



# Open Research Online

---

The Open University's repository of research publications and other research outputs

## Reducing embodied impacts of buildings – insights from a social power analysis of the UK and Sweden

Conference or Workshop Item

How to cite:

Moncaster, A. M. and Malmqvist, T. (2020). Reducing embodied impacts of buildings – insights from a social power analysis of the UK and Sweden. In: IOP Conference Series: Earth and Environmental Science, IOP Publishing, 588(3), article no. 032047.

For guidance on citations see [FAQs](#).

© [not recorded]

Version: Version of Record

Link(s) to article on publisher's website:

<http://dx.doi.org/doi:10.1088/1755-1315/588/3/032047>

---

Copyright and Moral Rights for the articles on this site are retained by the individual authors and/or other copyright owners. For more information on Open Research Online's data [policy](#) on reuse of materials please consult the policies page.

---

[oro.open.ac.uk](http://oro.open.ac.uk)

# Reducing embodied impacts of buildings – insights from a social power analysis of the UK and Sweden

A M Moncaster<sup>1</sup> and T Malmqvist<sup>2</sup>

<sup>1</sup>Open University, Milton Keynes, UK

<sup>2</sup>KTH Royal Institute of Technology, Stockholm Sweden

**Abstract.** With one of the highest carbon footprints, the construction sector should be at the forefront of climate action. Reducing embodied impacts of construction also means ensuring that buildings are durable, low maintenance, and fit for purpose, while maximizing resource efficiency. However, thirty years in to research in this field, embodied impacts continue to be ignored in the majority of building projects. This paper traces the recent history of embodied impact assessment within industry best practice in two contrasting countries, the UK and Sweden. Our data is drawn both from personal involvement in a number of projects and from qualitative case studies of the development of low embodied impact buildings. Through these we consider what has historically held progress back, what the new drivers are in both countries, and what the remaining barriers (both overt and hidden) might be. By applying social power theories we identify deep and complex reasons for the lack of traction, including in policy formation and professional practices. The insights provided help to explain the slow progress so far, as well as to support increased reduction of emissions across the building sector, and thus enable progress towards achieving several key Sustainable Development Goals.

## 1. Introduction

The embodied impacts of buildings, from their construction, refurbishment and demolition, can be equal to or greater than their operational impacts [1]. The case for their reduction is closely linked to a number of the UN Sustainable Development Goals (SDGs), including those for climate action (SDG13), responsible and maximally efficient use of resources (SDG12) and innovation in industry (SDG9). Research in this field has been active since the 1990s, based on the premise that, if only decision makers were provided with the correct tools and information, rational decisions would surely follow. Nevertheless, after almost thirty years of academic study, embodied impacts continue to be ignored in the majority of building projects, and in the majority of national regulations.

This paper traces the recent history of embodied impact assessment within industry practice in two European countries, Sweden and the UK. Through reference to multiple data sources we offer a short history of progress in each country. Social power theory is used to explore the deeper reasons for the slow and variable progress so far. This paper is the first output from a subtask of the on-going IEA EBC Annex 72 project which aims to shed new light on the uptake of embodied carbon assessment.

## 2. Literature Review: Embodied impacts

The embodied impacts of buildings have been researched across the world for many years [2-6]. Publications have increased rapidly over the last decade (see [7]). Within Europe this has been particularly evident following the publication of the suite of standards on Sustainability of Construction Works in 2011-12 and the focus on resource efficiency in the built environment in 2014-15 [8,9].



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](https://creativecommons.org/licenses/by/3.0/). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

While earlier papers often offered detailed LCAs of individual buildings, more recently academic focus has turned to identifying and explaining the exceptionally wide range of results [10-13]. Other than genuine differences in building design, methodological reasons can be seen as fitting into three broad categories – that is, variations in: life cycle stages considered (temporal); building components included (spatial); and choice of data for both materials and life cycle stages (physical) [14].

Additional research has now started to consider what is happening in industry practice [15-17]. Here assessments are often carried out at the early design phase, when little detailed information about material specifications is known. Variations are often further compounded by differences in assumptions, national contexts and project finances. In order to explore the reasons behind what happens in practice, we should therefore consider what informs these ‘social’ variations.

