skills and complete a complex building process (Moholt 50-50). This ties to Sennett's (ibid.) thoughts on craftspeople as agents of perfectionism – professionals who constantly strive to improve their craft in order to become better crafters. Craft practitioners thus embody a practice; how can we understand their acquired skills as competences?

5.5 Competences in craft practices

Craftspeople embody various competences in the reframing of sustainable buildings, as they need expertise in order to contain and deal with overflow situations. As shown in Article 2, new competences are needed in order for craftspeople to work as energy consultants. These new energy-intense competences are offered by the Norwegian state, through Enova and the Low-Energy Program, and are intended to upskill professionals in the building industry.

However, when energy consultants visit a home, they must reframe the strict top-down energy policies described in Article 1. As further described in Article 2, the frames in these policies strive for complete clarity, with little room for improvisation or creativity and little need for intuition. However, policies in practice are different than policies in theory. As Article 3 shows, policies' intended use of tools is not necessarily adhered to in localized, embodied settings, largely because the idealized assumptions made in the policies are not applicable to the particularities of all buildings. Energy consultants' disobedience to the policies – and most notably their domestication of the calculator tool, as seen in Article 3 – illuminates both a weakness in the policy and the innovative competences of craftspeople. Creativity ends up being key to implementing these solutions in practice, although it is not necessarily a policy focus in energy consulting policies. The practice of controlling the house, as described in Article 2, includes using hand-knowledge to see how individual buildings, and their dwellers' lives, can best benefit from energy retrofitting.

In this process, craft competence is a great benefit to energy consultants. Building and retrofitting a house requires a wide set of expertise, which the majority of lay people do not understand. As a carpenter told me in an interview, he needed to be able to smell the wood up close and know where it had grown in the forest in order to know where to best place it in a house construction. He told me that a tree that had faced northwards should be placed accordingly in the house so that its full strength would contribute to the structure.

This "hand-knowledge," as described by Sennett (2008), is quite distinct from "head-knowledge," in that it is embodied knowledge – similar to what Shove and colleagues (2012) call "know-how." Knowledge of how to craft materials is a competence requiring practice and experience of having worked with the same material over and over. Article 4 shows how this practice is still encouraged at contemporary construction sites, and indeed crucial for lean construction systems to work optimally (in contrast to the traditional Japanese Toyota model, which has more top-down control, Nordic lean takes influences from the worker involvement model, as described in the article).

The know-how of hand-knowledge is thus an integral part of craftspeople's expertise, and a competence they must continuously develop. But how do craftspeople connect meanings to their practices, and what does it mean for them to work within these frames – and to reframe them?

5.6 Meanings of craft practices

How can an understanding of what craftspeople think about their practices benefit our understanding of their containment of overflows in the framing of sustainable buildings? With new ways of practicing craft, new meanings can be found for craftsmanship. In the introduction to his book, Adamson (2013) argues that craft must be understood in relation to the symbolic value of the practice.

Craft is loaded with meanings, and, as Shove and colleagues (2012) theorize, meanings are a central aspect of social practices, as they allow for wider metaphysical, symbolic intra-relations within craftspeople, themselves, as well as meso-level interrelations between practitioners. Although the policies that regulate craftspeople are on a macro level and craftspeople work hands-on with houses at the micro level, craftspeople interact with a wide variety of building actors on the meso level.

Janda and Parag (2013) use the term "middle-out approach" to describe energy performance actions in buildings that work between the top governmental regulatory level and the bottom-up individual/grassroots level. This term could also fit my material, even though my informants constantly referred to themselves as "the boys on the floor" – taking pride in metaphors such as doing "bottom-up work."

Shove and colleagues (2012: 62) state that "if practices are to persist they need to recruit people willing and able to keep them alive." In the present context, this means that practitioners must find meaning in energy retrofitting buildings. In my studies, as especially exemplified in Article 2, I observed this process in energy consultants, who saw sustainable walls as simply walls with thicker insulation. And although the craftspeople were motivated by being paid – and to some extent upgrading their expertise – further reasons for them to become energy consultants could have been made a bit more explicit in the policy. Within the practice of selling green-energy solutions, as seen in Article 2, craftspeople also risked jeopardizing their professional reputation if they did not themselves believe the government solution to be the best one for their costumer.

Prescribing meanings into climate policy does not necessarily imply that those meanings are transferred to practitioners. There must be a strong connection in place, and this prompts the question: Why should a craftsperson build sustainably, if he or she does not believe that doing so is good practice? Although many craftspeople understand climate change issues, this understanding does not necessarily translate smoothly into their day-to-day practices. This is perhaps most true when craftspeople work alone and do not have, for instance, a network of energy consultants to share practical problems with.

Craftspeople themselves, as individuals and as a professional community, imbue energy practices with personal meaning. The government has identified the importance of craft as helping society reach energy goals, but these goals are not similarly understood or motivating to the craftspeople. So how can they, as a community develop meaning that works for them? One potential possibility is how it allows them to be an all-in-one craftsperson rather than an assembly worker, allowing them to require and maintain a professional skillset.

What craftspeople think they do and what other actors think they do, matter. Through my work, I found the act of crafting – and creating – to hold a wide variety of meanings to my informants. There was a difference between craftspeople's practices as assembly workers and their practices as "all-in-one craftspeople." Whereas an assembly worker needs only to assemble parts (leading to a dequalification of a skillset), an all-in-one worker must continuously requalify, changing his or her skillset in line with current standards. This process is quite apparent in energy consultants, who claim that while houses continuously challenge their skills, through hard work (i.e. of containing the overflows that threaten "strange" buildings), they are able to contain the frame and register houses into the system.

A study by Haugan (2012) showed that craftspeople saw themselves more as economic advisors than environmental advisors. This ties in to the aforementioned strong role of energy economization in Norway, and shows how practices develop in multiple trajectories, despite policy aims. Thus, energy retrofitting cannot be black boxed as a single practice, as it is a multitude of correlating practices.

5.7 A nexus of connected craft practices

Although at first glance craft may seem prone to individualism (e.g. the lone carpenter in his workshop working on a cabinet), it is, in reality, a complex social interactive practice. Who is the carpenter making the cabinet for? What deals does he or she have? Where does he or she buy the material? By whom did he or she learn the trade, and to whom does he or she teach it? How will the future owners of the cabinet interact with it? Will they appreciate that it is crafted aesthetics?

The networks in which craftspeople participate in the building sector are interdisciplinary. Not only is the entanglement of actors increasing, but buildings are also becoming more demanding and complex (see Article 3), and this is putting new demands on craftspeople retrofitting buildings. As article 2 showed, craftspeople also coordinate different actors in retrofitting projects, as they often have a holistic view of the building process.

When building or retrofitting, craftspeople have many connections: they participate in the building and they contribute to building networks. The ideal craftsperson can be widely different for an architect versus a homeowner. Thus, craftspeople must adapt to the expectations of many other actors involved in the building project, in addition to meeting political expectations (as described in Article 1) and reconciling the expectations of other relevant actors in their sector, such as engineers (who might have opinions that contradict those of the engineers involved in the specific building).

As Ryghaug and Sørensen (2009) describe, the views of other professionals are not necessarily positive. For example, many craftspeople have an ambivalent relationship to architects. As one of our informants said: "When I get the drawing from the architect, I need to redraw it, because it is useless in its current format, I can't build from that."

It can be problematic if craftspeople do not have a say in decisions. But as shown in Article 4, when craftspeople are included in the planning phases and enrolled in the continued evaluation of progress throughout a project, they can use their expertise and knowledge to reframe buildings more effectively. The Moholt 50-50 case, for example, enrolled craftspeople early in the process and worked with them to develop clear goals on how the building and the building process should be designed. This project was different from most retrofitting projects.

However, the framing of Norwegian buildings is just a small piece in a larger system. The global building sector, of which the Norwegian sector is just one part, is again a only a single part of the larger system of global energy usage (although a large part of it, accounting for 40% of global energy usage). Insulating the walls of a single house makes a infinitesimal contribution to the global energy usage, but it is an important drop; when everything becomes countable, practitioners become accountable.

The enormous climate calculations are, on a local level, difficult for the actors involved to fathom. An example relates to the "two degree goal,"[51] which is often discussed as *the most important* global climate goal. The "two degree" concept is not necessarily one that people can easily explain, and it is too diffuse to be used on a local level. As Article 1 shows, while the massive climate calculations must trickle down to the local level, convincing homeowners to retrofit their homes in order to contribute to the global two degree climate change mitigation goal is too complex to be easily accomplished. Gram-Hanssen (2014: 393) points out that homeowners often do not have the interest in or technical knowledge of retrofitting that government forces would like them to have. Shove and colleagues (2012) argue that:

> *Policy initiatives to promote more sustainable ways of life could and should be rooted in an understanding of the elements of which practices and systems of practice are formed, and of the connective tissue that holds them together.*

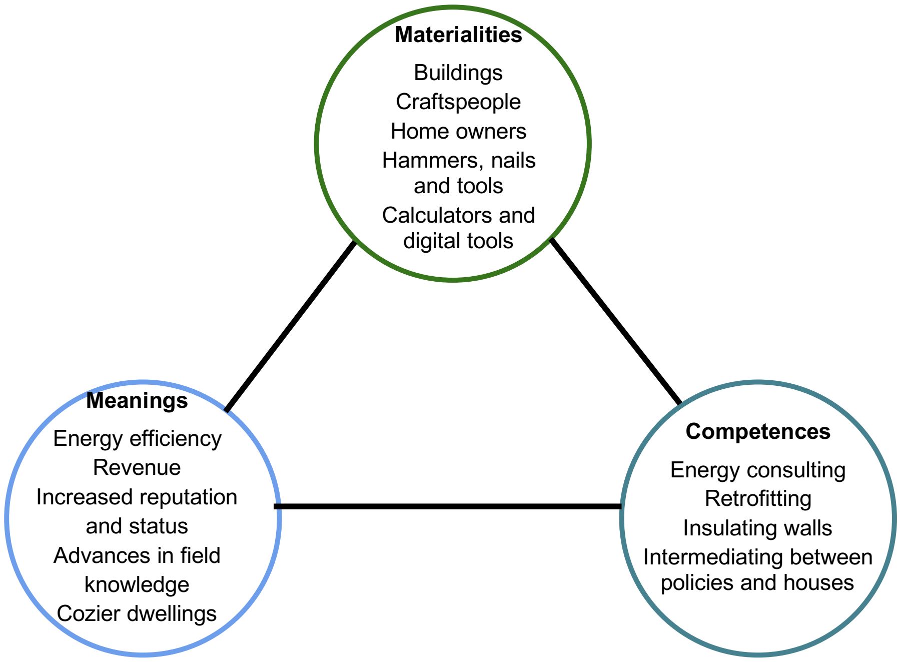
This close relationship between the practices of dwelling and retrofitting was also emphasized by Fyhn and Baron (2016), as well as in Articles 1 and 2, which argue for seeing craftspeople as an important tissue connecting homeowners and policies. In order to translate energy calculations to the local level, energy consultants are trained to intermediate between homeowners' situations, wishes, and plans and the national energy policies – a process described in Article 2. In order to do so, they must utilize energy

[51] The UN's "two degree goal" aims at capping the increase to the average global temperature at 2°C in the year 2100, relative to pre-industrial times (prior to 1880). See the UN's report for more information: http://www.un.org/sustainabledevelopment/climate-change-2/.

consultant tools, as described in Article 3. Understanding how a community self-represents is also important for their practice.

5.8 Framing sustainable buildings through craft practices

How do craftspeople's practices contribute to the sustainable building sector? Enova cannot check every building alone. As Article 1 shows, they need intermediaries, with their own situational practices (Article 2), who use specialized, domesticated tools (Article 3). Of course, the process is – and must be – standardized, but not to the extent that it is blind to innovative practices. In the diagram below, I show the interrelation between the practice elements of materialities, meanings, and competences:



The figure shows how these elements of practice are related and affect each other. The elements are also related to other practices, such as those of the building engineers also present at a construction site or the homeowners that craftspeople work for. Further, the meanings of homeowners strongly relate to the meaning practices of craftspeople, who must enact the meanings of homeowners in their buildings. If an important goal of retrofitting for a homeowner is for the homeowner to be able to walk barefoot in his or her well insulated house (perhaps a particular Norwegian cultural practice of meaning), then this goal must transfer to the meaning practice of the craftsperson responsible for the retrofitting, who must deal with this overflow of the original framing of the building.

I have shown that there is a tension between the standardized government policies and the craftspeople who physically enact these sustainable policies. In the framing of sustainable buildings, the competence and expertise of craftspeople must be heard in order for the framing to be made sustainable.

By incorporating the continuously evolving experience of craftspeople in containing overflows – which, according to Callon (1998), are always present – the framing of sustainable buildings could be improved. When the framings of sustainable buildings overflow, craftspeople's practices of sealing them become important. In this respect, improvisation to adapt to particular cases proves to be an important skillset.

Overflows can take many forms. In this analysis, I have examined various overflows, such as homeowners' "illogical" energy practices, "incalculable" houses, and the general problem of fitting both old and new buildings into the framing of sustainability. By actively containing these overflows, craftspeople ("green-collar workers," as described in Article 2) participate in the holistic shaping of sustainable buildings as intermediaries between social framings and natural framings – hands-on practitioners with face-to-face interaction with homeowners, a community of practitioners, and the non-human materialities of buildings.

6. Concluding remarks

These introductory chapters have discussed how the practices of craftspeople contribute to framing the contemporary Norwegian building sector. In order to meet larger energy reduction goals, reducing energy consumption in the building sector is key. Through the cross-cutting analysis of the four articles included in this thesis, I have tried to define a continuous trajectory. I have identified how different practices of craftspeople – such as practices of economizing, controlling, coordinating and selling – relate to their profession when framing sustainable buildings. I have also explored how these practices impact the competence and meaning creations of contemporary craftspeople. With this analysis, I have argued for an understanding of contemporary craftspeople as multiskilled practitioners who actively contain overflows in the framing of Norwegian buildings.

At the same time, the craft practices related to the reframing of sustainable buildings are changed by the framing. As shown in Article 2, "green-collar" practices are one result of this. Craft practices are thus adapting to changes in the profession, and one of these changes relates to sustainability. The framing of sustainable buildings is affected by the practices that craftspeople bring to the framing process, especially when containing overflows, and, according to Callon (1998), overflows must be dealt with. The buildings are thus reframed.

By studying craftspeople's practices in sustainable transformations, I have attempted to answer questions on how this group of professionals enacts the green-shift in everyday practice, arguing that the tools used by craftspeople must fit their practices. For instance, had craftspeople (users of the energy calculator) been enrolled in the tool's development, a great deal of frustration may have been prevented and the transition to a greener and more environmentally friendly building sector may have been made more efficient. This finding should inspire international and intersectional actors seeking to implement similar policies, practices, tools, and systems for sustainable buildings.

6.1 Research implications and recommendations

It is logical that research funded by a society should benefit that society. Therefore, I conclude my thesis with the following list of suggestions, drawn from my three years of studying craftspeople, of how policy makers and key decision makers can incorporate craft perspectives into their framing of the sustainable building sector.

1. Invest in craft education at all school levels in order to heighten competence in craft.[52]
2. Invest in craft research in order to understand how craft can contribute to societal challenges.[53]
3. Trust craftspeople's situated knowledge when it comes to retrofitting.[54]
4. Involve craftspeople as a user group in the development of digital tools.[55]
5. Invest in innovative companies and solutions for energy retrofitting.[56]
6. Develop pilot projects and studies of energy consulting and retrofitting that are much less expensive.[57]
7. Create and sustain networks of energy advising comparable to those in Danish networks.[58]

[52] "Arts and crafts" is currently a mandatory subject for Norwegian elementary and high school students. But in recent years, craft, especially woodworking, has been de-emphasized and fused with other subjects.

[53] The "Crafting climate" project has primarily investigated carpenters, but through our networks we have seen increased interest in other types of craft research, as well.

[54] Sometimes retrofitting an entire building at once makes sense, but not if it is solely for show, without making technical sense. Often, in conversations with homeowners, craftspeople see different situational demands. Enova has become much better at providing homeowners with partial support, but the benefits of a piecemeal approach should be further acknowledged.

[55] As shown primarily in Article 3 (concerning energy calculators), requiring craftspeople to use a tool without enrolling them in the development of that tool results in a huge competence loss.

[56] A top-down approach may result in slow implementation. Testing and encouraging creative, innovative solutions could enable goals to be reached more quickly.

[57] Energy consulting and retrofitting should not be only accessible to the rich. In Sweden, consulting is currently free. If energy consulting and retrofitting are important political goals, they should be made available to wide segments of the population.

[58] As mentioned in the section on previous research, Danish energy consulting is much more organized and more – and wider – research has been done on it.

7. Method

Methodologically, this research was built around a series of qualitative, semi-structured interviews with professionals in the building sector – primarily craftspeople – and participatory observation at construction sites. The research did, however, draw on the larger "Crafting climate" project, as mentioned in the Introduction, which collected a broad range of data, in both the main project and the pre-project.

7.1 Research teamwork

The "Crafting climate" project consisted of a four-person research group: doctoral candidate Roger Andre Søraa, postdoctoral fellow (and current project leader) Håkon Fyhn, senior researcher (and former project leader) Jøran Solli, and Professor Margrethe Aune. The project ran from October 2014 to December 2017, and was preceded by a pre-project in September and October 2013, which also included Assistant Professor Robert Næss. It was through this pre-project that the idea for the larger project was conceived. The pre-project included a literature overview and a user conference in which craftspeople, policy makers, industry members, and researchers participated. From this conference, Dr. Solli and Dr. Fyhn saw the potential for a larger project on craftspeople.

After adding me to the project, the project group began to approach the topic in a hands-on fashion. Not wanting it to be a "writing desk study," we spent the first year observing and interviewing informants. This began with our participation in a Norwegian "high school career day" – a job fair attended by thousands of students exploring potential professions. At this event, we aimed at getting an impression of how craft was perceived by those considering taking up trades; this provided interesting input into the research design.

When building, craftspeople interact with new energy demands. They also deal with energy demands when retrofitting houses, following Enova's energy program. Thus, our most interesting research activity was following a particular group of craftspeople working as energy consultants. These specialized craftspeople engaged in hands-on work, retrofitting buildings to meet energy reduction objectives, as outlined in the TEK. Although we were interested in developing an understanding of the roles and practices of craftspeople, our primary focus was energy consultants. For this reason, energy consultants are the overarching focus of this methodology section.

