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NEGOTIATING RESEARCH NORMS BETWEEN ACADEMIC AND INDUSTRIAL RESEARCH
THE CASE OF A RESEARCH CENTRE ON ZERO EMISSION BUILDINGS IN NORWAY

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Abstract

In this article, experiences from eight years of work in a large research centre on zero emission buildings, which included both academic and industrial research, are presented and analysed. Based on principles of empirical relativism, the aim is not to distinguish between good and bad science but rather to study empirically how different norms held by researchers and embedded in institutional rules have been performed and negotiated. The analysis focuses on episodes that reveal tensions between norms of academic and industrial research. These tensions were navigated in the centre's work through temporarily suspending specific sets of norms, by translating the universal approach of academic research into locally relevant knowledge and by engaging in work around pilot buildings that acted as boundary objects. Practical advice for similar research constellations concludes the article.

Keywords:
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Introduction

In the first two decades of the new millennium, building related research funding in Norway has disproportionally focused on *sustainable* buildings, often in the narrow sense of increased energy efficiency. Combined with stricter energy demands attached to building regulations, and a greater awareness of climate change in public opinion and politics, the hope that the built environment can help to mitigate climate change became one of the central drivers of change, both in Norway's construction sector and in design, architecture and planning research.

With the current shift in focus from high performance, new pilot buildings to the existing building stock, and from individual buildings to neighbourhoods, it is increasingly clear that zero emission goals for the built environment are more difficult to achieve than previously assumed. The discovery that generous research funding does not immediately translate into problem-solving impacts does not come as a surprise. A naive belief in the problem-solving power of research-based innovation has received criticism from prominent innovation scholars (e.g., Soete, 2013). In this article, however, the doubt whether focusing building-related research funding on "solving" climate change is based on realistic expectations, or whether it is desirable at all, is suspended. Moving from the question of "should building research focus on climate change" to "how does building research focus on climate change", the following pages are devoted to an analysis of the inner workings of a major recipient of research funding that promised to contribute to a solution for the problem of climate change through zero emission buildings.

The empirical case on which this article is based is the Norwegian Research Centre on Zero Emission Buildings (ZEB). Funded generously over a period of eight years between 2009 and 2017, this centre brought together central Norwegian research milieus and representatives from the whole construction value chain and a large number of public sector organizations. The basic promise of the FME scheme through which ZEB received funding from the Research Council of Norway was that through "world-leading research" and by including actively participating non-academic partners as equals, practical solutions would be generated that could help Norway to address the problem of climate change.

Although a case can be made that the centre overall was a success, measured by the degree it has managed to move Norwegian construction into a more sustainable direction, the work of the centre was not without external critics and internal tensions. Here, I focus on internal tensions related to the combination of academic and industrial research, which was at the core of the centre's claim to be able to perform research-based problem solving. These tensions arose, as is argued in the next section, based on a theory of science perspective and between different research norms, which included questions of universality, impartiality and critique.

An analysis of strategies used to deal with tensions between academic and industrial research is the main contribution of this article. More specifically, it was found that:

- different expectations and values were negotiated through temporary suspension of specific sets of norms in favour of other concerns,
- researchers engaged in translation from the language of universal science to that of locally applicable solutions and
- they gathered around boundary objects that allowed them to collaborate without sharing the same norms.

The article concludes by providing cautious, practical advice for work in similar constellations.

Empirical relativism and scientific norms

From a theories of science perspective, the statement that scientific research should solve societal problems is far from unproblematic. Introducing concerns and forces from society into scientific activity raises questions about the demarcation between science and non-science and the all-important question of objectivity and truth. If, for example, architectural researchers are forced to find “solutions” to climate change and, moreover, are encouraged to let non-academic partners influence their research, a possible reaction could be to refuse to do so on grounds of scientific integrity and commitment to the problems that are identified within their discipline. In what follows, drawing on theories of science, what we know about such commitments is presented.

From pure science to science as practice

The idea that science in order to be good science has to have the ability to produce truth is hardly controversial. However, scientists are fallible humans and science as a human institution is as fallible as its personnel. How is it then possible that scientists and their institutions produce truth? The positivist answer given by the Vienna circle (1924-36), arguing heroically against a world that drowned in the irrationality of fascism, was to restrict all science to logic and observation purified of both metaphysics and societal struggles. While this approach is specific for its time and context, it represents a broader strand of justification for the truthfulness of science that combines two elements: first, it argues that scientists are able to produce truth because they are trained to refrain from everything that cannot be proven empirically and logically – be it the existence of gods and spirits or emotionally laden concepts like love; and second, “real” scientists stay clear of any involvement with power struggles. Scientists in their private lives may very well believe in fairies, fall in love or fight for influence, but when they act as scientists they have to compartmentalize and leave these concerns outside their work. That scientists' work is mostly done in secluded spaces – a seminar for the carefully selected, a laboratory with strict access restrictions, a quiet study – was a practical necessity for "pure" science in order to remain "uncontaminated" both literally and figuratively. But it also helped to create an aura of the noble purity of the proverbial ivory tower, which originally was an epithet for Mary and her singular immaculacy.

Around 1980, observers like Karin Knorr Cetina (1981), Bruno Latour and Steve Woolgar (1979) for the first time entered these spaces and conducted empirical studies of the activities performed there. They were surprised at how little of what they observed was the search for truth, and how much was about trial and error, about mundane activities such as filling out forms and feeding lab rats, and they observed also very "impure" activities such as power struggles and fights for recognition and funding. In the spirit of positivist approaches, much of these observed activities would be irrelevant for science or even – as in the case of power struggles – endanger the truth-producing capacity of science. In line with this thinking, the explanation for the difference between good and bad science is that some scientists and their laboratories are less pure than others, that some are more distracted by filling out forms and unproductively engaging in trial and error – or that they even sacrifice their ability to search for truth through engaging in politics. However, the observed laboratories, in which so little "pure" science was found, were perfectly capable of producing world-leading scientific research. This led the said social scientists to reformulate the question: based on the whole of scientific activity, its mundane workings, its many failures and even its politics, how can we explain the special power of science to reveal the truth?

During the following 40 years, the methodological principle behind this approach, the so-called "strong programme of empirical relativism" (Bloor, 1976) – which encourages the analysis of *all* scientific activity instead of filtering out some observations based on preconceived notions of real vs. impure science – has led to a broad variety of explanations for what science and its institutions have to do with truth. It is important to note that this "relativism" was first and foremost "methodological": adherents to the methodological principle have consistently argued against the objection that such an approach necessarily leads to a form of relativism in which every knowledge claim weighs equally. Inherent qualities of science that explain its stunning successes have been described in different terms in different theoretical frameworks. For example, Karin Knorr Cetina, one of these first scholars who studied science empirically, has focused on repeated and comprehensive cycles of variation and selection that are part of scientific knowledge production (Knorr-

Cetina, 1981). And Bruno Latour has focused on scientists' extensive use of "inscription devices" and rigorously planned and documented trial and error in laboratory settings (Latour, 1983).

One ethos that sets science apart?

A special strand within science studies has applied the principle of methodological relativism in the study of scientists' own norms. From this perspective, there is no intrinsic relation between norms and the validity of the resulting science. Instead, the ambition is to study whether there are dominant beliefs held by scientists and embedded in scientific institutions that can explain science's special position in modern societies.

The influential precursor of such an exploration is Robert Merton's description of a specific scientific ethos, which is ensured through sanctions and incentives and is deeply internalized by scientists themselves. He described mutual control through organized scepticism as part of this ethos, which resonates with Knorr Cetina's cycles of variation and selection, but he also added the free sharing of resources and the norm to cleanse science from partial interests, so that "the acceptance of rejection of claims entering the list of science is not to depend on the social or personal attributes of their protagonists" (Merton, 1979 [1942], p. 270). Together these norms form what has become known as Merton's CUDOS norms (Communism, Universalism, Disinterestedness, Organized Scepticism).

Merton's thesis was formulated in 1942 in the context of attacks against the autonomy of science both from communist and fascist efforts to "revolutionize" science by making it complicit with each of their political programs. That scientists policed themselves in the service of producing scientific knowledge, Merton's defence went, made external interventions unnecessary or even detrimental to science (Turner, 2007). Thus, in its historical context, Merton's scientific ethos reacted to what was perceived as an unprecedented crisis of science's legitimacy.