7.2 Interviews

To select informants, we planned two interview periods. The first was an early face-to-face interview round. As craftspeople working as energy consultants were the primary research subjects, every energy consultant registered in Trondheim in 2016 was contacted for an interview. There were 44 in total, and we received replies from 7 (approximately 16%). Since there were 28 firms listed in Trondheim, the answer percentage representations by firm was 25%. The informants in this group were busy, and they did not necessarily have time to sit down and talk with researchers; thus, 25% was considered a positive response rate. The informants are marked as "Energy consultants A" in Table 1.[59]

Period	**Intervie-wees:**	**Key:**	**Time range:**	**Interviewer(s):**	**Location:**
2015 spring	7	Energy consultants A	45–90 minutes	Roger Søraa, Håkon Fyhn	Trøndelag county
2016 autumn	12	Energy consultants B	15–30 minutes	Roger Søraa	Norway
2015 autumn	4	Misc. craftspeople	20–90 minutes	Roger Søraa	Trøndelag county
2015 autumn	4	Energy calculator developers	25–60 minutes	Roger Søraa, Jøran Solli	Norway
2015 spring	6	Focus group X	180 minutes	Roger Søraa, Håkon Fyhn, Jøran Solli	Trondheim
2013 autumn	5	Focus group Y	160 minutes	Jøran Solli, Håkon Fyhn, Robert Næss	Trondheim

Five of the Energy consultants A interviewees had craftsperson backgrounds, while one was an architect, one primarily an engineer, and two had dual craftsperson/engineering backgrounds. These informants provided valuable information that informed how we

[59] Table 1 gives an overview of all informants in the study.

structured the rest of the research. However, some questions were left unanswered, so another round of interviews of craftspeople working as energy consultants was conducted in autumn 2016, in order to confirm some of the common statements from the first interview round and utilize another contact method.

During this second round, we interviewed a broader sample of craftspeople, drawn from a list of craftspeople registered on Enova's list of energy consultants over a geographically dispersed area, by telephone. These informants are marked as "Energy consultants B" in Table 1. The interviews resulted in confirmation of many of the findings from the previous research round. Every interview subject in this group had a craftsperson background. Shuy (2001) criticizes telephone interviews for not being able to give sufficiently rich data due to the lack of non-verbal communication. In this case, the telephone interviews were deemed adequate, as they built on prior knowledge from more detailed face-to-face interviews. Additionally, phone interviews can be an effective method of conducting shorter interviews when both interviewer(s) and interviewee are familiar with the subject (Christmann 2009; Sturges & Hanrahan 2004). Particularly in the interviews with two interviewers, there was ample opportunity for the secondary interviewer to reflect on and consider the questions that should be asked. Since the interviews followed a semi-structured format, their quality seemed adequate, especially when the interviewees explained new practices that were not prompted by direct questions in the interview guide.

It became clear after the two main rounds of interviews that one of the most significant challenges that energy consultants faced in their practice related to a particular group of novel tools for their trade, referred to as energy calculators. These calculators proved to be such an important barrier and boundary object between their practices and governmental energy policy that we deemed them worthy of further study. This resulted in further interviews with four people representing three groups responsible for developing the energy calculator: Enova; the Norwegian Water Resources and Energy Directorate (NVE); and EVRY, one of the largest northern IT companies that was responsible for programming the calculator. Two of these interviews were done face-to-face, whilst two were done over the telephone.

Additionally, two focus group interviews (with a total of 11 informants), marked "Focus group X" and "Focus group Y" in Table 1, helped highlight some of the daily life struggles of craftspeople and enabled us to gain entrance into the cosmology of craft. These interviews were supplemented by four extra interviews with craftspeople who had expert knowledge on themes of particular interest. These final interviews are labeled "Misc. craftspeople interviews" in Table 1.

In total, we engaged in 38 interviews. Although some were group interviews, the majority of interviews involved only a single interviewee. As can be seen in Table 1, most interviews were done in tandem with other project participants, whilst two group interviews involved an extra interviewer. All interviews were anonymized and fully transcribed.

7.3 Observations

Another important component of the data for this project was observational data. After the interviews, interviewees would often show us their facilities, workplaces, and workshops. This both extended the interviews beyond the recorded phase and provided useful observational data, particularly with respect to the craftspeople's relationship to the materials they used. Physical interaction with materials was often the highlight of the interview tours, as it demonstrated how the craftspeople were bound to actual craft in a way that could not be explained by mere speech. For this reason, studies of workers should incorporate workplace visits in order to generate rich data.

An important observational component of the project was participatory observation at a construction site. For a long time, the project had a deal with a local construction school that was planning to build a structure according to the passive house standard, wherein I would be able to engage in participatory observation of the students as they built. However, this deal was cancelled after two years of construction delays, as the building project was cancelled by local bureaucrats.

At this point, a new project was chosen: Moholt 50-50, a student housing complex of five high-rise buildings constructed of primarily massive wooden elements. This was a showcase project of Framtidens Bygg ("Future Buildings") and was built to the passive house standard. At the time of its construction, it was the largest massive wood building in Norway. Moholt 50-50 contains 632 student apartments and is heated by geothermal energy. Observations at this site were done by research team member Håkon Fyhn, who shared the data with the research group for analysis.

7.4 Literature review

In the project, we reviewed a wide range of literature, including white papers, technical demands and regulations, and academic research. The practices of craftspeople are gaining increased attention, especially in STS studies. Our research project gave paper presentations at each annual 4S conference, and at the 2016 conference we hosted our own session. This session had numerous paper contributions, showcasing the increased interest in craft and craftspeople as research topics. Additionally, we held a workshop in June 2017, which drew attention from a wide range of nationalities and incorporated multiple research topics within craftspeople studies. My understanding of craft was greatly enhanced by putting the field on the research agenda and encouraging other scholars to contribute to it.

7.5 Study of digital tools

In addition to the aforementioned components of our research, we also studied the digital tools used by craftspeople. After many of the craftspeople reported difficulty using the mandatory energy calculator, we decided to delve into it deeply. We did this by trying the calculator out for ourselves and conducting interviews with the calculator developers.

Digital tools in the context of energy transitions have gained renewed research interest, as evidenced by Yeatts and colleagues (2017) discussion of barriers to energy efficient technologies (EET). A methodological approach to digital tools would likely be improved by researchers trying out the digital tools, themselves. This is one of the reasons why we personally tested the energy calculator, in addition to interviewing key actors about it.

7.6 Analysis of the material

The four articles and the cross-cutting analysis employed different analytical methods. The timeline of the empirical data collection was quite long: some interviews were conducted prior to the start of my doctoral studies and other interviews built on previous data (this is especially true of the data used in Article 1). Common among all the data collection was a flexible constructivist grounded theory approach (Charmaz 2006), through which data gathering, data analysis, and writing were ongoing, intertwined processes. Some concepts grew in proportion over time (e.g. the energy calculator, which was not an initial focus) and developed into articles of their own, whilst other concepts that were initial foci seemed less relevant on the basis of feedback from our informants. This open-ended approach to analyzing the material allowed us to constantly compare data according to different methodologies (Bryant & Charmaz 2007; Strauss & Corbin 1998) and different tools for conceptualizing and sorting the material (e.g. conditional matrices, memo writing, and theoretical sampling).

For Article 1, we analyzed different policy tools created by the governmental agencies responsible for upgrading the building sector's energy efficiency. Here, we utilized the conditional matrix approach in a transposed manner, seeing craftspeople as one actor-group among many involved on the outskirts of the policy, and finding them intermediaries of governance.

For Article 2, I analyzed the practices of craftspeople working as energy consultants on the basis of their descriptions of "a normal day at work." ("Describe a normal day at work" was one of our open-ended interview questions.) The coding led us to one of the main irritations voiced by the entire profession – the calculator. This resulted in Article 3, in which we investigated the calculator according to the information provided by our informants. As the article describes, the calculator is built around different user expertise levels; this enabled us to analyze the technology through each of the various skill levels, ranging from novice (us) to expert (our informants). For Article 4, we undertook an ethnographic approach. Here, our analysis was shaped by field notes of participatory observations at a contemporary construction site and meeting and interview data with informants.

Finally, for the cross-cutting analysis, I disentangled the articles, reviewing the original data through the lens of the articles' findings. Through this approach, I synthesized the commonalities of the data and drew conclusions on how practitioners use tools in relation to governance policies, hands-on.

7.7 Methodological considerations and shortcomings

As my research was funded by a climate research program, I found it appropriate to conduct regional interviews face-to-face and to conduct interviews with people located far away over the telephone. Although face-to-face interviews are ideal, a 30-minute in-person interview did not seem to merit the environmental impact of extensive travel. Also, as previously mentioned, we considered telephone interviews adequate, as preliminary interviews within the same field had been conducted and we (the interviewers) knew the material well. The telephone interviews were also a natural follow-up to the rich baseline data we had generated in the face-to-face interviews.

Claims based on interview material should always be understood in their qualitative context, and are not necessarily appropriate for generalization (e.g. about *all* energy consultants). As this is a new field, with a multitude of actors shaping it, the research should be understood as a situational case study with the potential for contributing to a larger debate on the governance of sustainable buildings and the changing roles and practices of craftspeople in society.

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9. ARTICLE 1:

Why energy retrofitting in private dwellings is difficult: Coordinating the framing practices of government, craftspeople and homeowners

Abstract

In this article we approach the challenge of energy retrofitting private homes by analysing the way in which retrofitting is framed differently by the government, homeowners and craftspeople (both those who carry out retrofitting and those who act as energy consultants). We follow a programme designed to support the holistic retrofitting of homes in Norway from its introduction in 2012 through 2016, documenting how the programme was developed and modified in order for it to be made more attractive to homeowners. In so doing, we show how the government actors were able to change some aspects of the programme and not others, and how these unchangeable aspects made the programme less appealing to homeowners. We see this dynamic as a result of the governmental framing of energy retrofitting, which differs from the framing of homeowners and local energy consultants. We suggest that, for homeowners to implement energy policies in their dwellings, the various framings of stakeholders must be considered.

Keywords

energy consultants; framing theory; energy policy; craftspeople.

Journal and authorship

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9.1 Introduction

The transition to more energy efficient buildings has been held to be a crucial aspect of realising the low carbon society (ECF, 2010; European Commission, 2011; Yeatts et al., 2017). One of the most challenging aspects of achieving this goal has proven to be energy retrofitting private dwellings, as this activity is often performed by the homeowners, themselves, who may have little interest in and knowledge of energy retrofitting (Gram-Hansen, 2014). As the retrofitting of private dwellings is subject to fewer regulations than the retrofitting of new buildings and larger commercial projects, a number of policy incentives have been deployed as incentives for homeowners to engage in this work. Nonetheless, homeowners seem 'stubbornly resistant to improving their homes' energy efficiency' (Wilson et al., 2015: 19). In this paper, we look at one attempt to tackle this issue: the development of a programme for implementing energy efficient retrofitting in Norway.

Norwegian authorities have a 40-year history of energy efficiency policies, but social scientific energy research on energy efficiency policies, tools and results in Norway has shown that these initiatives have had quite limited success in reducing energy usage in buildings, generally (Ryghaug & Sørensen, 2009), and private dwellings, more specifically (Enova, 2012). Norwegians spend more than €6 billion on home renovations each year, primarily motivated by aesthetics or the need for repair – not energy reduction (Risholt & Berker, 2013). Owner occupied dwellings, which comprise 80 per cent of all homes, are responsible for more than half of all building-related energy usage. Thus, as part of larger energy mitigation efforts, the government considers it essential for these buildings to be upgraded to a higher energy standard through retrofitting (Arnstad et al., 2010). Over the past decade, efforts to achieve this goal – mainly through the implementation of strict building regulations – have increased, alongside non-regulatory incitements aimed at energy retrofitting.

In this paper, we analyse a particular non-regulatory policy measure: a support programme aimed at enhancing ambitious energy retrofitting in private dwellings. We follow the programme through its development, implementation and further development over a five-year period from 2012 to 2016. The goal of the programme was to develop an effective market for holistic energy retrofitting. Holistic retrofitting implies the upgrade of an entire house (in terms of insulating the walls and roof and improving tightening), with the aim of radically improving the house's energy efficiency.

The support programme was promoted, in particular, by two public enterprises in the Norwegian government apparatus that also played a dominant role in general efforts to reduce energy usage in private dwellings through retrofitting: the Norwegian Housing Bank (henceforth referred to as the 'Housing Bank') and Enova. The Housing Bank operates under the Ministry of Local Government and Regional Development. It was established in 1946 to improve the critical housing situation after World War II by providing preferential loans. Since its inception, the bank has financed more than half of all homes in Norway (https://husbanken.no/om-husbanken). The preferential loans are also used as a policy tool to enhance energy efficiency: if a homeowner receives a preferential loan to retrofit her house, she must retrofit to an energy efficiency that is higher than the regulatory prescribed level. In addition, the Housing Bank also supports research and development projects and pioneering projects that promote energy efficient solutions.

The other enterprise, Enova, operates under the Ministry of Petroleum and Energy. Enova was formed in 2001 specifically to enhance the transition to more environmentally friendly energy usage and production in several sectors (https://www.enova.no/om-enova). It also has a role in developing climate friendly technology and enhancing energy security, and is financed by the Norwegian 'Energy Fund' (money from the oil industry designated for the transition to an environmentally friendly energy system) and a particular tax on electricity. While most of Enova's efforts are aimed at larger industrial projects, it is still a main agent for upgrading the energy performance of existing private dwellings. For this task, Enova administers a number of policy tools, including financial support for retrofitting; technology, such as solar panels and heat pumps; and the certification of energy consultants for private homes. It also produces energy relevant technology, such as heating systems, and building components, such as insulation products.

Both the Housing Bank and Enova offer information campaigns and counselling services as part of their strategies, and they participate in the network of people and agents operating in the energy and building field. Among their many programmes, the 'Low-Energy Programme', which was collaboratively formed by the Housing Bank, Enova and the building industry, is of particular interest for this paper. The Norwegian Water Resources and Energy Directorate (NVE), which operates under the Ministry of Petroleum and Energy, also played an essential role in this programme, as it was responsible for energy marking buildings (assigning buildings an energy performance and 'cleanness' mark). Employees in these organisations tend to refer to their respective institutions as *virkemiddelapparatet* (Norwegian), which roughly translates to 'the government apparatus'.

Over a five-year period, we followed the development of the Low-Energy Programme and the related interactions between the government apparatus, craftsperson-consultants and homeowners. The programme aimed at making ambitious energy retrofitting projects more attractive to homeowners, but the success of the programme was limited. In this way, the Norwegian case falls into a pattern described in other countries (Wilson et al., 2015; Buessler, 2017), and the lessons from Norway should be relevant internationally. In order to understand the situation, we analyse the different ways in which energy retrofitting is framed by the government, homeowners and craftspeople. How does the encounter – and sometimes mismatch – between these framings impact the implementation of energy policy?

9.2 Longitudinal study of a policy programme

This qualitative study is based on fieldwork (including in-depth interviews, participatory observation and document/web studies) amongst a spectrum of actors involved in building-related energy policy in Norway. These actors ranged from government agents implementing policy (e.g. employees of Enova and the Housing Bank) to energy consultants making home visits and homeowners considering (or not) energy retrofitting projects. The research was conducted between 2012 and 2016, and the goal of the fieldwork was to observe transformations in energy policy and practice, with a particular focus on the support programme for holistic retrofitting.

Central informants from all of the major governmental actors were subject to qualitative interviews. In 2012, seven in-depth interviews were conducted with representatives from Enova (3), the Housing Bank (3) and the Low-Energy Programme (1), and follow-up interviews of the same informants were carried out in 2013 and 2014. In 2015, two more in-depth interviews were conducted with representatives from Enova and one more was conducted with a representative from NVE (Norwegian Water and Energy Directorate). The main actors engaged in implementing energy policy in private homes seemed to form a relatively small informal network, not unlike what Guy and Shove (2000: 19, 79–81) described for other Nordic countries. Participation in events in this network, such as conferences, public meetings and courses, formed an important part of the fieldwork, enabling us to observe how the actors interacted.

The energy consultants, who operated in the sphere between government actors and homeowners, consisted mainly of small private sector firms. These consultants engaged with either craftspeople in the building industry (mostly carpenters) or engineers who specialised in energy. There were also larger enterprises in this middle sphere, but it was mainly smaller actors – typically firms with one to ten employees – who interacted with private homeowners. In 2013, four independent energy consultants were interviewed just prior to the establishment of Enova and Lavenergiprogrammet's official consultation certification programme. After the programme was established, nineteen certified consultants were interviewed (seven in person in 2015, twelve over the telephone in 2016). Of particular importance for the study of these actors was one of the author's participation in Enova's energy consultancy course in 2014, as this enabled us to gain first-hand experience of the energy consultation tools and facilitated a close observation of participants' reception of the consultation methods and theories.

Participatory observation was most rewarding in the encounters between actors at different levels in the energy retrofitting field. Such encounters occurred at the energy consultation course, where future energy consultants met representatives from public enterprise. Further, participation in public meetings enabled us to observe the encounter between energy consultants and homeowners. In particular, participation in a door-to-door energy consultancy campaign initiated by Friends of the Earth Norway in 2013, through which 26 homes received a low threshold energy consultation, was valuable for this study.

In addition, we conducted five interviews with homeowners who were (or had been) engaged in retrofitting, regarding their retrofitting practice and experience with energy policy. Finally, we analysed documents (e.g. reports, white papers and regulations) and web interfaces (such as energy calculators and digital application forms) that played a key role in the encounter between government officials and homeowners.

The empirical research was developed in close connection to the hermeneutical development of research questions during the research period (cf. Ulin, 2001). During this process, Bruno Latour's (2005: 21) advice to 'feed controversies' drew our attention to the support programme in focus in this paper. As we picked up critical attitudes to the programme, we returned to key informants (mostly at Enova and the Housing Bank) to conduct follow-up interviews in order to discuss and get feedback on the criticisms. This back-and-forth dialogue was essential for developing ouresearch questions and body of data.

9.3 Theorising framings of energy retrofitting

Aune and colleagues (2016) point to a mismatch between household consumers and energy economists regarding the underlying rationality of their framings of energy consumption. When suggesting that a similar mismatch is at work between the government apparatus and homeowners with respect to energy retrofitting, we conceptualise the mismatch through the concepts of framing and overflows (Callon, 1998). These concepts were developed to enable social understandings of how 'markets' and 'calculativeness' are made and done.

Framing refers to the way in which elements and interactions of economic and market phenomena are defined and described to facilitate calculation. Overflows point to aspects that are not included in the frame, but still play a role, for better or for worse. While Callon used the concept for economic calculations, energy retrofitting involves more than simple calculations; thus, we also draw on Goffman's (1974) original concept of framing to describe the way in which interactional situations are shaped and organised.

In line with Callon's use of the framing concept, we acknowledge the dual nature of frames: elements that contribute to stabilising and structuring frames of interactions are also sources of overflows. In order to describe the different framings of energy retrofitting, we tend to approach the practices of homeowners and those of the government apparatus separately, analysing their practices through different theoretical strains.