Merton was concerned about a situation in which more and more governments had adopted stances that explicitly attacked mainstream science. Historical parallels are always tenuous because of the differences they hide. Nevertheless, the continuities between the crisis of the 1930s and 40s and today are obvious. Merton wrote that "a little while ago" science seemed immune to the kind of attacks that he witnessed in the 1940s. Similarly, we live in a time in which scientists are increasingly expected to contribute to agendas that are not grounded in their own research programs. In its soft version this comes as increased expectations towards the problem-solving capacity of science. But it also can take the form of open attacks on individual scientists that present inconvenient truths, and in extreme cases it targets science as such, which is then accused of hiding ulterior motives behind a façade of objectivity.

Both in the 1940s and today, the values embedded in CUDOS are at the heart of the defence of science's autonomy. The main problem with this defence, however, is that empirical studies of scientific practices that follow the principle of methodological relativism have produced a much more nuanced image of which norms actually guide scientists' conduct. Research has indeed confirmed that CUDOS norms are still relevant (Kim & Kim, 2018), but it was also found that the contexts in which scientific practices are performed can force scientists to act against their own norms. Bray & von Storch (2017), for instance, describe how climate scientists, despite endorsing CUDOS norms, withheld research findings before publication, were subjected to external influence, and ascribed special credibility to scientific findings when the authors had a higher status.

Scientists working in industrial settings can even be said to commit to a set of completely different norms, which were condensed into the acronym PLACE by Ziman (1987, p. 128; 2000, p. 78). Here, science produces proprietary results based on proprietary resources (P), it solves local problems (L), it is under the control of some external authority (A), which has commissioned the research (C), and the scientists act as expert problem solvers (E). Industrial research, which adheres to PLACE norms and which has been credited to be the actual source of innovation in the 20th Century (Edgerton, 2008), fulfils the demand to produce useful knowledge by definition and gives those who have a stake in a problem direct control and ownership of the results. It is no coincidence that PLACE in every "letter" marks the opposite of CUDOS. Like other explorations of research norms, such as Mitroff's (1974) "counternorms" encountered in a study of Apollo scientists, Ziman obviously takes Merton's contribution as the starting point of a more nuanced analysis of the norms that guide scientists in their institutional contexts.

The 1990s saw an emergence of analyses that examined more recent changes in the way scientific knowledge is produced. They stated a blurring of the once clear distinction between academic and other forms of research. New forms of knowledge production were described by both those who saw a new mode (dubbed mode 2; see Nowotny, Scott, & Gibbons, 2003) of knowledge production gaining ground after the second world war and those who observed new institutional arrangements in which industry, public and academic research became intertwined (triple, quadruple or more recently n-tuple helix; see Leydesdorff, 2012). These contributions render the assumption plausible that CUDOS and PLACE should first and foremost be seen as extreme positions that are mobilized in controversies around the autonomy of science, but that a blurring between these extremes is more likely to be encountered when preconceived notions about "real" and "pure" science are abandoned.

In the remainder of this article the blurring between these extreme (self-) policing schemes is empirically studied using a real-world example from the author's involvement in a major research centre on zero emission buildings.

Background and methodology

The Norwegian Research Centre on Zero Emission Buildings (ZEB, 2009–2017) was funded with roughly 30 million Euro from public and private sources. Together with other centres conducting climate-related research, e.g., on offshore wind or PV, the centre's funding was initiated by a cross-party initiative of the Norwegian parliament. It employed a "national team" of researchers from major building-related research institutions in Norway from the relevant public institutions and representatives from the whole value chain in construction.

The main goal of the centre was to develop solutions that would make buildings CO_2 neutral, including construction, materials, operation, use and demolition. Activities of the centre comprised research on materials, building concepts, installations and use and operation. In addition, the centre was involved in the construction of eleven pilot buildings.

The author of this article, trained in the social study of science and technology, was in charge of a work package on "Use, operation and implementation". The observations presented below are based on this involvement, which among others included bi-weekly meetings between the work package leaders, workshops with partners, participation in an annual conference organized by the centre and the author's own research activities funded by the centre. In methodological terms, the author's involvement is both an advantage and a problem. Being provided with access to the centre's inner workings, the author is able to give a broad overview of relevant episodes. At the same time, another participant in the centre's work will most likely recall other episodes or present some of the observations in another way. Thus, the account given here cannot claim to tell the whole, the only or the authoritative story of how norms were negotiated in the centre's daily operation. However, in what follows, the following steps were taken to make sure that the presented episodes from the life of the centre are based on more than the author's fallible memory. First, and most importantly, the majority of observations shared below consists of summaries of findings that are documented in peer reviewed research published elsewhere already, partly with the author's involvement. In these publications, which report findings from mostly qualitative, social science studies of the centre's work, further methodological measures are documented through which partiality was controlled. Second, the framework described so far allowed the author to take a fresh view on his own experiences, a process which was supported by growing temporal distance. Thus, for the author's own sake, the re-analysis of studies of the centre's work, provided an opportunity for reflection and learning. In this sense, what follows ultimately aims at conveying lessons learned by someone who was involved to researchers that have to navigate similar constellations.