When home retrofitting is analysed as social practice (Bartiaux et al., 2014; Judson & Maller, 2014; Vlasova & Gram-Hanssen, 2014), the analysis refers to a strain of practice theory often associated with everyday activities such as showering (Hand et al., 2005) and lighting (Crosbie & Guy, 2008). Implicit in the call for attention to the practices of retrofitting is the assumption that many policy approaches neglect the social nature of practices (Bartaux et al., 2014: 536; Shove, 2010, 2014) and would have more success if they were to approach their mission in terms of changing practices. This suggests a move away from the idea that homeowners should *choose* to carry out retrofitting and a shift in attention from subjects and their motivations towards the flow of praxis, itself (Shove et al., 2012: 4), wherein the practice exists 'between and beyond the specific moments of enactment' (Shove, 2014: 418). Thus, rather than approaching home retrofitting as an isolated event, we suggest that home retrofitting should be framed within a more general practice of 'dwelling' (i.e. continuously performing smaller or larger alterations to one's property as an aspect of living in the home) (Ingold, 2000).

Fyhn and Baron (2017) approach Ingold's concept of dwelling as a practice, relating to Shove's (2014) focus on the materialities, competences and meanings of practices. They understand retrofitting to occur according to the rhythms and needs of life in the house and the material house, itself. In this perspective, retrofitting does not necessarily imply calculations of the kind expected by mainstream economic theory, or even the kinds of decisions that tend to be expected by the government apparatus (Fyhn & Baron, 2017: 557).

Approaches to the government apparatus, on the other hand, tend to favour 'practices' in terms of a Foucauldian 'practice of government' (Dean, 2010: 40). This conceptualisation reflects Foucault's (1984) concept of governmentality, rather than social practice theory, and is closer to Callon's concept of framing, as it deals explicitly with calculation. Calculation is associated with the technical aspect of government – that is, the practical mechanisms or technologies through which the ends of government are sought (Dean, 2010: 42). Calculation, and thus quantification, allows centres of government to act at a distance.

Distance is an essential category that separates the practices of dwellers when living in their home and the practices of government when trying to manipulate the home from a distance. Ted Porter (1995: ix) describes quantification as a 'technology of distance', as numbers can easily be 'transported across oceans and continents'. According to Rose (1999: 199), the formation of 'networks of numbers' is essential in connecting those exercising political power with those or that which they seek to govern. Callon's (1998) attention to markets becomes particularly relevant as New Public Management seeks to replace 'the presumed inefficiency of hierarchical bureaucracy with the presumed efficiency of markets', implying a shift from bureaucratic mechanisms to market-based mechanisms as a frame and tool for control (Power, 1997: 43). This involves a shift towards what Power (1998: 43) calls 'value for money auditing'.

As we compare the respective framings of the practices of dwelling and governance, we should bear in mind that each framing relates to a different strain of theory; however, we should also let the different strains of theory reflect aspects of both frames. Between these two frames, we find carpenters serving as energy consultants. In practice, these carpenters are responsible for containing overflows in the governmental framing. However, as they find themselves caught between the two frames, the most relevant description of their experience may be one of 'role incongruence' (Goffman, 1959). Craftspeople serving as energy consultants are supposed to represent both homeowners and the government apparatus; thus, they must interact with actors who have different expectations of their role. However, before addressing the role of these craftspeople in detail, we will look more closely at the support programme for holistic retrofitting and the different framings of energy retrofitting suggested by the practices of the government, homeowners and energy consultants. How do these differences affect the implementation of energy retrofitting?

9.4 Practices of framing energy efficient retrofitting in the government apparatus

If we were to approach the government apparatus in terms of social practice, the material organisation would stand out as being quite different to the private dwelling. Together, Enova and the Housing Bank employ more than 400 people, but only (approximately) ten senior bureaucrats and case handlers work hands-on, energy retrofitting homes (the actual number varies, as most of these workers also perform other tasks). Enova has its main office in the city of Trondheim, while the Housing Bank has offices in several cities. The structures of these offices are quite similar: If homeowners visit either office, they must first address a reception desk at the entrance. If they are then granted an appointment with a bureaucrat, they are admitted into the locked area behind reception and into the appropriate office. In practice, most homeowners contact the offices by phone or online. The institutional websites are structured quite similarly to the physical offices. Online, users also meet a kind of 'reception' on the home page, with a menu that allows them to navigate to the appropriate 'office' to address their desired issue. When the offices are reached by phone, homeowners are asked to specify their request by pressing various numbers on their keypad.

The automatised structure of the public interface seems necessary, as only a handful of case handlers are responsible for implementing energy policy in 2.2 million private dwellings (which puts each case worker in charge of approximately 220,000 dwellings). This creates a form of 'numerical distance' between the bureaucrats and the homeowners, which, together with the geographical distance, puts certain constraints on the way in which the case handlers meet their clients. All of our informants in the two enterprises stressed that they rarely had direct contact with homeowners. However, in general, bureaucrats attempt to bridge this distance through (primarily) three strategies, which relate to each other and create a certain techno-economic framing of the government's activity:

1) documenting the energy qualities of the 2.2 million homes in a standardised and calculable format;
2) conceptualising the 2.2 million homes as a market; and
3) relying on intermediaries.

In the following three sections, we will use these three bridging activities to describe how the energy retrofitting of private dwellings is framed by the government apparatus, and how this framing both contains and creates overflows.

9.4.1 Documenting the energy qualities of 2.2 million homes

One way in which bureaucrats communicate with homeowners is via the documents that pass through their desks (or computers). This is also one way in which auditing is performed at a distance – through documents that capture measures and energy qualities. These documents reflect a certain practice of documentation. Briefly speaking, the documents record the energy qualities of a house (or policy measures) in numerical values; in so doing, they make energy qualities visible and calculable for case handlers. As all measures are documented according to the same standard (in kWh, or kilowatt-hours), case handlers are able to compare the results of retrofitting measures with measures in other sectors.

In addition to Enova and the Housing Bank, the entire government relies on calculable documentation (i.e. the Ministry of Petroleum and Energy uses the same form of calculable documentation when auditing Enova). In the framing of this documentation, Enova's effort to enhance energy efficiency is conceived of and measured as a 'production of kWh'. In 2010, a contract was entered into between Enova and the Ministry, wherein Enova was required to 'produce' 6.25 TWh (terawatt-hours) of renewable energy by the end of 2015. (As they met this goal, the contract was renewed in 2015.) Before 2010, the production of renewable energy was measured according to specific goals, but it was not until 2010 that it was formulated as a *requirement*, signalling a change in government practice.

In the initial and current contract with Enova, only energy in calculable form, documented according to rigid and standardised procedures by certified agents, contributes to the contracted objective. Thus, any energy saving effect of Enova's efforts that is not documented is externalised (Callon, 1998) from its official production. In particular, efforts aimed at home renovation are in danger of being externalised, as documentation is not a traditional practice of dwelling (Fyhn & Baron, 2016). We shall return to this problem soon, but will first look at other means of bridging the distance between homeowners and bureaucrats.

9.4.2 Conceptualising the 2.2 million homes as a market

The majority of the employees we interviewed in Enova and the Housing Bank were economists who framed the challenge of energy retrofitting in economic terms. Their activity – also in other sectors – tended to be framed through a general socioeconomic perspective, adhering to ideals such as a balanced market and the cost effectiveness of measures. For Enova, the main policy measure was economic support. They attempted to use this (via the market) to promote change, but they also had to ensure that their offer of support was cost effective. This concern, more than a lack of money, was what limited their support programmes. 'We are not so much bound by technical criteria and requirements, but by what is economically justifiable', a representative from Enova explained (interview, autumn 2012). 'The idea is that economic support should be balanced economically', he continued, 'for this is the goal: that the marginal cost of various measures, be it production of energy or rehabilitating, balances out'. Very expensive solutions with little gain were even described as 'socioeconomically reprehensible', indicating that economic rationality was so deeply founded that it even became a moral standard in practice.

In the case of the energy retrofitting of private dwellings, a specific kind of market philosophy was applied. In both Enova and the Housing Bank, interviewees referred to the same book: *Business Model Generation* by Osterwalder and Pigneur (2010). Relying on Rogers' (1962) curve for the diffusion of innovations, the fundamental idea of the book is that economic support should be used to help deliver the desired solutions across 'the valley of death' – the difficult phase between innovation and an established mass market. In light of this philosophy, both Enova and the Housing Bank saw themselves as market developers. This had not always been the case – particularly for the Housing Bank, which had a longer history than Enova. Previously, the Housing Bank had operated as a *corrective* to the market, whereby the basic loan was used as a permanent corrective to a market that did not, itself, incentivise the preferred solution or policy.

Over the past two decades, the Housing Bank has become a *developer* of markets, as the basic loan is now used to develop free markets in which preferred solutions, such as energy efficiency, 'ideally are demanded without subsidies' (interview, autumn 2012). Enova uses its economic support for private dwellings in exactly the same manner. An employee from Enova summarised: 'Our dream is that the homeowners naturally demand the preferred solutions, making us redundant' (interview, autumn 2012).

The introduction of air-to-air heat pumps in private dwellings through Enova's support programme in 2003 is often used as an example of this philosophy. At the time, heat pumps – used to warm Norwegian homes during cold winters – were considered a more energy efficient way to keep a house warm than electric radiators, which were then the dominant technology. Enova supported the purchase and installation of heat pumps to the value of approximately €575 per home (approximately 25 per cent of the total cost). This support was relatively accessible for homeowners; all they had to do was fill in a simple application and show the receipt from the heat pump provider to receive it. From the producer, Enova required a certain documented quality and energy efficiency for the heat pumps to be included in the support programme. Thus, it challenged producers to deliver high quality.

After supporting approximately 50,000 heat pumps, Enova concluded that the market for heat pumps was self-sufficient; it terminated the programme and returned to developing markets. With this programme, Enova contributed to developing a market for heat pumps with good energy quality in Norway. Financial support for other kinds of technology for energy retrofitting homes, such as solar panels or automatic pellet stoves, was offered according to the same philosophy. Also, non-economic measures, such as information services, pioneer projects and efforts aimed at technology producers, all had the long-term goal of developing independent markets for the technology.

Economic and calculative frameworks intersected in Enova's contract with the Ministry of Petroleum and Energy to 'produce' 6.25 TWh of renewable energy. Within this context, the use of economic support to enhance energy efficiency and thus contribute to fulfilling the contract was described as 'purchasing kWh'. In demanding that production be as cost effective as possible, the Ministry practised a form of 'value for money auditing' (Power, 1998: 43) that contributed to framing Enova's activity.

9.4.3 Relying on intermediaries

In addition to interacting with homeowners via documents and market manipulation, bureaucrats also interact with homeowners indirectly, through intermediary actors. Case handlers in the Housing Bank said they very rarely handled funding applications for energy renovation from individual homeowners; more frequently, applications were from larger entrepreneurs, housing cooperatives or municipalities, which again had connections to individual homeowners (interview, autumn 2012). The same was true for our informants from Enova. For example, in the support programme for heat pumps, contact with homeowners was said to have been limited to processing standardised applications that would progress through the system almost automatically. More substantial interaction – regarding, for example, documenting the effect of various heat pumps, procedures for sale and installation – was all conducted with heat pump producers and major retailers.

At Enova, this tendency may have been enhanced by the fact that the enterprise produced most of its kWh through the support of larger industrial projects: 'you can make binding agreements with them', a representative from Enova explained (interview, Enova, autumn 2015). This implies that Enova was able to produce the same kind of documentation as it relied on, in practice, and referred to in contracts and other documents. This was not necessarily the case with homeowners, however, as became obvious when Enova and the Housing Bank extended their policy measures to reach deeper into the renovation processes of private dwellings through the support programme for holistic renovation.

9.5 Enhancing holistic energy retrofitting and containing new overflows

The introduction of specific technologies such as heat pumps has only a limited effect in reducing overall energy usage in homes. A major study of the technical potential for energy reduction in existing dwellings (13.4 TWh) suggested that these dwellings must be retrofitted in a deep, ambitious and holistic manner (Enova, 2012b). Accordingly, there is consensus among the main actors in Norwegian energy policy that, in order to significantly reduce the energy usage in homes, the complete house must be retrofitted holistically (Dokka & Andersen, 2012).

In this respect, insulation and work on a building's envelope is considered more important than the adoption and use of particular technologies in the building. Thus, in

2012, Enova introduced a support programme for holistic retrofitting with the long-term goal of developing a self-sufficient market for this work. The programme was coordinated with the Housing Bank's programme for affordable loans. The principle of holistic retrofitting was visualised in the 'Kyoto pyramid' (Fig. 1), which was developed by the Housing Bank in conjunction with the research institution SINTEF (Dokka & Andersen, 2012).

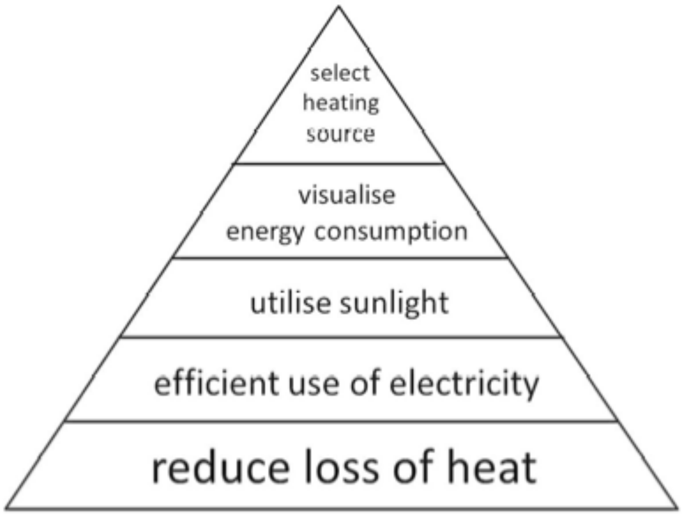

Figure 1. The Kyoto pyramid.

When planning retrofitting, one should start from the base of the pyramid by reducing any loss of heat. This action serves as the foundation for all other measures and is achieved by passive measures such as increasing insulation and improving tightening. Following this, one should progress to the next step and ensure that electricity is used as efficiently as possible. In this fashion, one continues up the pyramid, step by step, until reaching the top, when one selects an appropriate heating source. In abiding by this holistic approach, one avoids taking measures that prevent optimal solutions in the future. For example, if a homeowner were to install a heating system that was calibrated for a house with poor insulation, the system would be over-dimensioned and sub-optimal when the house was later insulated and the demand for heating reduced; at this point, the heat source would be difficult to dispose of, and would create 'energy lock-in'.

The support programme for holistic retrofitting was set up to support complete retrofitting, with the aim of avoiding energy lock-in. In this programme, a house's total energy reduction qualified it for financial support. When a house achieved a 'low energy level' – a standard slightly more ambitious than the building code in 2012 (TEK, 2012: 10) – Enova offered €69 per square meter (up to a total of €12,600) in support, directly to the homeowners. One of the conditions for this support was that the house needed to be retrofitted by a professional who could describe the work in a binding contract. Also, the retrofitting had to be performed in a single operation (i.e. homeowners did not receive support for, e.g., insulating the foundation one year and the walls and roof the next year), as the case handling system of the government enterprises was not set up to handle cases that stretched over years. Finally, the complete energy result needed to be documented by a certified agent.

9.5.1 Documentation practices creating new overflows

Briefly speaking, documentation transforms the energy qualities of a house and the energy gained by retrofitting into a numerical value. This process makes the energy qualities visible and calculable as kWh for case handlers. When made calculable, poor tightening in the corner of a home transforms it from a cold draft (as experienced by the dwellers) into a numerical 'leakage value'. Similarly, the wall's ability to keep cold out and heat inside transforms it from being a wall that feels cold to the touch to one that is no more than a numerical u-value (a measure of thermal transmittance). When the house is represented in numerical values, its energy usage can be estimated through calculations and represented in $kWh/m^2/y$ (kWh per square meter per year). From this perspective, improved energy quality equals a lower $kWh/m^2/y$ value. In the Low-Energy Programme, the case handlers at Enova used these documented values to determine who would receive support for holistic renovation and to communicate back up to the Ministry.

Documentation was also required in the support programme for heat pumps, but this did not cause overflows, as the pump producers had systems and practices in place to document the properties of the pumps. With the programme for holistic retrofitting, however, documentation became a source of overflow, as the average homeowner did not have systems and practices in place for such documentation. We discussed the issue with one of the first homeowners to receive support for holistic retrofitting in 2012. He said that in order to achieve support he had to hire a consultant to document the energy effect of the retrofitting.

This consultant operated within the same calculative framing as the programme and was an actor Enova could make binding agreements with. Documentation of the house proved to be a substantial job and, in the end, the consultant's fee was 70 to 80 per cent of the total funding the homeowner received. 'I really had hoped it would be the other way around', he said, shaking his head (retrospective interview, winter 2015). Could it be possible to relinquish the rigid documentation procedures? A representative from Enova (interview, spring 2012) explained:

> *We need a system to assure us that the money we hand out is actually being used to improve the building you have applied for. It may sound bureaucratic, but we are dependent on certain systems for auditing.*

Such documentation procedures – and the framing they represent – had been part of Enova's practices from the start. They were necessary, due to the way in which public enterprises worked across numerical distance. This framing did not emerge as a problematic issue in Enova's dealings with heat pump producers, but when homeowners suddenly had to organise documentation, it caused overflows. Enova's staff were aware of the problem from the start, but they could not do away with the practice as the entire government apparatus relied on calculable documentation. Also, Enova needed to document their production of kWh in order to fulfil their contract with the Ministry. Because only energy documented in a calculable form counted in this contract, they passed the obligation to provide such documentation down to the homeowners.

The responsible parties in Enova were well aware of the problem, and worked to solve it. In 2014, a solution was introduced: a course was set up to train builders in energy consulting. By receiving this training, small-scale contracting builders who already had a foot in the 2.2 million homes and carried out much of the practical retrofitting work also became qualified to document the work. In this way, a new class of intermediaries was created. Those taking the course were mostly master builders and builders (carpenters and other craftspeople), though some were architects or engineers. Those who passed became Enova-certified energy consultants and were allowed to perform the necessary consultation and documentation work for homeowners to achieve support from Enova for holistic retrofitting.

In this way, Enova sought to contain the overflow caused when homeowners had to deal with energy documentation. A consultation by a craftsperson-consultant normally cost €1000, and Enova would refund 50 per cent of the consultation fee (up to €500). In order to ease the documentation procedures, an ‘energy calculator’, which automatically made the energy calculations, was developed as part of the programme.

With this new programme, a homeowner considering retrofitting who wanted financial support from Enova was meant to, as a first step, call one of the certified energy consultants. After conducting a home audit, the consultant would document the energy efficiency of the house according to categories such as: type of insulation, sizes and u-values of windows and shape of the house. This numerical information would be fed into the energy calculator according to a rigorous and standardised procedure, and the calculator would estimate energy efficiency and provide an energy label for the house.

The next step would be for the energy consultant to suggest improvements to the house, such as better insulation or new windows. These suggestions would be fed into the calculator, which would estimate a *new* energy balance and generate a new energy label on the basis of the suggested measures. If the suggested measures enabled the house to achieve a ‘low energy level’ and thus qualify for support, the calculator would automatically create the application for this support. In the same operation, the calculator would also automatically provide an application to Enova to finance 50 per cent of the consultation fee.

With the help of the calculator, craftspeople in the building industry became enrolled in the governmental network of numbers (Rose, 1999). They proved able to engage in the calculation regime via the energy calculator, but their traditional practices as craftspeople were not framed by the sort of calculations produced. Rather, these practices were framed by their concern for the materiality of the house and their face-to-face interactions with homeowners. Rather than seeing the house as a set of atemporal calculations, our craftsperson-consultant informants saw the house as a series of retrofitting cycles over the long term. For example, changing the roof had a different time cycle than changing panelling or draining the foundation, all of which depended on local weather conditions and use. Economic considerations implied a strong concern for their reputation as good craftspeople, as new jobs depended strongly on their reputation amongst homeowners; thus, they stressed the importance of recommending solutions that would fit the economy of the homeowner and not be more expensive than necessary.

Through the energy consultation programme, these professionals saw a change in their daily work practices of craftsmanship. When conducting energy consulting, they engaged in areas of economising (e.g. advising homeowners on the economic aspects of renovating their houses for sustainability; controlling and measuring houses to fit the government schemes; coordinating other workers; and selling – which implied balancing the need to advise on energy upgrades with the need to sell their own services for carrying out those upgrades). Authors (forthcoming) described the new role of the energy consultant as evidence of a transition to 'green-collar workers' engaged in climate and energy issues. However, our informants reported that they had so few energy consultation missions that they mostly continued to work as traditional craftspeople. When conducting energy consultation, they found their new role difficult to balance with their role as a craftsperson, particularly with respect to giving proper advice.

The craftsperson-consultants significantly reduced the cost of documentation, making it radically easier for homeowners to achieve support for holistic retrofitting. Thus, the overflow in the encounter between the government's documentation practice and the uncalculative practice of homeowners was contained. However, the number of homeowners receiving support remained low. When the programme was introduced in 2012, it aimed at establishing a mass and natural market for holistic retrofitting. However, by the end of the study period, no more than 100 homeowners a year had achieved support, or 500 in total (ca. 0.02% of the 2.2 million private dwellings in Norway). We do not know how the programme will develop in the future, but to date, the numbers indicate that the programme for holistic retrofitting is far from repeating the success of the heat pump programme in terms of establishing a self-sufficient market. Are there new sources of overflow? We seek to answer this question by attending to the situation of the craftspeople who serve as intermediaries between the framings of homeowners and the framings of the government apparatus.

9.6 Limits of reframing

In the following discussion, we present the reasons offered by craftsperson-consultants for the failure of the holistic energy retrofitting programme to achieve wide popularity. In response, we also present government explanations as to why the programme was designed as it was. The craftspeople point to possible sources of overflow, while the government representatives explain why these overflows cannot be contained.

The support programme demands that retrofitting be conducted in a single operation, but, according to an energy consultant: 'this is simply not the way people retrofit; they do it batch by batch' (interview, autumn 2013). 'Over-time retrofitting' (Fawcett, 2014: 478), which is performed according to the private economy and the rhythm of the household (Fyhn & Baron, 2016), seems the norm. Most energy consultants we spoke with agreed that, from a purely technical point of view, the best solution for maximising the energy benefit is to retrofit in a single operation; but from a professional point of view, taking the homeowner's situation and the natural cycles of home renovation into account, they rarely recommend that homeowners retrofit the entire house in one operation. As they told us, such advice 'makes us appear unprofessional' (interview, carpenter, autumn 2015).

One energy consultant suggested a solution that would satisfy both the technical and the dwelling perspective: 'Why not make a holistic retrofitting plan, with clearly defined measures, and then let the homeowners do the work in their own time?' (interview, autumn 2013). We put this suggestion forward to a representative of Enova and received a clear answer why this could not be done: 'We cannot stretch out a case in time like that' (interview, autumn 2013). The real problem is not technical, but related to the framing of retrofitting projects that is stipulated by the bureaucratic practice of the policy apparatus. For a retrofitting job to enter the system, it must be defined as a case. A case must be opened, processed and swiftly closed, as only then can the results be counted.

Upgrading a house to a low energy level easily costs €150,000 or more. In light of this, €12,600 does not make enough of a difference to motivate people. 'I think they have missed [the mark] with this programme. It fails when people see they have to do so much for so little money', an energy consultant said (interview, spring 2014). By recommending the full suite of interventions needed to achieve the required energy level, the carpenters risked their professional reputation by giving advice that did not serve their customers well. 'Either you need to lower the level of requirements, or you need to raise the level of support', an energy consultant suggested (interview, spring 2015). For Enova, lowering ambitions is not an option. As their contract with the Ministry only counts energy reductions beyond the current building code, they have to demand a low energy level. 'Below the building code' is also the Housing Bank's criteria for handing out affordable loans.

If lowering ambitions is not an option, why not contain the overflow by raising the level of support? When suggesting this to a representative of Enova, we learned that this is also not an option – not due to a lack of money but due to the economic rationality that governs the enterprise. 'We are not so much bound by technical criteria and requirements, but by what is economically justifiable', the representative explained (interview, autumn 2012), referring to their ideology of balancing measures in a balanced market. They referred to the activity of supporting retrofitting and other energy saving projects as 'purchasing kWh' – a purchase framed by 'value for money auditing' from the Ministry. In this framing of economic rationality, it makes sense to 'purchase' the least expensive product when choosing between two equally good products. As all kWh are equal in the government calculations, kWh from private homes compete with kWh from large industrial projects. For private homes, this is bad news, as private homes represent the most expensive kWh: 'Different areas have different costs. Supporting a large hotel downtown will often be cheaper per kWh than [supporting] individual homes, when case handling costs and everything connected to it is included' (interview, Enova, autumn 2012). Enova still supports home retrofitting, despite these calculations; but as one representative from Enova said: 'We should not push it too far' (interview, autumn 2012). In other words, for the goal of producing 6.25 TWh, all kWh are equal; but for the long-term goal of developing a market for ambitious energy retrofitting in private homes, there is a huge difference between kWh from homes and kWh from hotels. This difference is a difficult overflow to contain within an 'audit by prize' system.

During interviews, representatives from Enova and the Housing Bank acknowledged the overflows pointed out by the craftsperson-consultants, but they could not contain these, as they were bound by the governmental framing. In particular, representatives from Enova stressed that they applied several measures – independent of the support programme – with the long-term aim of developing markets for energy efficient solutions. However, ultimately, they had to give priority to measures that implied 'buying kWh' for the production of 6.25 TWh. In the case of home energy retrofitting, they pointed to a direct contradiction between their requirement for TWh produced and the long-term goal of developing a market. Only after they had secured the target they were audited by could they devote effort to the long-term market goal.

The craftsperson-consultants were also bound by the governmental framing provided by the support and consultation programme. Several informants told us that they started the energy consultation course optimistic and enthusiastic, but ended up disappointed. They found themselves caught between their role as a government representative – facing homeowners in order to sell the energy retrofitting programme and document the energy qualities of the house – and their role as a carpenter – dependent on creating a good dialogue with homeowners in order to find the best solutions for homes. In this situation, they had to negotiate between the two framings and the two roles, and this negotiation often ended in 'role incongruence' (Goffman, 1959), as the roles were more or less mutually exclusive. As energy consultants for the government, the craftspeople had to accept the techno-economic frame of the support programme, but their own framing of retrofitting was not given much place in the programme. This was particularly evident in the use of the energy calculator, around which the entire home consultation was structured. The calculator was developed according to the government framing and the craftspeople who used it had no opportunity to feed back on its design (even though they pointed out many areas for improvement) (Authors, 2018b). Caught between the two frames and roles, our informants' loyalty ended up being strongest to their role as a craftsperson; this was what they made a living from and identified with most strongly. Thus, the rigid framing of the consultation activity contributed to greater overflow, as the consultant – in most cases – ended up advising homeowners *not* to apply for the renovation programme.

9.7 Conclusion

We have explored energy policy with respect to private dwelling retrofitting by observing how a support programme for energy retrofitting was implemented and developed over a five-year period in order to contain overflows that occurred in the encounter between the respective framings of homeowners, craftspeople and the government. The implementation of the programme was analysed according to three ways in which the government apparatus bridged the distance between homeowners: relying on numerical documentation; conceptualising the mass of private homes as a market; and engaging craftspeople trained as energy consultants, as intermediaries.

While these three strategies aimed at reducing distance, we argue that they also produced a certain distance. Even though the craftspeople engaged were able to take part in the governmental practice of calculation, they found it difficult to represent the support programme to homeowners, as the recommended solutions were inconsistent with their personal recommendations as craftspeople. While they suggested certain solutions to this problem that seemed reasonable from their perspective, the solutions were impossible to implement within the governmental framing. We showed how this framing was not easy to change, as the larger government apparatus was structured around it. Thus, the framing of craftspeople was not given enough room.

A more general lesson is that, in order to achieve substantial energy reductions through home energy retrofitting, we must do more than simply analyse the situation of homeowners or the government in isolation. Rather, we must take into account the practices of homeowners, the government apparatus and the intermediary hands that do the job. Only when the framings of these practices are coordinated can the policy actually be implemented. In the Norwegian case, this has proven difficult, as the different frames seem deeply rooted in the practices of the involved actors.

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10. ARTICLE 2:

Crafting environmental policies into action: Energy consulting practices of craftspeople

Abstract

This article discusses the relation between policies of energy-efficient home refurbishment and the practices of craftspeople – particularly carpenters – by implementing them in the building sector. The political aim of making buildings more sustainable and energy friendly by reducing the 40 percent of the energy used in the building sector provides new challenges for craftspeople that are tasked to effect these changes. Based on qualitative interviews, this article explores how craftspeople working as 'energy consultants' form their new role. The article explains how energy policies are translated into physical buildings by energy consultants. Four practices of craftspeople working as energy consultants are analysed.

These are the practices of: economizing; controlling; coordinating; and selling. These practices are part of a complex sustainable transition that is taking place in the building sector, where craftspeople are increasingly becoming 'green-collar workers'. It is necessary to understand the practices of craftspeople in order to further reduce energy usage in buildings, as this is a profession that enacts energy policies, by working with energy mitigation hands on.

Keywords

craftspeople; energy practices; green-collar worker; environment policy; energy consulting; buildings in transition

Journal and authorship

This paper was submitted to *Craft Research* in October 2017, and has been accepted for publication with revisions in volume 9.2, September 2018. I am the sole author.

11. ARTICLE 3:
Energy consultants calculating sustainability in the built environment

Abstract

Purpose – This paper investigates the role of a particular energy calculator in enhancing the energy efficiency of existing homes, by asking how this calculator was developed and how it is domesticated by craftspeople working as energy consultants.

Design/methodology/approach – The study is based on qualitative interviews with users and producers of the energy calculator (n = 26), as well as participation in energy consultation training.

Findings – The paper finds that, in the energy calculator, there is a striking lack of connection between the domestication and script due to a lack of energy consultants' involvement (as users) in the design process and a lack of consideration of user feedback.

Practical implications – The enrollment of energy consultants as energy calculator users earlier in and throughout the design process could be valuable for reducing frustration later on and making the transition to a greener and more environmentally friendly building sector more efficient.

Social implications – The paper calls to recognize the role of energy consultants, especially craftspeople, as participants in the design process for tools of governance. This is a call to acknowledge the value of the particular skills and experiences possessed by craftspeople doing home consultation.

Originality/value – By understanding the intricate developer–user synchronicity in tools developed for upgrading the building sector, energy mitigation can be made more effective.

Keywords – facilities; energy consultants; energy calculators; sustainable transitions; home renovation; energy audits; craftspeople; domesticating energy; energy management; user enrollment; energy policies; building policies;

Journal and authorship – This paper was submitted to *Facilities* in October 2017. As of January 2018, it was under its second review. The authors are Søraa, Fyhn, and Solli.

11.1 Introduction

The building sector accounts for approximately 40% of worldwide energy consumption (unep.org, 2015), and Norway's energy consumption in the building sector closely maps onto this average, accounting for approximately 40% of national energy use. The building sector is defined, both globally (Janda and Parag, 2013; Shove and Walker, 2007) and locally (Aune, 2007; Solli and Ryghaug, 2014), as one of the most promising sectors for energy use mitigation. The challenge of reducing energy use in buildings has been approached by means of a wide range of policy measures. For instance, increased political attention towards the built environment and its relationship to climate change has resulted in regulatory measures in the form of stricter building codes and mandatory energy labeling of dwellings (Directives 2002/91/EU and 2010/31/EU).

Still, policymakers face a number of challenges in attempting to facilitate efficient measures. One such challenge relates to upgrading existing buildings (Vlasova and Gram-Hanssen, 2014). Renovation of existing buildings poses a particular challenge for policies, as it is not subject to regulation in the same way as new construction. In Norway, as many as 90% of dwellings are owned by the dwellers themselves. The majority of these houses are detached and semi-detached. There are approximately 2.2 million houses that fall within this category (Enova, 2012), and renovation is often conducted by the homeowners, themselves, or by small contractors and builders. Taken as a whole, these houses comprise a complex mass of buildings and actors that is difficult for the government to reach.

This situation can be described as a certain *distance* – between the offices governing energy transition and the houses subject to this governance – that needs to be bridged (Fyhn, Solli and Søraa, forthcoming). Government representatives do not visit the houses, themselves; rather, they depend on intermediaries and systems for control. Recently, they have taken steps to engage actors who are already involved in home renovation, such as contractors, builders and craftspeople, by facilitating a more active role for these professionals as energy consultants. Risholt and Berker (2013) argued that craftspeople have been a barrier to energy efficiency, but that the profession holds great potential. In order to enable efficient policies, the government has introduced new digital tools designed to support energy consultants and enhance the set of existing measures.

How have such tools been designed? And how does their supporting role work in practice? This paper approaches these questions through a close examination of a specific tool – an energy calculator. Energy-calculators are used in a variety of countries when assessing energy-performance of buildings. The calculations themselves differ, partly based on the method used to collect house data (Wang, Yan & Xia: 2012). Energy modeling programs have been critizised by Boyer et al. (1998) as being too tailored to specific professions; they suggest a multiple-model approach of building systems that take into account the need for more holistic tools.

This paper investigates the Norwegian energy calculator by drawing on data from qualitative, semi-structured interviews with both users and producers of an energy calculator that was commissioned by the Norwegian Energy Authorities to measure the energy efficiency of buildings. The tool, which is colloquially referred to as the "energy calculator," was developed for Enova, a public enterprise owned by the Ministry of Petroleum and Energy. Enova was established in 2001 in order to drive the changeover to more environmentally friendly consumption and energy generation in Norway. Enova's measures include full renovation support and support for energy saving measures – such as the implementation of heat pumps, solar energy utilization and balanced ventilation – as well as monetary support for energy consultation and renovation. Further, Enova, in collaboration with the building industry represented by "The Low-Energy Program," set up a course to educate and certify energy consultants. Energy-concerns is however not necessarily a motivation factor. In their study of consulting engineers, Hojem and Lagesen (2011) found that "the doing of environmental concerns predominantly was considered a very practical question." This doing was primarily the enforcement of climate policy regulations in action, and does according to Solli (2013) create a form of uncertainty.

The certified energy consultants are meant to visit homeowners and thoroughly review their buildings in order to suggest concrete measures for increasing energy efficiency. In this work, they are required to use Enova's energy calculator to measure energy efficiency. The search for more efficient ways to reduce energy use can benefit from an assessment of how current policy measures are working in practice. Without grasping the way such tools and measures work and how they connect into larger assemblages, it is difficult to understand the way in which large transitions – such as a radical downsize in energy use – happen or fail to happen, in practice. This paper contributes to our understanding of this transition by investigating the way in which energy consultants use the energy calculator to measure sustainability in the built environment. Despite having a localized focus, the green shift this increase in energy efficiency represents could have implications for the building sector globally. This article can serve as inspiration for other countries implementing, or planning to implement, similar calculators and audit practises.

11.1.1 A tool for sustainable transitions

This article analyzes the implementation of an energy calculator, drawing on the analytical strands of sustainable transition and domestication theory. Sustainable transition research focuses on the way in which societies adapt to the problems caused by climate change by transitioning to a more energy friendly society (Shove and Walker, 2007; Smith et al., 2005; Tukker and Butter, 2007). This article focuses on the role of sustainable transition actors who are implementing sustainable transition policies in literally a "hands on" manner. Monetary subsidies are a central tool in the implementation of energy efficiency policy, and they are also used actively in single projects.

Åm (2015) and Jørgensen (2012) define niches in sustainable transitions as protected spheres in which certain technologies can "take bloom" before they are released on the wider market. Niches created through economic incentives are relevant to the focus of this article: energy consulting is dependent, in part, on protection from market forces through the monetary subsidies provided by policies. Scrutiny of both the design and the practical use of tools such as the energy calculator can produce knowledge about the nature and effect of seemingly modest entities and technologies. Historical and social scientific analyses of academic and bureaucratic practices have, for example, shown that tables, reports and surveys function as "little tools of knowledge" (Becker and Clark, 2001)). This may imply that tools shape practices and that bureaucratic or political technologies may influence or execute control (Callon, 2002) and potentially shape decision makers (Asdal, 2004). This paper investigates *the way in which users of sustainable transition tools make sense of and evaluate* the energy calculator as a tool that could potentially enable sustainable transitions.

Thus, as an analytical resource in this paper, sustainable transitions serve a general role, partly demarcating the field and object of research. Domestication theory, in contrast, provides specific concepts for the task of making sense of and evaluating the energy calculator. The domestication perspective underlines the significance of investigating what users do with new technologies, tools and knowledge. When a tool is domesticated, it is transformed from an unknown element to an aspect of social and cultural practice. This process has *practical*, *symbolic* and *cognitive* aspects (Lie and Sørensen, 1996; Sørensen et al., 2000; Berker et al., 2006; Aune, 2007). The practical aspect concerns users' actual physical manipulation of the material object or technology in question; the symbolic dimension focuses on the meaning that users put into the technology – what it symbolizes for them; and the cognitive aspect focuses on users' learning of the technology. An important feature of the domestication perspective lies in the opportunity to describe how something is *not* successfully domesticated (Sørensen, 2006). This paper asks whether the energy consultants domesticate the energy calculator tool, and, if so, how they do so. Another model that could have been used to understand the implementation of technology is the "Technology Acceptance Model" and its later extensions (Venkatesh and Davis, 2000). However, since this study focuses on a sociotechnical multifaceted usage of the tool, domestication theory was chosen as the main analytical theory.

To strengthen the analysis, a partial approach is adopted, providing accounts from the implementers and designers of the energy calculator. For this purpose, the concept of "script" is used; here, script refers to the user guidelines that are written into or inscribed in an object (Ackrich, 1992; Ainamo and Pantzar, 1999; Wilhite, 2013), based on the designers' beliefs and assessments of the end user. The concept of script is also used to focus on designers' attempts to control a technology's usage through its design. This is not necessarily straightforward, since the process of domestication described above involves finding new ways of using an object that were not originally intended by its creators. Aune and colleagues (2008) see the enrolment of different actors in the building process as key to the transition to a more energy efficient building sector. Although their article focuses on building operators, this article adds craftspeople engagement as an important element in the transition. In this paper we ask: What do designers expect from the use of the tool, and how do they describe its script? Is the tool domesticated by its users, and, if so, how? And how are the users included in the design and implementation process? From this, the paper investigates the tool's ability to contribute to sustainable transitions.