Empirical observations

Communism or proprietary knowledge

The format of the centre – called a FME (forskningssenter for miljøvennlig energi) – was new in 2009. Initially, much time was spent to work out the details of the interdisciplinary and transdisciplinary collaboration. More specifically, it took about a year to finalize a consortium agreement. One industry partner insisted on being able to restrict dissemination of findings indefinitely, while at least one public sector partner was obliged by law to only support publicly accessible research. The compromise that was eventually found was that all partners would screen all publications and could ask for an embargo period, but that all research in the end would be public. In practice, this embargo period was never requested, which is interesting in itself. But before attempting an explanation, let's have a look at the practical consequences of this hybrid between the Communism of CUDOS and the Proprietary knowledge of PLACE.

As is characteristic for every compromise, the solution to operate with an embargo period left all sides slightly dissatisfied. The researchers employed by universities clearly favoured CUDOS' communism. A large part of the funding received by university researchers was used to produce PhDs, which would have to be based on freely published research. In addition, postdoc projects were funded in which strong incentives existed to avoid restrictions in publishing. Researchers from private research organizations, most importantly SINTEF, did not rely directly on publishing, but would obviously have liked to see their work spread widely, too. A practical consequence of the need to allow for screening was that researchers, who were working towards submission deadlines, had to plan ahead in unfamiliar ways. This did not always work, and in the second half of the centre's life, the screening was simplified by allowing the centre leader to make the decision whether specific partners might have to see the publication before publishing. This pragmatic simplification was also possible because industry partners were likely to have been involved in relevant research that led to the publication and were able to flag concerns earlier in the process.

Particularly in the final phase of the centre, the centre's board, which prominently included industry and public sector partners, repeatedly expressed the wish of more public visibility of the centre's results. This call to share more instead of less, was in line with industry partners' motivation to participate in research to increase profits by flagging the environmental engagement, which because of its connection to partial interests can be seen as a part of industrial research. At the same time, however, it complied with the free sharing of results prescribed by CUDOS norms. In this sense, the call for public visibility in popular science dissemination became a more productive compromise than the embargo period that was implemented originally and then gradually weakened.

Universal knowledge or local problem solving

Most key researchers involved in the centre had a long history of working together and had been involved in collaborative research on sustainable buildings before. A unifying element in these engagements was an orientation towards the work done in Germany and Austria to create passive houses (a more in-depth account of the following is presented in Müller & Berker, 2013). This specific vision of a building that is so well insulated that it is able to make up for the additional cost by (almost) eliminating active heating systems, became one cornerstone proposed by the centre, in the search for solutions that would allow for building to become carbon neutral. The basic logic in the context of the centre's research was that after reducing heating demand based on passive house principles, it would be easier to make up for the remaining energy consumption by renewable energy on site, even including the energy used to produce and demolish the building. However, this vision, which had been realised in Germany, Austria and elsewhere in a growing number of buildings, met a number of barriers related to the specific conditions in Norway. First and most importantly, climatic conditions in Norway differed considerably, particularly in the northern parts of the country. Also, the structure of the building stock was different with Norway having a larger share of detached single-family homes. The Passive House Institute (PHI) in Germany sought to exert an iron grip on the principles through the formulation of standards, a software package and a related certification scheme. A central argument used by the PHI was that passive houses are a matter of natural laws and universal science, and all changes would amount to a dissolving of the unique performance characteristics of a passive house. Already, the extension to Austria had led to local adaptations that were partly outside the control of the PHI. Now it was Norway's turn by formulating its own standard, which accounted not only for a different climate and building stock, but also for different calculation tools and methods embedded in Norwegian standards and practices. The results were NS 3701:2012 (non-residential) and NS 3700:2013 (residential buildings), which were developed with the strong involvement of ZEB key researchers. This translation from a scientifically based set of principles into locally applicable solutions, although not directly funded by the centre, became arguably one of the central contributions of ZEB researchers to spread energy efficient buildings in Norway.