11.1.2 Method

We investigated the topic through qualitative, semi-structured interviews with actors involved in both making and using the energy calculator. A qualitative approach was chosen in order to present the energy calculator tool technology as a case study, and qualitative interviews are well suited for this purpose (McCracken, 1988; Rubin and Rubin, 2011; Seale et al., 2004). On the producer side, Enova ordered the calculator; the Norwegian Water Resources and Energy Directorate (NVE), owned by the Norwegian Ministry of Petroleum and Energy, developed the tool; and EVRY, Norway's largest IT company, developed it. Two employees from Enova were interviewed in person. These interviews were based on experiences from three previous in-depth interviews with representatives from Enova made by one of the authors in a previous project in 2012/13.

These interviews also focused on energy refurbishment, but were conducted before the calculator was fully introduced (Fyhn and Baron 2017). Telephone interviews were conducted with a NVE employee and an EVRY employee, both key agencies in the development of the calculator, with follow-up questions subsequently emailed for clarification. All Telephone interviews were conducted with a NVE employee and an EVRY employee, both key in the development of the calculator.interviews were conducted in autumn 2015.

On the user side, 19 unique interviews were conducted with Enova-certified energy consultants in Norway. Seven of the energy consultants were interviewed in person in spring 2015, with the interviews lasting around one hour, conducted with an interview guide. Whilst the majority, five, of these consultants had a background in craftsmanship (primarily carpentry), three had a background in engineering and one had an architectural background (some had dual backgrounds). 18 months later, in autumn 2016, 12 interviews were done over telephone. The telephone interviews were conducted after the in-person interviews, and helped to confirm topics that emerged in the face-to-face interview round. An overview of the interviews can be seen in the table below:

Table 4: interviews

Period	**Interviewees**	**Occupation**	**Type of interview**	**Interviewer(s)**
2015 spring	7	Energy consultants	In person interviews	Roger Søraa & Håkon Fyhn
2016 autumn	12	Energy consultants	Telephone interviews	Roger Søraa
2015 autumn	2	Enova	In person interviews	Roger Søraa & Håkon Fyhn
2015 autumn	1	EVRY	EVRY interview	Roger Søraa & Jøran Solli
2015 autumn	21	NVE	NVE interview	Roger Søraa & Jøran Solli

All interviews (n =23) were later transcribed verbatim, and as they had been conducted in Norwegian, they were translated to English by the authors. For a closer observation of the way in which policy activities aimed at energy use reduction were played out in practice, one of the authors participated in a course for energy consultants arranged by Enova. The authors also conducted tests of the energy calculator, as the tool is available for public use. In fact, when selling a house in Norway, one must use the energy calculator to energy mark the house.

11.2 A script for sustainable transitions

When energy marking a house in Norway, one needs to use an energy marking tool. How is this tool scripted – or intended used? Energy marking a house requires a visit to Enova's website. On Enova.no's "Tool" page, one can find the energy mark calculator, with the following information:

> *Energy mark calculator: Give me an A! A green one. In our Energy mark calculator you can check what you can do to improve the energy mark for your dwelling […] The Energy mark calculator does not require logging in, or pre-knowledge, and gives you useful knowledge on energy renovation.*

When a user clicks the link to the energy calculator, he or she is redirected to the main page of the energy calculator. This page describes the energy mark of a building in Norway as a point that results from two values: energy efficiency (represented by a letter) and the share of delivered energy produced from fossil or green energy sources (represented by a colour). The page provides a choice between two modes of registration: (1) simple; and (2) detailed. (In this study, these are referred to as the "simple" and "advanced" calculators, respectively.) The choice is supported by the following information: "(1) Easy registration: It is based on standard values and has few choices. (2) Detailed registration: It is more comprehensive, but requires the registration of additions, changes, and actions taken for the building." Further, the page explains how everyone selling a building in Norway must calculate the building's energy mark. It also states that it is illegal for sellers to report an incorrect energy mark when selling, and that violation of this law can prompt prosecution.

In order to register an energy mark, a person must access Norway's "My ID-web," which is the log-in portal for public services for Norwegian citizens. The site provides information on taxes, student loans, moving and so forth, as well as energy marking a dwelling. It is emphasized that logging in is only required for energy marking a building. The information on this site is aimed at the homeowner. For the expert, there are two additional modes, beyond the "simple" and "advanced" described above: (3) experts can adjust the input data directly, in the form of calculation data, in order to represent the building as accurately as possible; or (4) they can import an XML file from an external calculation. In data provided by EVRY (as of 20 October 2015), the percentage of use of these four modes of registration, to nearest hundred, was:

Table 3: modes

Mode	(1) Simple	(2) Advanced	(3) Direct input	(4) XML file
Number	438,000	41,500	9,900	61,000
Percentage	79.6%	7.5%	1.8%	11.1%

The simple method was utilized much more often than the other methods. This is probably due to the fact that methods (3) and (4) are only available to experts, and, along with (2), are used for providing energy advice for renovation projects. Method (1) – and to some extent (2) – can be used by homeowners who simply need an energy mark; for instance, when selling their building. Energy consultants use the more advanced versions as they are much more precise. The large number of simple mode users is likely due to the fact that everyone who sells a house must use the method to calculate the house's energy level. Because commercial buildings and all new dwellings must be marked by an expert, utilization of modes (2), (3) and (4) will necessarily increase in the future. The next section will analyze the calculator input more closely.

11.2.1 Calculator input and output

The image below shows the simple (1) mode to the left and the advanced mode (2) to the right (translated to English for this article). To use the simple mode, one must provide input data on several building categories: type, year, construction material, floor space, number of floors, basement type, heating source, ventilation and types of heating and ventilation. After these parameters are filled in (which only takes a few minutes if one has the information to hand), a summary is provided, resulting in an energy mark and information on how the energy mark can be improved.

Table 1: Simple

1	Building category
2	Building type in detail
3	Technical equipment
Summary	
Control	
Result	

Table 2: Advanced

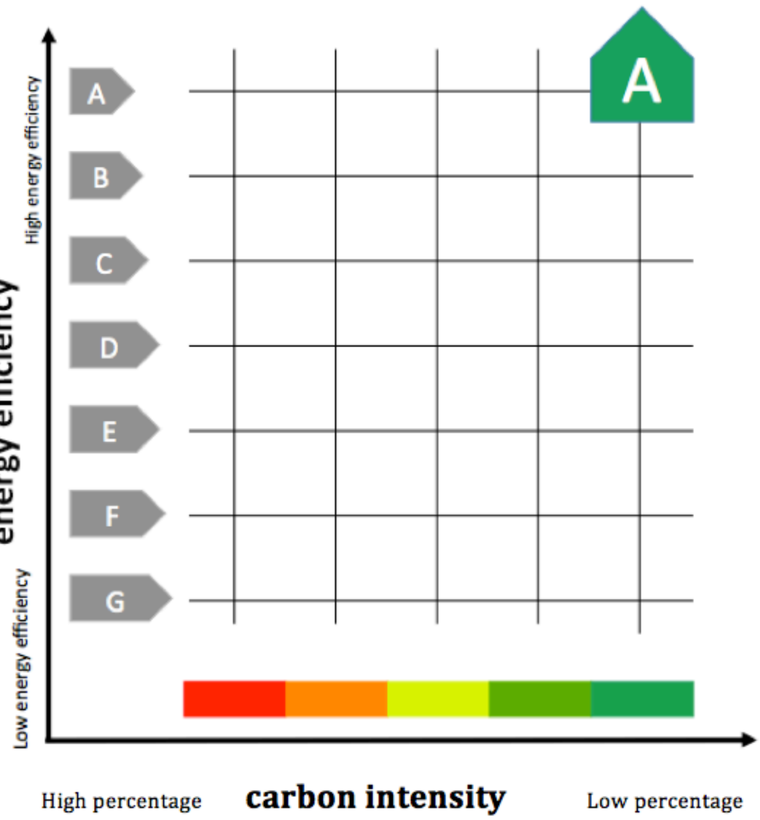
1	Building category
2	Building type in detail
3	Floor plan in detail
4	Walls and windows
5	Doors
6	Roof construction
7	Floors
8	Tightness of construction
9	Location in terrain
10	Geological ground conditions
11	Technical equipment
Summary	
Control	
Result	

In the advanced mode, the input data is considerably more complex. In addition to requiring mode (1)'s general data, mode (2) goes into more depth, asking users to provide various details for different categories as shown in the table. Each of these categories includes many sub-categories, for which users must provide further detail.

How did the calculator designers intend the tool to be used? From the information described, one can get a sense of what the designers expected, of both the way in which users would use the tool and what the calculator would produce: what is inscribed in the calculator as a tool and technology. When interviewing Enova about the intention behind the calculator, they responded: "It's really meant both for experts and for those homeowners with a little bit of knowledge." However, this "little bit of knowledge" seems rather extensive, and as demonstrated by the numbers above, the vast majority of users chose the simple calculation mode. However, as all commercial buildings and new dwellings must be energy marked, it might be interesting to see what incentives are provided (or not) to encourage advanced registration. When a person is building a new structure, he or she should know the numbers required by the advanced mode fairly well; but do such persons choose the simple or advanced registration mode? One of the input issues described to us by an architect energy consultant was that users were not required to enter the building's insulation *type* – only the insulation *thickness* (interview energy consultant):

> *Choosing a material that is good for the environment is not rewarded, neither are you punished for choosing a bad one. For example, polyurea foam develops hydrogen cyanide gas when burning, but your score in the calculator is the same. You stand there dressed in a moon suit and foam the house, but the brochure says it's environmentally friendly and not dangerous.*

The energy consultant suggested that the calculator should include a warning when "bad" materials are used, but it does not currently do this. By not separating between different qualities of insulation, the calculator hides potentially relevant information form view. This creates a form of uncertainty, which is also described by Solli (2013), wherein building engineers must make ethical choices due to a lack of information and regulation. When all input data is processed, the energy calculator gives an output in the form of an energy report. This report states where the building falls on the energy mark scale, as indicated by a letter from A (best) to G (worst) vertically, and a colour from green (best) to red (worst) horizontally, as shown on the figure below:



Both the simple and advanced calculator modes lead to general advice on improving energy use in the building. Advice is given on actions that will affect the energy mark, such as insulating walls (such advice could be provided following the simple or advanced mode) or changing a leaky front door (such advice would only be given following the advanced mode). Advice is also provided on actions that will *not* affect the energy mark, such as using less energy and turning off lights. The advice is dependent on the data that is input (e.g. advice relating to changing a leaky front door would only be displayed if data had been input to indicate that an old door is present that could thus be improved). On energimerking.no, users can read about potential next steps:

> *Discuss the actions with a craftsperson or energy consultant [...] Let the output of the energy calculator be part of a thought process towards rehabilitation of the dwelling [...] Maybe some of the actions awakened*

your interest? It will always be most profitable if you already want to do something with the house. We recommend that you discuss options with a specialist who sees the actual cost and saving possibilities.

While this recommendation takes into account that homeowners may have other reasons for renovation than energy efficiency, and thus encourage them to consider energy upgrading in combination with other works being done, it could also be read as somewhat passive or subdued, presenting it as a "thought process" that could "maybe" lead to action. On the professional side, the calculator generates the same report, but as the data required is normally much more extensive, the energy consultant typically has much more precise insight into the building to determine what can be done to upgrade its energy efficiency. The energy calculator is thus scripted as a way to calculate energy performances of buildings, by inputting correct values for the parameters introduced. The next section will see how this technology adapted in practice by its users.

11.2.2 Domesticating energy calculators

Technological innovation can be described in the language of a push/pull (Chidamber and Kon, 1994; Horbach et al., 2012; Zmud, 1984), emphasizing the way in which technologies are imposed on the users (by "force") or requested by them in some way. Although this dichotomy is likely too simplistic to describe actual innovation processes, it is relatively clear that, in our case, a "push" tendency can be seen, as the energy calculator is a tool that working professionals in the building sector must adhere to in order to engage in (lawful) business. The central question, then, is: How do energy calculator users utilize the tool in their daily work life? In other words, how is the energy calculator *domesticated*?

In the previous section, the script and intended use of the energy calculator were described. During practical energy consulting sessions, use of the technology does not necessarily follow the script; rather, the calculator can be used for unintended purposes and thereby transformed. Aune and colleagues (2008) argue that energy efficiency is not primarily dependent on technical solutions; rather, the fulfilment of these technical solutions' potential when implemented in a building is of primary importance. Taking a closer look at the *practical* dimension of the domestication of the energy calculator, one can find that the tool is used in ways that differ from its original intention, as suggested by the quote from this energy consultant (interview energy consultant):

Where it is possible to write comments, I always write that I have deviated from the program because "this and that," so that one afterwards can see how I have thought. I think that is quite nice.

This illustrates that some users engaged in constructive dialogue with the technology, bypassing the difficulties that were put upon them. This kind of bypassing proved to be quite common, as houses often did not match the pre-defined categories provided by the calculator. However, it did make for some "educated guesses" by the energy consultants who did not know how much freedom was allowed in the calculator, and it was also more time consuming to write down a lot of comments. Much of these categorical misfits pertained to the shape of the building (interview energy consultant):

It is not possible to get it 100% right [...] It is difficult to include extra space without having problems with the total space. It [the calculator] keeps calculating the total space [...] It is very difficult, as you only have a few standard figures to use, and in a typical house built in the '80s there are a lot of extensions [...] which are very difficult to include, and then you have to cheat when describing the with and length to get the total area right.

On enova.no, users can read about the challenges of strange building components:

How can I energy mark my crow-castle (a big old house with many extensions, nooks and carneys) when it's put together by different parts with different standards? With detailed registration it is possible to get a long way with detailed information, putting in different standards on walls, etc. Many deviations from unitary constructions mean longer registration time. The most complex buildings will get the most accurate registrations by an expert. Experts have the opportunity to register in other ways, including using their own expert tools.

The attitude among many craftspeople towards the calculator was one of disapproval, but acceptance, as many of our interviewees told us "we have to use it if we want energy consultant jobs". In addition to contributing to the tool's practical dimension, the domestication of the tool also pertained to the way in which the users understood it – its *symbolic* dimension. It became quite clear during the interviews that the calculator was seen as a symbol of a "rule from above" that took little notice of how "the boys on the ground" had to relate to the technology.

Several reported an observation of a general shift towards more paperwork and bureaucracy, of which the calculator was seen as an agent. Whilst carpentry has traditionally been a very practical profession, the computerized world of numbers comprised an interesting and new field of focus. Many of the informants – especially the older craftspeople – described having difficulty with the increasingly digital work tasks. This was especially true for mandatory digital tasks such as reporting, for which the computer was the only possible tool. Tales of older craftspeople resigning from a profession that had turned to digital bureaucracy were not uncommon. Some companies had chosen to hire their own "computer specialist" to handle all of the documentation demands that had arisen. These findings are similar to those of Aune and Bye (2005), wherein building operators were "feeling more like office workers." This finding was also emphasized by Søraa (forthcoming), who discussed the phenomenon of craftspeople blurring the line between traditional blue-collar work of manual labour and white-collar office work, thus creating a new form of green-collar workers, i.e. working hands-on with energy related problems.

Hojem and Lagesen (2011) found that legal codes and regulations seem to be the most effective instruments for shaping the environmental practices of consulting engineers. Looking at the *cognitive* dimension of the energy consultants' domestication of the energy calculator technology, the authors observed novel ways of thinking about energy and buildings and the emergence of new skills. This can be seen, for example, in an interview with an energy consultant, when asked if he would have preferred a different system (interview energy consultant):

> *No, there are really not that many ways to do that. I think Enova have come up with a decent solution. Maybe they should have provided a "general" category as well, where you can check off that you have to deviate, and describe why you've digressed. For it does not match the landscape, we can't fit it in. You must feel free to do some experimenting on you own.*

The user here expresses a desire for greater flexibility in the program, as he thinks that it lacks a "general" category. The world of the calculator and the world of the energy consultants – or the world of numbers and the world of materiality – did not always translate perfectly. As the users became familiar with the program, many told us that some "tweaking" was necessary to fit the material world they had traditionally worked in to this new world of the digital calculator. By doing so, some learned new ways of using the calculator.

One of the more tech-savvy energy consultants interviewed told us that he had developed several "mini programs" that he used to get input data for the energy calculator. These mini programs provided features that he felt the program was lacking, so he had made them himself. This might have given the energy consultant an advantage in the competitive landscape and might explain why he had not fed his criticism back to Enova: if the necessary technology was not provided by the producer, he could develop and use it himself and thus gain an advantage over those who were unable to access such technology. Sharing these innovative ways of dealing with problems could potentially benefit the larger community of energy consultants, but, at that time, suggestions for improvements do not seem to have been taken into consideration. The domestication of the tool does thus not allow much for changing the script.

11.2.3 Designed without user enrolment

Good computer programs are dependent on user involvement in the development process (Ives & Olson, 1984; Pagana and Brügge, 2013). This is both to ensure that customers get what they pay for and to minimize the development of unnecessary bad user interfaces. A piece of commercial software requires customers who will buy and use the program, and explicit knowledge of the target consumer group is vital for successfully developing the software. However, during interviews with NVE, it became clear that the target customer group was never obvious. When designing the energy calculator, NVE did not target energy consultants as the primary user group. This led the developers to refer to normal homeowners as "the users," and they assumed that the calculator was primarily designed for this group. During the interviews, it was necessary to clarify what was meant by "the energy calculator," as it apparently meant different things to different actors (interview NVE):

> *To us, the calculator is the one you can use without logging in, where you can play around with the system. That is the calculator. The calculator that we are referring to, it exists for playing around with the energy mark – see which energy mark you get by choosing different measures. If you are talking about the kind of calculator that energy consultants say they want, then we have misunderstood each other.*

The relationship between the energy calculator used for "playing around" and the one used for creating an energy label was cleared up later in the interview:

> *Computationally, they are identical, they use the same background data, it's just that you do not log in, and then you cannot save a certificate. But, you can take data registrations over into the energy label system. You must, however, log in, and then you can create a certificate from it. [...] You get a code that you can take care of in order to find the data you have registered.*

The intentions that were scripted into the energy calculator by the programmers do not seem to target energy consultants; rather they target a user who wants to "play around" with the energy mark. How did this affect consultants' use of the tool? In the case of the energy calculator, neither the layperson nor the expert users seem to have been included in the design process. As the programmers told us: "No, we have not seen that Enova spoke to any craftspeople when they made the calculator in an interview"; "There has been no testing of users, and we have not been doing inquiries on user responses either" (interview EVRY).