Another barrier against the passive house vision specific to the Norwegian context was a strong opposition against what was by some critics called ‘plastic bag houses’ (“plastposehus”), i.e., houses that relied on advanced insulation combined with mechanical ventilation to provide energy efficiency and good indoor climate. In what was one of the few instances in history in which discussions around building standards became national news, a coalition of critics argued ardently against passive houses, mainly driven by the fear of relying too much on new, complicated and unproven technology. While similar arguments existed in other countries, in Norway the dominant building type – a reasonably well insulated, owner occupied, wooden, detached single-family home – created a particularly strong contrast to the passive house vision originally created in a very different context. Objections accordingly were mostly about the fear of a more expensive, ugly building that would not “breath” naturally, and that would quickly start to trap moisture-producing mould. ZEB researchers also in this case participated extensively in the translation of the context into a Norwegian context by engaging in public debates, referring extensively to successful examples from Germany and Austria and to the work of adaptation done in Norway.

A third major obstacle against the solutions proposed by ZEB concerned the part of renewable energy production on site (the following is adapted from Kvellheim, 2017). Norway’s energy system is one of a kind in Europe as its domestic energy production is almost exclusively based on renewable hydro power. In this national context, the production of energy through solar collectors and PV may appear as a very bad idea as it is very inefficient (compared to a hydrogen power plant at least), or it may even be seen as destabilizing a well-functioning system by introducing a fluctuating energy source. Not surprisingly, the energy producers particularly opposed this initiative from the construction sector, arguing that energy would better be left in their hands instead of importing concerns about fluctuating renewable energy, which the rest of Europe had no way to avoid. The counterargument of ZEB researchers referred to the wide use of electricity in space heating, which made Norway one of the countries with the highest per capita electricity consumption in the world. This electricity, it was argued, could be freed to be used in the transport sector or for export. A small piece of common ground was eventually found by ZEB researchers by shifting the attention from energy consumption to the shaving of local peak loads, which presented an opportunity for the energy sector to avoid costly infrastructure developments. But the controversy between a universal need for increasing renewable energy production and the argument that if only domestic energy consumption in Norway is accounted for, there might even already be too much renewable energy, continued well beyond the centre’s lifetime.

In all three cases, we saw that ZEB researchers, seldom directly funded by the centre but often using their work in the centre as argument, engaged in translating universal principles into solutions of local problems. This translation was more than just an application of already established facts, as it also involved careful adaptation to local conditions and negotiations with opponents, without compromising the scientific commitment to universal truths.

External control, trust and negotiated disinterestedness

In three of the eleven official pilot buildings of the centre, episodes occurred in which the disinterestedness mandated by CUDOS' "D" was threatened, but never compromised, by external influence from stakeholders.

In the first case, the building was planned to break local regulations in terms of height, and the centre's zero emission ambition was used as central argument to give dispensation. As described more in depth by Berker & Larssæther (2016), concerns for the economic viability of the building, which arguably qualifies as a reason external to the scientific endeavour, were as important for the rule-breaking design as the need to produce enough area for the solar cells to produce as much renewable energy as needed to achieve the zero emission balance.

A second case met strong resistance from local politicians because its realization outside the city and disconnected from public transport would increase CO_2 emissions for transport that were not accounted for in the centre's scientific mission. The developer used the centre's support for what it was worth in this conflict, and the area is now, well after the end of the centre's funding period moving into the construction phase (for more details, see Gohari & Larssæther, 2019).

In the third case, conflicts between actors involved in the building's construction phase that were documented in an evaluation conducted by the centre's researchers, were kept from publication by the building owner with the argument that this publication would overemphasize the conflicts that occurred in only a specific phase and would give the impression that zero emission buildings were not feasible. The researchers argued that their mandate of disinterested evaluation would force them to document the conflicts anyway. The compromise found in this specific case was to suspend the publication in expectation of further evaluations of the building's use phase that most likely would set the conflicts encountered in another context. For reasons unrelated to the disagreement, it never came to this publication.

All three cases have in common that developers tried to enrol the authority of research to serve their interests. There is an overlap between the researchers' interest of testing and demonstrating zero emission solutions in pilot buildings and the developers' interest in realizing the building, which creates a grey zone between disinterestedness and the support of concerns that are outside the scientific research. Acting in this grey zone, researchers have an interest not to compromise the continuation of collaborations with building owners, which presuppose a modicum of mutual trust. It is reasonable to assume that given massive investments related to construction projects, the topic of evaluation is particularly prone to lead to conflicts between the desire to report flaws in a disinterested manner and the wish to protect the investments made by stakeholders. An enlightened stakeholder might see the virtue in not covering over conflicts and mistakes for his or her own sake, because it enables learning. Whether the same stakeholder then wants to give this learning opportunity to the public is another question. But also the involved researchers, for instance when they were responsible for parts of the design of the building, may not always be as disinterested in its success as strictly prescribed by the CUDOS norms. Janda & Topouzi (2015) have in this context identified the prevalence of "hero stories" in accounts of sustainable buildings, which focus on the achievements rather than the actual performance. If the mentioned need to preserve trust of stakeholders is combined with a preference for "hero stories" that is shared by researchers and stakeholders, disinterestedness will quickly tip towards external control. A research endeavour that has the ambition to test and demonstrate its solutions in the "real world" will have to deal with disinterestedness to become a *negotiated* value, which was also the case here.

Between organized scepticism and commissioned expertise

Besides the episodes of more or less open tensions described in the previous sections, the role of the researchers in the design and construction of the eleven zero emission pilot buildings was also far from homogeneous and self-evident. When the centre started its work, some buildings were already on board via the public and industrial partners. But it was not before the second half of the centre's lifetime that a clear definition emerged from the scientific work of what a zero emission building really is. While the principle of balancing CO_2 emissions caused by the building's production, construction, operation and demolition was given from the beginning, many details had to be worked out before clear criteria could be established. In relation to the difference between the organized scepticism of CUDOS and the commissioned expertise of PLACE, these criteria were both used to critique alternative proposals for climate-friendly buildings *and* they were applied in the pilots' development, with researchers in the role of consulting experts. A key role in this dual work was played by a system of classification established around the pilots, which allowed to distinguish between different levels of ambition (Fufa et al., 2016). While the most basic zero emission level only included emissions connected to the operation without equipment, the most ambitious one would demand to take into account emissions caused on all parts of the building's life cycle. The commissioned expertise performed by researchers here lay in providing consultancy when it came to choosing the appropriate level but also, and more importantly, to solve specific problems encountered when trying to comply to the chosen level. Very much in the style of consulting work, this was done on demand, i.e., partners asked for reports or small presentations when they needed specific advice. For research work, this turned out to occasionally being demanding, because the rhythm of a construction project did obviously not correspond with the temporal flow of research work. The side of organized scepticism, i.e., mainly the control exerted through peer reviewed presenting and publishing, which followed its own rhythm, made sure that the specific advice that often had to be given quickly and ad hoc, was rooted in a scientifically grounded approach. At the same time, by allowing also for much less ambitious zero emission levels, the partners could base their work on resources and expertise that they already had at their disposal, which relieved the researchers from much of the practical consultancy and allowed them to focus on critical choices. The asynchronous but mostly seamless transition between research and consultancy was facilitated by a group of three or four key researchers that in fact were soon hired by large industrial actors and continued their work there.

It was already mentioned that the main research partners were a large private research institute, SINTEF, and NTNU, which is today Norway's largest university. The division of labour between these two partners followed roughly the line between organized scepticism and commissioned expertise. Occasionally, research reports received critique from university researchers for their lack of "real research". In light of the tension between CUDOS and PLACE that are explored here, this critique appears as a classic instance of the kind of boundary work (Gieryn, 1983) that characterizes the policing of CUDOS norms. At the same time, based only on the organized scepticism as, for instance, performed in PhD projects, the centre's contribution to the pilot buildings would arguably have been marginal.

In hindsight, facilitated by the division of labour between NTNU and SINTEF, of key researchers with legs in both research and industry (Berker & Müller, 2022), and by a flexible but not arbitrary system of definitions that allowed for different ambition levels, the centre succeeded in doing both: providing focused consultancy and producing knowledge based on science's organized scepticism. In this way, the pilot buildings could become boundary objects, i.e., common objects of concern without complete agreement on the concerns, which enabled collaboration both between disciplines and between academia and industry (Berker & Kvellheim, 2018).

Discussion

The episodes in the research centre's life, which were presented to shed light on tensions between academic norms, condensed in the CUDOS acronym, and industrial research as it is described in PLACE, fall into three different categories. We encountered instances of temporary suspension, translation and collaboration facilitated by boundary objects.