Without performing user tests, how can developers know if their program is being used as intended or if a user group has any problems with it? Some of the problems reported with the calculator and deviations from its intended use (as described in the previous section) can be seen to have resulted from the omission of professional users from the development process. When asked why there had not been any user testing prior to the program's release, this answer was given:

> *I guess it's something you should do when you develop that kind of thing, but we actually had no money and time here at that time [...] Enova had*

some kind of milestone, they were to present the energy marking on a TV program, I think it was on the Consumer Inspectors.

Ironically, it seems that Enova needed to produce the calculator quickly in order to reach a deadline to take part in a popular TV program, *Forbrukerinspektørene* [Consumer Inspectors], which highlights consumer-related issues. However, whilst the users were not included in the initial design phase, their experiences could be included in further development of the calculator. Some of the challenges that the energy consultants faced in using and domesticating the calculator seem to be problems that the programmers could fix without too much effort. Energy consultants who use the calculator are encouraged to leave user feedback. The feedback from energy consultants goes straight to Enova and can then be sent onwards to NVE and the programmers. According to the programmers, though, very little feedback reached them.

It seems, from our data, that the governmental actors did not consider the calculator to be something that should be improved. An employee from NVE told us: "After all, that is how it is built. It will take a lot to change it." This static view of the calculator also seems to be the result of poor communication within the network. Whilst some energy consultants might have desired certain changes in the calculator, they had to send their feedback to Enova, who had to then send it on to NVE, who had to then send it on to EVRY for eventual implementation. Somewhere along this network, requests seemed to get lost. NVE were quite firm in their claim that "the program was made that way"; that is, that the program would be difficult to change. Whether or not the program was actually difficult to change is unclear, as the programmers would be the ones to make any changes, in practice. In this specific situation, perhaps a direct link between "user" and "maker" would limit the frustration over program bugs and missing parts, but the flow of information has to be routed through the automatic passage points of Enova and NVE.

There seems to have been a mismatch between what the programmers perceived as easy fixes and what the developers believed would be too much trouble to fix. Taking the extra effort to include expert user feedback could benefit the transition to a more sustainable building sector. This is evident from the detailed descriptions in our interviews of the program being too cumbersome; in the informants' view, the program should be fixed by (for example) incorporating easier ways of navigating registration when having to recalculate or "lacking opportunities for categorizing different types/bodies of buildings."

The accounts illustrate both the practical and the cognitive dimensions of domestication that were not built into the design process.

11.3 Playing the calculator?

The energy calculator is intended as a government tool for enhancing energy efficiency in existing homes. The tool is supposed to support homeowners and energy consultants visiting homes in documenting energy efficiency and suggesting optimal solutions. It was designed as a tool between the 2.2 million homes needing renovation and the government. This article has shown how these intentions are affected by differences between the script of the calculator and the way the calculator is used and domesticated by energy consultants. Seeing how users interact with the tool, there is a striking lack of connection between the domestication and script due to a lack of user involvement in the design process and a lack of consideration of user feedback. Thus, the potential for social learning in a broad sense is not being exploited by the designers. The lack of user testing and effective feedback implies that, for the user, potential influence is limited to domestication rather than further development or real co-production of the tool for sustainable transitions. With the political goal of creating a static reporting tool something was lost in translation when it came down to the actual users. As the tool has gone through several stages of development, the dynamic nature of the hands-on usage of it does not seem to have been included to its full potential.

The analysis of the energy calculator domestication illustrates that many users do not adhere to the expectations that are written into the technology's script. The energy calculator developers claimed that they expected the users to "play around with it" like a game. However, many of the advanced users – the energy consultants – did not want to be part of this game, and instead made practical adaptations to get their job done. Interestingly, these users took the intentions behind the calculator in new directions and potentially contributed to transforming these original intentions, similar to the way in which the consulting engineers tackled uncertainty in the study conducted by Solli (2013).

Risholt and Berker (2013) point out that craftspeople could play an important role as mediators between available products and a specific building requiring renovation, but that, "today, due to a lack of knowledge and incentives, craftsmen are an important barrier to energy efficiency." The responsibility for this incentive barrier does not rest on craftspeople, alone. This article has shown that the incentive barrier has a crucial pressure point in the energy calculator, itself, as well as its design process, which hinders craftspeople working as energy consultants from performing their job most efficiently. The enrolment of craftspeople as users of the energy calculator could have proven fruitful earlier in the design process, but it might also be useful now, by reducing later frustration and making the transition to a greener and more environmentally friendly building sector more efficient. This could also serve as inspiration for international and intersectional actors seeking to implement similar tools of sustainability. Conclusively, tools for sustainable transitions can benefit from feedback on the domestication of the technology.

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12. ARTICLE 4:
Craftsmanship in the machine: sustainability through new roles in building craft at the technologized building site

Abstract

The building industry is becoming increasingly characterized by automated production, and in line with this, the nature of craftsmanship is transforming. In this article, we look for a sustainable path for this transformation through a case study that follows a team of carpenters building a set of tower blocks at a high-tech building site using "lean" construction techniques and robotic production technology. The builders are organized according to complex schedules of lean construction, making work at the building site resemble that of a large machine. The builders hold multiple roles within this machine: more than simply "living mechanisms" inside the machine, they also take on more parental roles as "machinists," employing their crafting skills in planning, problem solving, improvising, coordinating and fettling in order to make the building machine run smoothly and to minimize environmental uncertainty.

The craftsmanship in action is characterized by what we call *workmanship of uncertainty* – the ability to produce certain results in uncertain conditions. We identify this as the collective skill of a community of practice. The sustainability of craftsmanship in the machine is analyzed according to three kinds of sustainability: cultural, social and ecological. We suggest that all three forms depend on the building company's ability to provide working conditions that allow the builders to form stable communities of practice in order to perform, share and develop craftmanship. Finally, we show that working in and with technological production systems does not require fewer skills (of craftsmanship) than traditional building, but a nuanced application of these skills.

Keywords

craft; work automation; community of practice; lean construction; workmanship of risk

Journal and authorship

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12.1 Introduction

What will be the nature of craftsmanship in the building industry of the future? In this article, we explore this question by observing the building crafts in action at a modern, high-tech building site. At the site, builders and machines work together in a complex production system designed to raise five tower blocks. The towers are made from wooden elements that are produced by robots at a factory and built through a "lean" construction system on site in Trondheim, Norway. Lean construction implies a tightly coordinated building process wherein the builders contribute to planning and improving the process (Koskela et al. 2002). In this study, we follow a community of carpenters through the entire building process, focusing on the transformation in their craftsmanship as the building process becomes increasingly technological, and exploring their work as a community of practitioners. We investigate the particular skills that enable this community of workers to transform plans and designs into reality in the form of five tower blocks.

In any investigation of the future of craftsmanship, sustainability is an issue. Analyzing the direction of a certain development leads one to question whether this development forms a trajectory that is able to sustain itself, including the society and environment it is part of, both now and in the future. For building crafts, three kinds of sustainability seem particularly relevant: cultural, social and ecological sustainability. (A fourth kind of sustainability, economical sustainability, is not addressed in this paper). *Cultural sustainability* is addressed through an analysis of the preservation and development of traditional building crafts and craft cultures in the technologized building industry. *Social sustainability* is investigated through an analysis of the transformations in the building industry that have made it increasingly difficult for builders to sustain a decent life. Finally, *ecological sustainability* is addressed through an analysis of the building industry's increasingly important role in the transition to a sustainable low-carbon society (European Commission 2011). While ecological sustainability is not the main focus of the present study, the case indicates that the building industry's ability to contribute to ecological sustainability depends, in large part, on the former two kinds of sustainability.

In the following, we give a brief account of the technological and social transformations occurring in the building industry, before presenting our methods and the case study analyzed in this paper. We then introduce a theoretical framework for craftsmanship and technologization, before describing the role of crafts in the "machinery of building" and discussing this role as it relates to sustainability.

12.1.1 Technological Unemployment, Deskilling and Reskilling

For a long time, the Norwegian building industry has been seen as rather conservative (Ryghaug and Sørensen 2009); but during the last couple of decades, many changes have occurred in the industry, taking it in the direction of automatized production. We identify this tendency through the adoption of two kinds of technologies: First, automation technology, such as robots that perform tasks such as drilling, painting and laying bricks (tasks previously done only by humans). Such technology also includes the more radical development of large 3D printers that are able to print complete houses.[60] The increased use of prefabrication is also part of this development, wherein elements are produced in a factory for later assembly on the building site. Prefabricated houses have been produced in Norway for more than a hundred years, but the scale of such production has escalated during the past decade, with the added element of customisation. As a result, prefabrication now plays a role at almost every building site. The second new technology comprises advanced production techniques, such as lean construction (Koskela et al. 2002), which make the on-site building process subject to the same kind of technological management as factory production. Such technologization gives the entire building process a machine-like quality. While technologization of the building site is the main focus of the present paper, we see it in close relation to automated production.

A narrative that is often used to frame automation in relation to craftsmanship is that of machines taking jobs from humans: rather than serving as a tool for a bricklayer, the bricklaying robot may replace the human worker altogether. Although, historically speaking, automation has produced a variety of new jobs for humans (who must subsequently construct and operate the machines), the fear of "technological unemployment," as Keynes described it in the 1930s (Susskind and Susskind 2015: 284), has gained renewed interest in recent years. This is particularly true in relation to the so-called "Industry 4.0," wherein industrial robots are able to perform rather customized forms of production that were previously restricted to humans (Schwab 2016). The situation has inspired many public reports estimating the number of jobs that will be lost to machines within the next couple of decades. The reports indicate that a significant proportion of contemporary jobs will disappear in countries such as the USA (Frey and Osborne 2013), Sweden (Hultman 2014) and Norway (Pajarinen et al. 2015). These reports tend to be particularly pessimistic with respect to the fate of skilled workers in the building

[60] https://www.sciencealert.com/the-world-s-largest-3d-printer-can-now-make-entire-houses-out-of-clay.

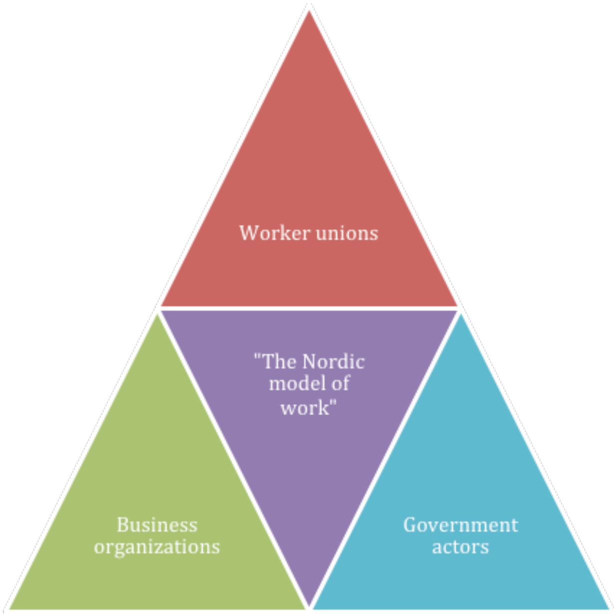
industry. For instance, a Norwegian report estimates that eighty-two percent of bricklayers will be redundant within twenty years, along with eighty-one percent of painters, eighty percent of building construction workers and seventy-two percent of carpenters.

However, when discussing the issue with builders, we found that they did not seem very concerned about being replaced by machines. "No, the building process is too unpredictable, you will always need human workers," a crew leader said, rather confidently. It was another aspect of this development that seemed to concern the builders – not the loss of work, but the loss of craftsmanship. This was particularly voiced in relation to prefabrication technology. Although the production of prefabricated elements required much of the same work as on-site building, it was not always seen as proper craftsmanship: "You are not a craftsman, you are a factory worker," an old master mason told us. "Being able to work outside, in rain, snow, and sunshine is part of real craftsmanship," he argued. A more precarious threat to building craft seemed to face the builders who worked out in the snow and rain, assembling the prefabricated elements: the risk of *deskilling*, or losing the ability to build houses from scratch. A young carpenter who worked with prefabrication commented: "With this, you are not a craftsman; you are an assembly worker." Deskilling implies a loss of status and identity (Fyhn 2018), but as our study indicates, there might also be an element of reskilling (acquiring new skills) that deserves inclusion in the narrative of technologization and craftsmanship.

12.1.2 The Nordic Model of Work

The craft skills in question exist in a cultural context: Norwegian builders tend to regard themselves as craftspersons and they distance themselves from unskilled workers, industry workers and assembly workers (Fyhn 2018). This status reflects the training system in Norway, which is a standardized version of the traditional training system for the crafts: one to two years of vocational school followed by two years of apprenticeship before the journeyman test, which initiates builders into the ranks of journeymen. This educational structure is the same for carpenters, bricklayers, plumbers and electricians, as well as goldsmiths, potters and other manual craftspersons.

The status of craftsperson in the Norwegian building industry is also affected by what is commonly called "the Nordic model of work" (Gustavsen 2011). See our figure below:



The hallmark of the Nordic model is an organized relationship between worker unions, organizations (representing business leaders) and government. This three-part collaboration is responsible for ordered and relatively fair negotiations about workers' conditions and serves to give workers a voice. As a result, builders expect to have a say in how things should be run at the building site, and they are prepared to take responsibility for solving any problems that occur. Taken together, the Nordic model and the Norwegian emphasis on formal skills seem to empower builders in Norway (see Tesfaye 2013).

Over the past ten to fifteen years, working conditions in the building industry have changed, due to new business models and the internationalization of the labour market. Building companies are shifting from their previous reliance on permanently employed builders to relying on casual workers, who they employ from job to job – a business model associated with "social dumping" (Alber and Standing 2000; Bals 2017). Today, the number of casual workers employed through vacancy agencies is far greater than the number of permanently employed builders at major building companies (Marsdal 2015). The typical building company is no longer a community of builders and office workers, but only office staff – those who plan projects and produce tenders; the focus of such companies seems more oriented towards economic speculation, while the actual building work is outsourced (Røyrvik 2011). Builders on temporary contracts provide the office flexibility in the event that the company does not win a contract. But it is the builders who pay for this flexibility, as they are forced to live in uncertainty and form what Standing

(2011) calls a "precariat." This development is dreaded by builders in Norway, who wait for the day on which *their* company will sack its permanent builders and rely on vacancy agencies for staffing. Having to work for vacancy agencies and line up for jobs with the "casuals" is described by the builders as a "worst nightmare" (Fyhn forthcoming). In many cases, working conditions on job sites are illegal, but this is difficult to prove, as workers hired by a subcontractor may have been hired by another subcontractor, which again may have used a third subcontractor (etc.), comprising a network that is designed to be difficult for authorities and unions to track (Bals 2017). As a result, the Nordic model is irrelevant at many building sites, and achieving the necessary conditions for social sustainability proves difficult.

Cultural sustainability is also threatened when building sites and companies no longer exhibit stable communities of practice. We were told that it takes several years of training following the apprentice period to become a skilled carpenter. This learning becomes difficult when there is no community to learn from. The quality of the work is said to drop without a stable community of practice. "The casuals come in for a few days to do a job, they make lots of building errors and then they leave without even knowing they made them," a frustrated builder told us. He continued, "at the next building site they make the same mistakes over again, happily unaware." According to some builders, such errors have consequences for ecological sustainability, as houses may not perform as well as they should in terms of energy efficiency.

From the builders' perspective, it seems that the tendency to rely on casual workers does not enhance sustainability. Despite this, it has proven difficult for companies relying on permanently employed builders to compete with companies using outsourced workers, due to higher personnel costs. However, some companies still seem able to compete. The company responsible for the building at Moholt (the site examined in this case) is an example: rather than sacking its skilled builders, it employed more. Relying on relatively expensive yet permanently employed builders, the company engaged in a stable community of practice. Its argument was that this community would be able to build more effectively and with fewer errors than would temporary workers at other companies. An essential aspect of this approach was involving builders in the planning process and applying lean construction principles. But this system also implied challenges in terms of redefining the traditional role of craftspersons. What is the new role of craftsmanship in the building industry? Does it point to a way forward for craftsmanship that is sustainable in any of the three ways we have suggested? We approach this question through a case study of the Moholt site.

12.1.3 Studying Craft at the Building Site Moholt 50-50

This study is based on fieldwork at a building site at which the company Veidekke built five tower blocks for student housing for the local university. The tower blocks stood nine storeys high. They were energy efficient, fulfilling the passive house level, and were made entirely of massive wood – except for the basement and ground floors, which were made of concrete in order to "anchor" the light towers. While concrete production produces substantial CO^2 emissions, massive wood binds with CO^2 in the air, reducing carbon emissions by fifty-five to sixty percent.

The tower blocks' wood construction made the building site special. While concrete-based building sites tend to be wet, drafty and noisy from constant drilling, this site was dry and quiet. There was no need to drill holes as screws could be inserted directly into the wood. Also, the site had a distinct smell of pine, rather than wet concrete. "This warms the heart of a carpenter," one of the crew leaders said on one of the first days of the fieldwork, reminding us that the craftsperson identity also has an aesthetic side.

The fieldwork was conducted by the first author in concentrated periods throughout the entire building process, during which the same community of carpenters was followed. These carpenters called themselves *snekker*, in Norwegian. In English, we would use the term "carpenter," but in other contexts the term may also be translated as "builder" or "construction worker" (even though a *snekker* is always considered a craftsperson). The fieldwork started in February 2016, when the building site was covered in snow. At that time, the first storeys had been built atop the concrete basements. The next period of fieldwork was in March and April, during which most towers were erected to their full height. The fieldwork continued in June, which saw much work done on both the inside and the outside of the fully erected towers. In June, the weather was nice and the builders wore short working trousers in signal colours, in addition to their obligatory safety shoes, helmets and protection glasses. At this time, the builders clearly longed for the summer holiday, but they had to work hard as the first three towers were scheduled to be finished at the end of the summer. The final period of fieldwork was in November 2016, after students had moved into the first three towers and as the final two were being prepared for the final inspection before being handed over to the client.

The fieldwork involved participation in many planning meetings, daily conversations with people and observations at the site. Much of the fieldwork focused on understanding what the builders did and said, attempting to learn their vocabulary and the principles by which they worked. In particular, the fieldwork involved significant contact with the crew leaders on site (called *bas* in Norwegian) and the foremen at the office (*formann* in Norwegian), who were all extremely helpful in making the process of building a tower block understandable for us anthropologists. In addition to participating and observing, we also conducted eight formal interviews with people involved in the building process: one with the client, two with engineers and five with carpenters.

The fieldwork was framed by a larger study of craftspersons and apprentices in the Norwegian building industry: "Crafting Climate Transitions from Below." This research project seeks to understand the role of craftspersons in the transition to more climate friendly building practices. The project includes studies of discourses of craftsmanship tools and policy, in addition to analyses of interviews with craftspersons, conducted by all authors between 2013 and 2017.