Temporary suspension of norms

The simplest category, temporary suspension of norms, bears the marks of a compromise on its sleeve. In a nutshell, it consists of a set of norms being applied for a certain period of time until it is replaced by another set. Its weakness is its vulnerability to renegotiations, or rather, as we have seen in both the case of the embargo period for publications that was watered down over time and when one pilot evaluation was postponed forever, its tendency to be subject to pragmatic adaptations in which one set of norms prevails. In the episodes presented above, this strengthened CUDOS norms in one case and PLACE norms in another. It is easy to imagine a situation in which one part could have made an issue out of these cases. In the end, the strict adherence to norms was not important enough to the majority of the involved parties. Other related issues, where everyone could agree, came into the foreground, such as the desire for "visibility" of the centre's research in public dissemination or the maintenance of a trustful relation between researchers and building owners.

A similar pragmatism around norms could also be noticed in the flexible definition of the centre's central concept, the zero emission building, and in the division of labour between the main research partners. These instances each involve a specific kind of temporary suspension. For some pilots, certain rules that would follow from a strict, comprehensive scientific definition of "zero emission" were suspended to allow for local problem solving. This was possible because it was seen as only one step forward in both the involved organizations' learning curve and the building sector's development in general. And when commissioned consultancy was delivered, strict CUDOS norms were suspended in favour of local relevance. Again, for the centre as a whole this was acceptable since science guided by CUDOS norms would not be ruled out in principle.

Temporary suspension, not surprisingly, slowed down research both in its academic and its industrial form. The embargo period, i.e., not publishing findings as quickly as possible, definitions partly tailored to the practical abilities of the centre's partners and allocation of funds for commissioned problem solving, all these suspensions are also temporary barriers to the spread of the produced knowledge. However, no matter what their effect on the speed of knowledge diffusion was, all of these suspensions were crucial to make the centre work at all. The sum of these compromises kept the majority of partners within the centre.

Without them, it is difficult to see such a broad coalition producing anything at all. The broad range of partners arguably has given the centre a stronger overall position, both in Norway and internationally, and has in this way supported its ability to disseminate knowledge. The pragmatic question in this context is whether some of this general influence was bought through compromises that were too costly in terms of restrictions in the free flow of knowledge.

Translation

Just as every translation between two languages involves necessary changes in what is said, actor-network theory (ANT) states that moving knowledge and technologies between different contexts also involves changes in the objects that are moved. Translation in our case was observed when passive house principles were 'moved' from, among others, Germany and Austria to Norway and when renewable energy production on-site was adapted to Norway's unique energy system. The researchers engaged in extra work in which general principles were reformulated in ways that made sense in a Norwegian context. This involved standardisation, negotiation and also persuasion (Callon, 1986). In this way, this work included, but went beyond, the pure application and "teaching" of universal principles. In ANT terms, the main activity of translation can be described as establishing new relations, e.g., to ZEB calculation methods inscribed in ZEB standards, without compromising the passive house principles' relations to the laws of physics.

Those critics of the centre's work who belonged to the group warning against "plastic bag buildings" suggested that the strong presence of insulation companies in the centre had introduced an external interest in passive house principles to be adapted to Norwegian markets. Countering this critique, the centre's scientists would – based on building physics – refer to the universal superiority of this particular set of solutions in terms of energy efficiency and rather treat the insulation companies as welcome allies, instead of as clients. If we rule out the possibility that this is an instance of deliberate deception, translation efforts are, thus, neither exclusively directed by CUDOS – i.e., completely refusing local interests – nor PLACE – i.e., being controlled by these interests.

Different from the temporary suspensions discussed in the previous section, translation activities do not slow down the diffusion of knowledge but rather support it. Without localised standards or the scientists weighing in publicly against opposition, the whole science around zero emission buildings could easily have ended as stillborn for the Norwegian building sector. Rephrased in ANT terms, this would amount to the failure to establish durable links both to building physics and the Norwegian buildings. Particularly, the engagement in debates that was observed is very much in line with calls for a public engagement of science, which would take into account that scientists reflect on their role as citizens

(Wynne, 2006). That this work did not take away resources from the centre strengthens the case for translations between the U(niversality) of CUDOS and L(ocal problem solving) of PLACE to be a central support for the free flow of knowledge from science into society.