12.2 Understanding Craftsmanship in a Technologized Context

Craftsmanship at a high-tech building site such as Moholt must be seen in relation to the technology it works with. This implies automation and technological production systems such as *lean construction*. While craftsmanship, in its simplest definition, refers to "skills in a particular craft" (*Oxford English Dictionary*), craftsmanship in a technological context requires more specificity. The craftsman and philosopher David Pye offers some direction in his work *The Nature and Art of Workmanship* (1968). Pye prefers the slightly more modest term "workmanship" over "craftsmanship," commenting that it is not possible to say where one ends and the other begins (ibid.: 20). In his work, Pye concludes that it is futile to separate between work done by hand and work done with machinery (ibid: 25). For example, a dentist drilling a tooth with an electric drill is more reliant upon his steady hand than a carpenter using a hand-driven wheelbase to drill a straight hole in a piece of wood. Rather, Pye suggests that the degree of *risk* at play serves as a better way to distinguish workmanship from machine production. While the dentist drills with great risk of failure, the carpenter operating the wheelbase hardly exercises any risk at all, unless he/she is fool enough to break the drill. Pye thus introduces the term *workmanship of risk*, in contrast to *workmanship of certainty*. An example of workmanship of risk is sawing and scarfing boards to build a cabinet by hand. When using a planer and other tools, a workman still relies on his judgment, dexterity and skill to achieve the desired result. The workman needs to be alert and present in the work as the result is *continually at risk* through the whole process of making. This presence implies being more or less "immersed with his whole being in a sensuous engagement with the material," as Ingold (2000: s.295) puts it (even though the degree to which his "whole being" is immersed, in practice, seems to vary).

If, on the other hand, the pieces of cabinet are routed by machines at a factory, the result follows from the set-up of the machines and does not depend on the judgement, dexterity and skill of the workman. As such, workmanship of certainty is in effect when the workman is operating the machine. Let us not forget that workmanship of certainty is also workmanship, and implies the worker's skill and presence. Such workmanship is different from a traditional understanding of workmanship, but may become more important as machines and machine systems become more complex. In practice, building work at a contemporary building site implies both forms of workmanship and, as we suggest, also a third form.

While workmanship of risk has traditionally played an essential role in house building, the introduction of prefabrication and automation has moved more of the work into the sphere of workmanship of certainty. Still, workmanship of risk plays a role. At a modern building site it can apply to more than scarfing boards, fittings and joinings. As the following case study indicates, unforeseen things tend to happen at building sites, introducing an element of uncertainty to even the simplest tasks. This calls for a form of workmanship we might call *workmanship of uncertainty*, rather than of *workmanship of risk*. The word "risk" points to the risk of loss, as the desired result is at stake at every moment of the work. The word "uncertainty," on the other hand, points to a condition of not knowing what lies ahead (Whyte 2009). While Pye's workmanship of risk implies a reliance on judgement, dexterity and skill to produce a certain result under the constant risk of error, workmanship of uncertainty implies the production of certain results under uncertain conditions. Risk is always present, as the result is at stake throughout the entire process, but the risk of messing it up is also connected to not knowing exactly what is ahead, and this risk seems to increase as the building process becomes more complex. In this respect, even the task of assembling prefabricated elements implies a risk that calls for skill and judgement.

The ability of craftsmanship to produce a certain result under uncertain conditions also implies an element of *improvisation*. While improvisation in this setting means dealing spontaneously with situations that arise, it does not mean being unprepared. On the contrary, improvisation in the building process is something builders should be well prepared for. When a carpenter sets out to build a house, he/she cannot know all the challenges that will occur further down the track, but he/she will have already built so many houses that he/she will have a certain idea of what to expect, and will trust that he/she will make the right decisions along the way, even if he/she cannot foresee all these decisions. The carpenter's skills, experience and preparation become *improvisation potential* (cf. Jørgensen 2004) – the potential to make the right decisions and perform the right actions at the right times during an unpredictable process. Improvisation along the way, involving finding solutions to problems as/when they occur, makes it possible to produce even and predictable results from uneven and unpredictable situationa. This is workmanship of uncertainty.

Workmanship of uncertainty also implies planning – not necessarily planning in terms of articulating the finished state of the building (as in an architect's drawing), but planning in terms of looking ahead, beyond the next step, to find a sustainable way forward – planning in terms of discerning the way, rather than articulating the result, as distinguished by Ingold (2013: 109–11). The ability to plan is part of improvisation, as it is part of any craft. At a large building site, the ability to plan stands out as even more essential than it might otherwise be for a craftsperson working alone.

Building a house is rarely a solitary activity; rather, it typically involves teamwork. In the present case, more than 50 builders were engaged in work at the building site. The community of builders solved problems, improvised and produced steady results, because they worked in uncertainty. Their ability to succeed depended on their ability to collaborate, learn, plan and improvise as a community of practice (cf. Wenger 1998). This required a certain level of organization.

The community of practice was also essential for managing the different skill levels between builders. Builders' concerns with respect to their skills often relate to fears about becoming assembly workers, but losing a community of practice may be equally detrimental for their skill development. Building skills are learned and practiced (trained) through work at the building site. The apprentice learns through active participation: doing the practical work and making mistakes while being guided and corrected by senior builders on site. Also, after the apprentice period, training continues through engagement with actual work. It is the collective of builders that develops new builders – enabling them to observe and learn from more experienced members of the community – through the combined efforts of colleagues in the community of peer practitioners (Søraa et al. 2017).

12.2.1 Craftsmanship in the Era of Technologization

Understanding craftsmanship in technologized building projects calls us to inquire into the nature of the technological more closely. In particular, the aspect we might conceive as machine technology might be useful for the craft perspective. A machine is defined as "an assemblage of parts that transmit forces, motion, and energy one to another in a predetermined manner" (*Webster's English Dictionary*). While a machine is often understood as one particular solid entity, such as the engine of a car or a robot at a factory, it can also be understood more abstractly, as a principle. However, there is always design behind it: the dictionary points out that a machine is "a constructed thing whether material or immaterial." The term can also be used more metaphorically to describe "a group of people who control and organize something," as exemplified by "Churchill's war machine" (*Oxford English Dictionary*). The technologization of the building site implies the introduction of machines as entities; but more importantly, it makes the more abstract principle relevant, as the building process is organized as an assemblage of parts and people that work together in a (more or less) predetermined manner.

One characteristic of the machine – be this an entity or a principle – is the *predetermined manner* in which it works and is expected to produce results. From the point of view of craftsmanship, this is what links the machine to workmanship of certainty. Ingold's (2000: 304–8) deconstruction of the industrial production machine throws light on this: in the old manufacturing workshop, the craftsperson would guide the tool with his dexterous hands, in interaction with the material. With "machinofacture," the tool is guided by the machine, as the edge of a carving knife or the spindle of a loom (the "working-point") is mounted on a moving mechanism. As the movement of the working-point follows a set course – one that is fixed in advance by the machine's design (cf. Ingold 2000: 296–306) – a particular kind of certainty is introduced to the work, even if errors might still occur. Further, the machine implies a particular instrumentality, which is separate from the experiencing human hand and sensibility (cf. Bruzina 1982: 167).

Ingold's argument suggests an opposition between the craftsperson, who is "immersed" in sensuous engagement with the material, and the machine operator, "whose job is to set in motion an exterior system of productive forces, according to principles of mechanical functioning that are entirely different to particular human aptitudes and sensibilities" (Ingold 2000: 295). Still, he does not suggest a fundamental duality between the human operator and the machine, as the operator should be seen as part of the machine (transmitting force, motion and energy), in addition to the work-piece (following the argumentation put forward by Relaux in 1871). As part of the machine system, the human operator can be said to be in a different relation with the machine; it is not the machine that is serving the human, but the human operator serving the machine system (as pointed out by Marx 1930: 451).

Marx describes a similar role for human workers in the pre-industrial manufacturing workshops, as "the living mechanisms of manufacture" (1930: 356, 451; Ingold 2000: 309). The idea of humans serving machines becomes more obvious as the manufacturing workshop is turned into a factory hall in which lines of machines form a single production system. The archetypical example is Ford's plant at Highland Park, where a great number of machines were coordinated into a production line transforming raw steel bars into finished Model T cars. The production and transportation of steel into the plant were coordinated as parts of the same machine system, along with the workers on the production line. This plant represented the start of what was a few years later called *mass production*.

Mass production is characterized by a great number of similar products being pushed forward along the production line. The focus is on large quantities, minimal costs and continuous operation of the production line. Work at each work station should be so simple that a worker can be trained for the task within minutes. Thus, workers are not only parts of the machine system, but *replaceable* parts, in stark contrast to the craftspersons of manufacturing workshops. The activities of mass production workers are limited to the monotonous and predetermined tasks of the workstation; they are not included in planning, nor do they make any other contribution to improving production. The slightly inhuman aspect of mass production work has been caricatured in movies such as *Modern Times* by Charlie Chaplin, forming a clear opposition to the rather romantic view of craftsmanship presented by Ingold.

Lean production replaced much mass production in the car industry during the 1990s, and is currently becoming integrated into other industries. Lean production systems tend to be coordinated in such a way that they align with understandings of a machine, as both an abstract principle and a metaphor. "The Toyota machine" is similar to "Churchill's war machine," as suggested in the title of the book that opened the world's eyes to lean production: *The Machine that Changed the World* (Womack et al. 1990). This book presents the principles that developed Toyota from almost nothing after WW2 to the largest car producer in the world. The Toyota production system has some different properties than mass market production systems, also when seen from the perspective of the workers.

Lean production is more than a production system; it is also a different way of thinking that requires penetration throughout the entire organisation in order to work. For workers, lean production implies a different role for worker groups, giving them more responsibility and multiple functions in the production process than what is otherwise offered to them in mass production systems (Melles 1997). It moves from a "push system," wherein products and components are pushed down an assembly line, to a "pull system," wherein only the products and components that are asked for are delivered to each station. "Just in time" (JiT) delivery is an essential aspect of lean production and implies the tight involvement of external suppliers. This calls for a different relationship between producers and subproducers, wherein a strict contract relationship allows for a trust-based relationship founded on a sense of shared destiny. This sense of shared destiny is also said to characterize the relation between workers and the company at Toyota, as the workers are often employed for life.

With JiT there are no reservoirs of components piling up at workstations, as buffers. This implies the constant risk of stops in production if a component does not arrive in time, but such risk is actually said to make workers and producers more alert (as we saw in workmanship of risk), contributing to fewer stops. The build-up of spare components that is so typical of mass production is, within lean, considered a form of waste (called *muda* in Japanese). Unnecessary use of space, time and movement are also forms of *muda*. Another essential term in lean is *kaizen*, referring to the philosophy of continuous improvement. In a lean production system, when a mistake is detected, the assembly line is stopped and the source of the problem is tracked down and removed. This process actively involves all workers and any worker is allowed to stop the production line; in mass production systems, only production leaders are entrusted with this task. *Kaizen* significantly reduced the time that Toyota's production lines stood still, as the causes of stopping were continuously removed. Another essential term in lean is *genchi genbutsu*, meaning something like "go to the right place and see." The idea here is that decisions should be made as close to the actual work as possible – normally in the production hall – and leaders should spend time there, rather than at the distant office. As variations of the lean production philosophy have been introduced at other car producers, the costs of production have significantly reduced. For example, Porsche was able to reduce its production costs per car by 53 percent by adopting lean production techniques (Khattak and Sharwar 2014). However, while achieving high customer satisfaction, lean production has been criticised for not sufficiently considering worker satisfaction (Babson 1993).

Lean production principles were first introduced to the building industry under the description of *lean construction* (Koskela 1997). In contrast to cars, which are produced in great numbers, building projects are typically bespoke projects. They are also more stationary and take more time to complete. For these reasons, lean philosophy had to be modified to suit industry needs. But the fundamental principles of lean remained: *kaizen*, constant learning; *muda*, elimination of waste; *JiT*, just in time delivery; and *genchi genbutsu,* worker involvement. In lean construction, worker involvement implies significant involvement in project planning, as every project needs to be planned in a more unique way than in car production. The *Last Planner System* is a systematic approach to construction planning that is commonly associated with lean construction, involving regular meetings with workers. At Moholt, a planning system called *Involved Planning* was developed to take advantage of the Nordic model of work and to involve the workers to an even greater extent than was otherwise possible through the Last Planner System (Andersen 2012, 2017). The practice at Moholt showed traces of Volvo's *Reflective Production* program, which was also developed within the Nordic model and emphasised workers' involvement in planning to ensure meaningful work situations (Ellegård 2007). Similarly, over time, Toyota's production system became more worker-focused than the original customer-focused system that served as the model for lean (Pil and Fujimoto 2007).

12.3 Lean building at Moholt

The Moholt project followed a specific principle within lean construction called *TAKT*. TAKT was developed by Porsche Consulting[61] and adjusted to fit Norwegian work life. When the building work started, there was much excitement as to how the TAKT model would work. This was the third building project in which the company had used this principle. In their first attempt, they had not managed to maintain the required pace of work, but many essential lessons were learned from the problems that occurred (Andersen 2012; Kattak and Sarwar 2014). The second attempt was executed more smoothly, but was

[61]https://www.porsche-consulting.com/en/services/industry-expertise/construction/.

still not perfect (Mordal 2014). By the time they were preparing for the third attempt, the workers had gathered so much experience that they hoped to hit the mark properly.

With TAKT, the entire building process was structured as a factory hall – an assembly line through which objects being built moved from work station to work station, where the necessary operations wereconducted. At the building site, it was the workers who moved through the building, resembling a production line, while the building stood still. The moving teams of builders were called "wagons," as they moved through the building like wagons in a train. The wagons typically consisted of two to four builders performing specific operations. In total, twenty-three wagons moved through the tower blocks at Moholt, covering all operations, from putting up structuring walls to cleaning the finished rooms. Each wagon completed one storey of a single tower in one week, implying that the towers were built at the speed of one floor per week. When wagon one fished the first floor, it would move up to work on the second floor while wagon two would move onto the first floor. The week after, wagon one would move to the third floor, wagon two would move to the second floor and wagon three would start working on the first floor. In this way, the process progressed until all twenty-three wagons were engaged "in the train." Once the first wagon finished the top floor of the first tower, the "train" would move on to repeat the process in the next tower, until all five towers were complete. Every wagon used forty weeks to move through the entire building complex, with the last wagon starting and finishing twenty-three weeks after the first.

When the concrete foundation was in place, workers started to assemble the prefabricated elements that made up the outer and inner walls and served as a carrying structure for the towers. When the roof was tightened and the wood dried, work started inside the building. This preparation was conducted by the first wagon. The second wagon consisted of carpenters, who carried out the timber work on the floor. The third wagon installed plumbing, whilst the fourth installed the main ventilation. The fifth and sixth wagons installed electric gates and cables, respectively. The seventh installed insulation and plasterboard, and the eighth and ninth wagons put up the inner roofing. The tenth installed more ventilation and plumbing. The eleventh put up more roofing and inner cladding. The twelfth laid the floors, and the thirteenth wagon painted. New wagons with new tasks continued to move through the towers until the twenty-third and final wagon, which consisted of cleaners, prepared the building for handover to the client.

During this period, the builders found ways to be more effective and to build faster, according to the *kaizen* principle. As the speed of the train was fixed to one floor per week, increased efficiency was “cashed out” by gradually reducing the number of builders in each wagon. During the building time, we saw fewer and fewer builders in each wagon. Reducing the number of builders in different wagons was a common topic at weekly meetings. Builders removed from a particular wagon would be given other tasks on site or added to other wagons later in the train. When this process worked smoothly, it could radically improve building efficiency; but it was also quite vulnerable, as it depended on tight coordination. Delay in a single wagon could halt the train and stop the building.

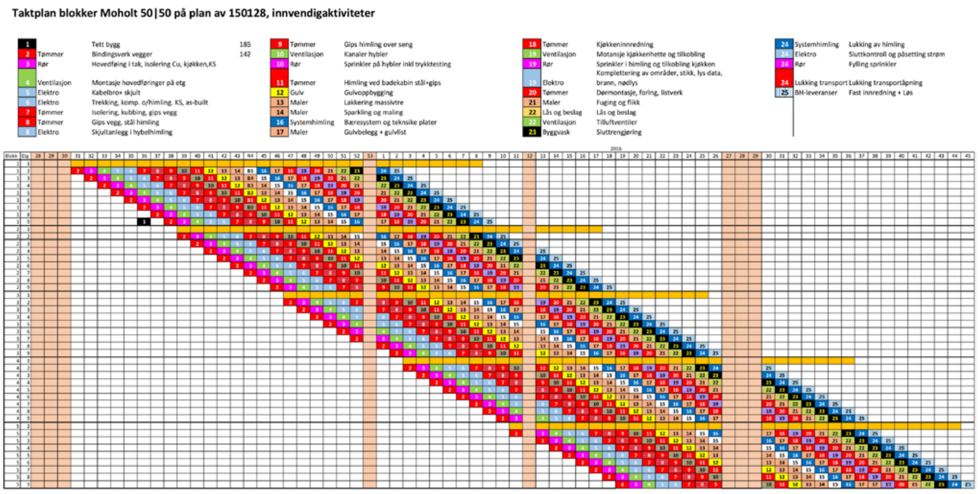


Figure 2: The Gantt diagram shows the plan for the building process. Horizontal lines show time, squares equal one week and vertical lines represent tower floors. Each wagon has an individual number and each craft an individual colour; one coloured field is the work of one wagon in one week. It might be difficult to see all the details in this image, but the idea is to show the complexity and general movement of the whole system, as a train working its way diagonally down the diagram. The light pink vertical lines that interrupt the general movement represent holidays; building halts for one week at Christmas, one week at Easter and three weeks over the summer holiday.

Looking at the building from a distance, over time, we formed an impression of the building site as a gigantic machine, with a production line that moved systematically through the tower blocks, one floor per week, like an old steam train with the sound of carpentry. It was constantly fed stacks of plasterboards, pipes and other material. At regular intervals, the machine stopped and builders came out for their nine o'clock coffee breaks and lunch breaks, before they – and thus the machine – moved on. In this way, the large machine moved rhythmically according to the predefined movement of the schedule, just as one would expect from a production machine.

12.3.1 Workmanship of Uncertainty in the Machinery of Building

What was the role of craftsmanship and builders in the machine building at Moholt? Looking at the steady movement of the wagons from a distance, we imagined that the builders were playing the role of cogs in the machinery, striving to work according to the predefined course as smoothly and predictably as possible, not unlike the machine operators of mass production. Being inside the building, observing a single wagon in action, we saw carpenters, painters and other craftspersons doing handiwork. The carpenters were happy to have the floor to themselves, without having to step over plumbers or wait for electricians to install cable gates – situations that were apparently quite common at other building sites, but which the TAKT machine had ordered. Observing their work, we saw that plasterboards and listings were cut by hand and put into the timber frames with screwdrivers; measures were made with rulers or by eye; paint was put on the walls by hand. No robots or production machinery were present inside the building. Seen in isolation, the work on each floor resembled old fashioned craftsmanship, characterized by workmanship of risk. The craftspersons seemed to resemble "the living mechanisms" of manufacture more than "cogs" in the machinery of mass production; they were organic, more than mechanic.

Another difference from machinery, which is routed permanently in steel, was that the character of the work changed over time. For example, the carpenters learned and found new ways of doing things (*kaizen*). After a few weeks, they stopped using rulers and cut plasterboard directly with their dexterous hands. They also had plasterboards delivered in increasingly efficient ways: rather than storing a large stack by the loading window, they spread them out in smaller stacks closer to the rooms in which they were actually being used. Even after thirty weeks, the carpenters managed to find new ways to improve their efficiency and reduce the number of workers in the wagons. As expected in lean construction, it was mainly the workers (e.g. the carpenters) who came up with these improvements and put them into effect; in this way, the workers' roles were more than simply parts in a machine.

But the builders were also less predictable than machine parts. They got sick and made errors, thus representing an element of risk for the goal of having the machine run at the exact pace of one floor per week. How was this handled? One approach was economic encouragement, requiring each wagon to compensate the subsequent wagon according to an agreed rate if they did not finish their floor in time (by Friday). Also, as their piecework rate required them to perform at pace, much of their income depended on them finishing on time. If a wagon was not finished by Friday, they had the option of working through the weekend to keep to schedule, but that option was rarely used; rather, the wagons almost always finished on time. When the builders were asked how they managed to keep the pace, several stressed that more important than the contractual arrangements was the shared understanding of how this building method worked and the *necessity* of keeping the pace. There was also a strong sense of shared destiny, as they all wanted to succeed. Thus, the different professions helped each other finish on time, and there were many informal agreements between wagons, providing flexibility by adjusting the strict schedule. For example, the electricians would allow the carpenters in the next wagon to deliver their stacks of plasterboards while they were still working on the floor on the Friday, and in return, they would be allowed to return to install the heaters after the painters had finished, later on. Such agreements were natural, given the holistic understanding of the building project and the mutual interdependence of the workers involved (Andersen 2017).

The flexibility of the builders was absolutely necessary for the wagons to move at the right pace. Our impression from the building site was that much of the work – particularly for the crew leaders – consisted of solving the more or less unforeseen problems that occurred each day. There were many sources of unforeseen events; some were due to the human nature of the builders, while most had other causes. Such causes could include surprising discoveries made during groundwork or rough weather conditions. For example, strong winds could stop the building by preventing cranes from lifting large prefabricated elements in place, as the winds would blow these elements away, like kites.

The most important source of uncertainty was the JiT delivery of materials, components and services. The building plan was vulnerable, as it presupposed that everything would be delivered to the place in which it would be used at the time at which it would be needed. On a Monday morning, when the carpenters in wagon seven would be starting to put up the walls for fire protection on the fifth floor, the stack of plasterboards would be there, ready for use, as it would have been delivered through the window hatch on the Friday evening. The following week, the same delivery would come through the window hatch onto the sixth floor, and so forth. For this system to work, the plasterboard supplier needed to perform precise deliveries. If the boards came in too late, the entire train would halt. Thus, the producers and suppliers were enrolled in the pace of the building machine, just as the builders were – preferably by sharing the sense of a common destiny. This was managed sufficiently well by the suppliers who collaborated directly with the building project, but these suppliers also depended on third parties that were one step further away; further, some of these suppliers depended on even more distant suppliers. The more distant the supplier from the building site, the less likely they were to appreciate the importance of JiT delivery. Having suppliers and producers understand the principles of lean building and realize the importance of JiT delivery was said to be one of the most challenging tasks at the building site. Suppliers who were out of pace seemed to be the most common source of problems. This vulnerability called for the community of builders to improvise.

Small delays were handled by borrowing from other wagons, reorganizing the work order or finding useful things to do while waiting for a delivery. Major delays, however, needed major transformations in the plan. For example, a flood during the winter of 2016 destroyed the factory that was producing windows for the tower blocks. Suddenly, no more windows were coming and no new deliveries were expected for three months. This called for a series of sudden rearrangements to the work order.

Deliveries not only caused problems when late but also when too early. If the plasterboards for the carpenters in wagon seven arrived a week too early, the boards would fill the workspace and cause a mess for the electricians in wagon six. There was simply no place to store materials that arrived too soon. Such deliveries also required personnel to unload the truck as it arrived, and no one was happy about dropping out of their wagon to handle such tasks, risking a delay in their scheduled work. The message that deliveries should not arrive early did not reach all suppliers. One example pertains to the delivery of kitchens from an Italian producer. The exact date for the delivery was set according to the building plan and agreed with the kitchen supplier. The drive through Europe would take several days and a truck was sent from the factory at a precise time in order for it to reach the building site at the right moment. Once on site, the kitchens would be unloaded to a temporary storage. But miraculously, the truck transporting the kitchens arrived several days ahead of schedule. In order to manage this, the truck driver, who had been hired for the occasion, must have broken all possible speed limits and neglected all possible requirements for resting time. He probably expected honour for arriving ahead of schedule, but instead was made to wait until the next day, when the truck could be unloaded. The truck driver was very unhappy, but unloading the kitchens ahead of schedule was simply not possible.

Yet another source of uncertainty pertained to the periodic building errors. Although the number of errors at this building site was said to be exceptionally low, they did still occur, and they required improvisation. For example, in one instance the attachment points for the lift system in one of the towers proved sixty centimeters off, and this prevented them from being installed. The carpenters' and lift fitters' drawings had not been properly coordinated, and showed different heights. In a complex building project, it is difficult to avoid such mistakes, but it seems that they can be handled by builders who are able to work in uncertain conditions.

Observing the building over time, we saw an almost constant stream of unexpected problems and builders engaged in solving these. This lends yet another dimension to their workmanship of uncertainty, implying that they held more than skilled, flexible and learning roles inside a larger machine. The craftspersons also worked *outside* the machine, as "machinists." Viewed as a machine, the building process at Moholt was not a modern engine that ran smoothly independently; rather, it was an old steam engine with all kinds of whims. The constant fettling and adjusting needed to keep it running called for the craftsmanship of a skilled machinist. The lean construction system at Moholt was a machine that required constant attention of a quite sophisticated kind, calling for craftspersons to improvise, communicate and rearrange plans.

12.3.2 Planning

The plan for the building process at Moholt resembled the outlines of a machine: when set in motion, the causal relations between the rubrics of the Gantt diagram produced the desired results with a similar form of causality as when the parts of a production machine work together. The "building machine" ran smoothly only when the builders were able to follow the plan with precision and fettle and improvise to keep it running. But this was not enough. The plan also needed to be "buildable." Thus, it was essential for the builders to be involved in the planning process.

As described above, the planning practice at Moholt was called Involved Planning, and it had been developed within the company in collaboration with the researcher Lars Andersen (Andersen 2012; Veidekke 2011). The system built on the principles of lean construction and the Last Planner System (Ballard 2000), but was more oriented towards the Nordic model of involving employees in decision processes and implied more worker participation in planning. The Involved Planning system included the builders throughout the entire building process, forming a systematic approach to all levels of planning, from the general project design to the day to day planning. Builder representatives were involved in much of the planning that had traditionally been left to architects and engineers. At the other end of the spectrum, much of the planning that had traditionally been done by builders on site was moved into the barracks meeting room and formalized.

The lean construction system required a lot of detailed planning. As with most building sites, Moholt was initially planned by architects, and this initial plan was later developed into more detailed technical plans that were eventually made into specifications for each craft involved (e.g. plans for the electric system, the plumbing and ventilation systems, the firewalls, etc.). These more detailed plans were developed alongside plans describing the building process. Both kinds of plans needed to interact perfectly.

The structure of the tower blocks consisted of prefabricated wooden elements that were routed by robots at a factory and joined together on site. Within these elements, the holes for cables and pipes were also routed by the robots. The order in which the carpenters, plumbers, electricians and painters worked had to be reflected in the position of these holes. For example, because the wagon with the plumber came before the electricians, it was essential that the holes for plumbing were located inside the holes for the electric cables, so the sewer pipes would not block the electricians when it came time for them to pull their cables. Not only the holes, but a myriad of building logistics needed to be incorporated into the elements, together with detailed specifications for each of the professions involved. All this was sorted out and fed to the robots before any of the actual building work started. Thus, the participation of builders in the early stages of planning was essential, as only they knew their work in sufficient detail to feed into completely buildable plans. In these early meetings, the rough order of the building process – as shown in the Gantt diagram – was planned. However, much still depended on factors that could not be easily foreseen, and thus more had to be planned at a later stage.

Planning meetings were arranged throughout the building process. In these meetings, builders, leaders and engineers would meet to plan work for different periods of time, such as two months, two weeks or one week. For example, the foremen and crew leaders would meet every Thursday to plan for the next week. Every Monday, the carpenters would meet to plan for the current week. During these meetings, plans would be made according to the information at hand; the closer the meeting was to the time planned for, the more up-to-date the information would be. Therefore, it was important that planning was conducted at the right times, often as late as possible, to ensure the best information was available. For example, on Thursdays, it would be possible to predict rather accurately which builders would be present the following week and to plan the task for each builder in detail; on Mondays, it would be possible to know (for example) who had an appointment with the physiotherapist on Wednesday at twelve o'clock. Such details could not have been planned two months in advance.

Planning has always been part of craftsmanship and improvisation, in terms of "looking ahead," and it stands in contrast to the articulation of the finished state that characterizes architectural drawings. While architects and engineers traditionally generate articulate plans, builders – as craftspersons – tend to plan along the way, whilst embedded in the actual building work (Ingold 2013). At Moholt much of this planning was formalized in regular meetings, in which the builders took part in terms of both looking ahead and articulating the finished state. All in all, the builders spent more time making plans in the meeting room than they would have in a traditional building process. Still, the builders seemed to agree that they actually saved time by doing this, as the building went more smoothly, with fewer errors. Also, participation in planning was said to contribute to a feeling of having a say in their working situation and being included more fully in the project.

To plan in such detail and with such accuracy as the lean construction system required, it was essential that the crew leaders who were coordinating the plans knew the builders well. A crew leader stressed that they could never have built in this way without permanently employed builders: "It would be impossible to have this matrix work if I did not know the lads," he commented one Thursday whilst organizing tasks and people for the following week. "One working hour is never similar to another working hour," he said. "The difference can be as much as a hundred percent." Also, when unforeseen tasks arose, he needed to know exactly who could handle that particular job and who could not. For example, he knew that "Jon" would go mad if he had to screw roofing for four weeks in a row, while "Paul" would actually prefer to have the same task for months. He also knew that "Simon" needed a proper task with good piecework pay, following his efforts in the basement. And when "Peter" came to him with an aching back, the crew leader was able to find him alternative tasks that would not cause him greater injury. Because the crew leader knew "Peter" well and could constantly adjust the plans, it was possible for him to negotiate the situation and avoid losing a good carpenter to sick leave. Had he not known the builders, he could not have managed this. This day to day negotiation of solutions suited the builders and was necessary for the successful implementation of the project. Solutions could not be standardized as in mass production, as the matrix of builders and tasks had more in common with a living polyphony than a Gantt diagram. They were more like crafted items – tailor made for each situation and flexible to accommodate moment to moment adjustments in line with unpredictable occurrences. Managing the building project required constant attention, as the result was constantly at risk. In this way, even the day to day planning on site was an aspect of workmanship of uncertainty.

Day to day planning of work tasks was not the responsibility of the crew leader, alone. It also required active contributions from the entire community of builders. When asked directly if he could have managed this process with casual workers, the crew leader asked how we thought Rosenborg, the local football team, would have performed if they had relied on hiring players from match to match. “Impossible!” he said. This analogy reminded us that the day to day fettling of the work matrix required more than knowledge of the players; the players took active roles in the polyphonic dialogue we call a community of practice, learning and developing together, and handling uncertainty together.

12.4 Towards Sustainable Building Crafts

Above, we described the Moholt building project as one in which skilled builders interacted with each other, suppliers, the materiality of the building site and the robots that prefabricated the elements. The builders formed a community, applying their skills both within and outside the complex building system and constantly reformulating plans. In our eyes, this building project had some properties that pointed to a possible path for future building projects. Could Moholt represent a sustainable path for building crafts? We approach this question in terms of the three forms of sustainability defined above: cultural, social and ecological sustainability.

Cultural sustainability concerns the continuation or preservation of craftsmanship in terms of skill, culture and tradition. The increased use of prefabrication and robot technology is connected to a concern among builders about losing their craftsmanship and status as craftspersons and becoming “assembly workers.” The negative connotations that are attached to this term can be linked to its association with mass production and assembly workers spending their days doing monotonous tasks it takes them fifteen minutes to learn. The preservation of craftsmanship does not seem complementary to the idea that builders are replaceable parts in the machinery of building. In this sense, lean production models may be relevant, as they are generally more focused on the skills of builders and other workers. But lean has also been criticised for placing too much focus on organizational performance at the expense of worker status (Pil and Fujimoto 2007). In this respect, Volvo's *reflexive production*, developed within the Nordic model, may serve as an alternative source of inspiration. At Volvo's experimental Uddevalla plant, the same team of skilled workers assembled the entire car, in sharp contrast to the task breakdown in mass production and lean systems. The car stood still while the workers moved around it, using mostly handheld tools (Ellegård 2007). In this production system, the development and use of skills was more aligned with traditional craftsmanship, and this led to increased worker satisfaction (ibid.). We see some clear parallels between the system at Uddevalla and the Involved Planning principle at Moholt, even though the latter explicitly adhered to lean, with the TAKT principle producing an "assembly line effect" throughout the buildings. The TAKT system was welcomed by the builders, as it gave the different wagons good working space by allowing them to have entire floors to themselves. But it also involved monotonous tasks for the builders. For example, even though most carpentry jobs began as craftsmanship of risk, these same work operations were repeated over forty floors, resembling the production lines of mass production. The crew leaders told us that they strove to rotate the builders in order to prevent them from performing the same task for too long. But not all of the builders wanted variation; some actually preferred the monotony of nailing identical plates of plasterboard for forty weeks in a row. Seen in this perspective, the idea that there is one narrow understanding of craftsmanship seems futile. At the building site, we saw a polyphony of skills in action, but as the builders worked in a community of practice, they complemented each other. The "polyphonically skilled" community may be a more fertile unit for analyzing the cultural sustainability of craftsmanship than the skilled individual.

Is craftsmanship threatened by automation? Although the builders at Moholt had concerns about becoming assembly workers, the constant uncertainty inherent in building projects made them rather certain that they would *not* be replaced by machines. Their skills as builders enabled them to handle unforeseen situations that, to date, no machine has been able to. For this reason, they seemed to believe that human craftsmanship had a future even in a world of machines, emphasizing elements we associate with workmanship of uncertainty. To the builders, the traditional skills of workmanship of risk were still needed, but their nature seemed to be transforming in line with developments in building technologies. In addition, they felt that automated production technology and lean construction systems put more emphasis than traditional building on the ability to *work with machines* in complex, machine-like construction systems. We describe this as working simultaneously *in* the machine as craftspersons and *outside* as "machinists" and planners, navigating uncertainty; these builders *were* the machine as much as they were running the machine. Such systems required the builders to work with not only machines, but also other humans in functioning communities of practice. This last issue was said to be essential for handling uncertainty, and an essential aspect of workmanship of uncertainty. If the practice at Moholt pointed to a culturally sustainable path, this path was not a museum-like preservation of old school crafting and building techniques; rather, it depended on sustainable communities of practice involving learning, using and developing high-level crafting skills in a transforming world.

As for social sustainability, which path did Moholt point to? When the first attempts at lean construction were introduced in Norway, there was some critique from labour unions – for example in a document published by NTL in 2011: "Yes to participation and trust. No to lean." Some argued that the Nordic model of collaboration could be threatened by lean if the autonomy of workers was lost when standardized, short-term decision processes replaced the Nordic model's participatory decision processes (Ingvaldsen et al. 2012). However, they also pointed to the possibility that lean principles could be adapted to accommodate the tradition of participation in Nordic work life. The system of Involved Planning can be seen as seeking exactly that, as it involves builders in the planning in a more fundamental way than in some versions of lean. For example, the lean principle TAKT, which was applied at Moholt, was said to be very different from the German version, which had a more top-down command structure. Lean and similar principles should be discussed in relation to the cultural circumstances they are adapted within. In this case, the Nordic model of work played a key role.

Seen from the perspective of builders and craftsmanship, another major issue regarding lean and lean-like practices is the business model of outsourcing that has come to dominate the building industry during the past decade. This model relies on casual workers on short-term contracts to achieve flexibility for the company office. The burden of uncertainty connected to winning or losing contracts is thus carried by the builders, who go from being permanent employees to not knowing whether they will have work the next day. This business model creates conditions for the builders – both Norwegian and immigrant – that do not appear sustainable in a social sense. The use of casual workers invokes the logic of mass production, wherein workers are seen as replaceable parts, rather than able members of a skilled community. The practice also seems to put the quality of the building at risk. If part of a company's workforce is temporal labour, then the quality of production can be secured by various control systems (as exemplified by Pil and Fujimoto 2007). However, if almost one hundred percent of a workforce consists of temporal labour, the community of practice is destroyed and, with it, the level and development of the workers' crafting skills. The role of the community is particularly obvious in complex building projects. Builders at Moholt stressed that they could not have built in that way if they had not been permanently employed builders who knew and trusted each other. This was also key to the company's competitive advantage: by relying on a steady community of skilled workers that had been trained by the company, the company was able to achieve a high level of skill and handle complex constructions, enabling them to build quickly and with few errors, and thus to compete with companies relying on cheaper, temporal labour. In contrast to temporary workers, who provide certainty in an uncertain situation by living uncertain and precarious lives, a community of permanently employed builders provides certainty through workmanship of uncertainty. Although some critiques of lean construction might hold weight in this scenario, lean seems far better suited to accommodate sustainable social conditions than outsourcing, as it requires skilled communities and thus permanent employment. In combination with Involved Planning, it also seems to take a step towards the Nordic model of worker involvement.

Finally, lean building practice is also relevant for ecological sustainability, as the constant focus on eliminating waste (*muda*) contributes to a building process that minimises material use. Further, the ability to build with accuracy and few errors is important for achieving low-emission buildings (such as the Moholt tower blocks), which are characterized by technological complexity, a need for high accuracy and tightness and great negative consequences for building errors (for example, in terms of moisture damage). The engineer responsible for the environmental aspects of Moholt stated that they would not have been able to achieve these results without the active involvement of the builders. Other companies might have been able to achieve the same results in other ways, but when the builders left Moholt, they had managed to finish on time, below budget and apparently without serious errors. Also, they had avoided major injuries and had almost no short-term sick leaves. The leaders told us they were certain that they would continue to develop down this path.

A general conclusion regarding craftsmanship is that high-tech building projects that are increasingly characterized by prefabrication and complex building systems do not diminish the importance of high-quality craftsmanship. Rather, the quality of craftsmanship may be even more important, though it is transformed into a craftsmanship of uncertainty, with greater emphasis on improvisation, planning and collaboration. These skills should be approached as collective skills, and the results they produce should be subject to the same kind of professional pride as more classical skills. Thus, technologization does not necessarily imply a loss of craft.

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