Boundary objects

Boundary objects that allow the productive collaboration across different world views (Star & Griesemer, 1989; Star, 2010) were introduced above in relation to the work with pilot buildings. The common desire to make buildings a solution to a pressing problem – climate change – indeed was a central motivation for all participants in the centre's work. Some may have seen in this first and foremost an opportunity to make their businesses future proof, while others may have been moved by idealistic ideals of universal science-based progress. However, these overarching motivations did not matter when these actors collaborated to make the pilot buildings part of the solution to a larger challenge. While this pilot work certainly was not free of conflict related to different norms – some of these problematic episodes were described above – it still represented in the majority of pilot processes the only instance in which the different norms governing research were not temporarily suspended in order to not stand in each other's way, but were employed in parallel to produce an object that would at the same time allow all involved parties to learn and that would be highly visible to the rest of the world.

Table 1. Types and episodes of negotiation
As the table shows, temporary suspension was the most broadly applied strategy observed in episodes related to publication, definition and the work with pilot buildings. Translation was relevant above all in activities related to the acceptance of the solutions provided by the centre. Boundary objects, finally, were found in the pilot buildings that were built with the support of the centre's researchers.

Temporary suspension	Translation	Boundary objects
Embargo period on publications	Norwegian passive house standards	Pilot buildings
Allowing for different degrees of compliance to a strict and comprehensive zero emission definition	Researchers engage in the Norwegian "passive house controversy"	
Maintaining trustful relations with building owners through delayed criticism	Adding load shaving to the arguments for renewable energy production on-site	
Division of labour between research organizations		

Practical implications and concluding remarks

In this article, episodes from eight years of the ZEB centre's operation were revisited in light of a tension between the norms of academic research, summarized in Merton's CUDOS norms, and those of industrial research (PLACE). Forced to collaborate, the centre's researchers navigated these tensions through temporary suspension, translation and boundary objects. Finding and implementing these three types of strategies produced additional work for the involved researchers and it was responsible for systemic delays and conflicts. As long as a research project can be sure that all participants are committed to the same norms, be it CUDOS or PLACE, common commitments can without penalty be taken for granted. When, however, different norms meet and are forced to collaborate, additional efforts, of which some were described here, are a necessary part of the project's work.

This work should be acknowledged and planned for. According to the findings presented here, it seems relevant to consider to provide the project with additional resources for activities that

- allow for making different norms explicit,
- support careful planning of which norms are to be suspended for which periods of time,
- help to translate knowledge, for example, in the form of public engagement of science and that
- identify and use boundary objects.

The episodes presented above also revealed a number of pitfalls that should be considered with care. Developers who tried to instrumentalise science to make their projects happen, point to potentially very problematic sides of the pragmatic mixture of different research norms. Without a reflexive awareness and active strategy when CUDOS and PLACE are mixed, the research can easily end up with producing the kind of knowledge that aims to manipulate; with other words, science becomes ideology.

Avoiding these pitfalls and deliberately employing strategies to negotiate norms requires researchers' preparedness to reflect on norms guiding their own research. As the growing literature on responsible research and innovation (RRI; for an introduction, see Owen et al., 2012) shows, this capacity for reflection is a necessary ingredient of a larger turn towards a science that accepts that it is always already entangled with society. Thirty years ago, contours of a more engaged science that replaces science performed "outside" society were outlined under the labels "mode 2" and "triple helix". With the more recent push towards the primacy of societal problem-solving that was described in the introduction, the need for a reflection on the role of science and scientists in society has become even more important.

Design, architectural and planning research have for a long time been keenly aware of their entanglements with society. If things are designed, buildings built and cities planned, society is always implied and has "talked back" for a long time. Within these disciplines, this "practical" side of research has led to much soul searching with regard to what kind of science they are – or whether they even are a proper science. Based on the reflections presented here, it seems reasonable to assume that research related to design, architectural and planning research are about to become much less special in this regard. In this sense, the experiences with navigating tensions produced by conflicting norms when defining, developing and building zero emission buildings encountered in this study are relevant far beyond the specific case.

Based on an analysis following the principles of methodological relativism, this article has proposed possible tools to implement reflexive, active strategies to deal with tensions that arise in constellations that bridge different research norms. The list is by no means exhaustive. It is likely that other constellations produce different lessons. However, the more important point made here is that a naive, poorly reflected approach to making science useful will create ineffective science or even ideology.

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