### **3. Theory: Social power**

Social power can be defined as ‘a form of causation that has its effects in and through social relations’ [18]. There has been a long history of theories of social power, and several authors such as Scott [18] and Lukes [19] have synthesised these into unified frameworks. Lukes defines three different ‘dimensions’ of power, each of which incorporates and extends the previous. The first dimension is the simplest, the overt and visible power of A over B to get B to do something that s/he would otherwise not have done, following Dahl [20] and other ‘pluralists’. The second dimension is based on a critique of the pluralists by Bachrach and Baratz [21]; they suggested that A’s power over B could also be exercised by restricting what is open for discussion to those issues in A’s interest. Both the first and second dimensions imply conflict, either overt or hidden, and have observable effects. They are exercised by one individual over another, and are possible due to the first individual having greater resource, which might be physical strength, knowledge, or charisma. The third dimension is more insidious; here, A exercises power over B in a way that persuades B to believe it is in B’s own interest, through ‘influencing, shaping or determining his [sic] very wants’ [19]. Lukes termed this, ‘willing consent to domination’. This form of power is more likely to be exercised by a group rather than an individual, and Lukes uses it to explain unquestioned hierarchies and norms of social behaviour.

A second useful synthesis is offered by Scott [18], who considers the applications, rather than the forms, of power. Two of particular relevance are those of expertise, and policy formation. For the first, Scott considers the power of experts to be based on their knowledge, organised through ‘discursively formed symbolic monopolies... to buttress their position’ [18]. The key point is that expert knowledge and expertise are defined by the experts themselves. Their monopoly on that knowledge is retained through the use of specialised language and tools, and membership is restricted through requiring specific disciplinary training and mandatory membership of expert institutions. While the main action of expert power is through the persuasion of lay people, where experts are working with rivals they may also compete with other experts ‘for rights over a particular sphere of activity’ [18].

Scott’s description of the process of policy formation is based again on a critique of the pluralists. They saw policy as a democratic process responding to the collective interests of the population, as expressed through multiple different special interest groups each with potential power to make changes; however their critics saw this as over simplistic. Laumann and Knoke [22] suggested that the groups range along a continuum from ‘issue networks’, loosely controlled organisations with wide membership and multiple interests, to ‘policy communities’, with controlled membership and interests closely aligned with those of the political agents. Scott suggests that social power within policy formation therefore depends on who is included and who excluded. Considering the relationship between expertise and policy formation, Scott suggests that ‘The apparent neutrality of expertise obscures its character as power and can help to legitimate contentious policies and decisions’ [18]. Conversely, ‘Professional claims are particularly strong when they are underwritten by state power’ [18].

### **4. Methodology**

This paper draws on data from a variety of sources in the two countries. The two authors are senior researchers who have actively participated in the move to integrate life cycle assessment and embodied carbon management in their respective building and construction sectors over many years. The historical

narrative sections of the paper use documented evidence interpreted through the insights of this personal experience. Two case studies for each country are offered, one focused on the production of a particularly key report and the other on a building project; these are each based on a number of sources of qualitative data, of which further details are available in the relevant cited documents and papers.

## 5. Analysis: Sweden

### 5.1 Historical narrative

The broader coordinated focus on environmental aspects in the Swedish building sector first developed during the 1990s, with the non-profit association Kretsloppsrådet (Eco-cycle council) formed in 1994. This dealt with the wide palette of environmental aspects, focusing on waste separation and hazardous substances in materials but also touching on embodied carbon. At the end of the '90s and over the coming decade the basis for the development of LCA methods specifically for use on building projects was developed; this primarily included the EcoEffect tool [23], the Environmental Load Profile (ELP) [24,25], and later the more commercially oriented Anavitor tool [26]. The tools were driven by different actors; EcoEffect was led by academia, ELP was developed as part of a large brownfield development by Stockholm municipality, and Anavitor was driven on commercial basis by one of the predominant building LCA experts in Sweden. These tools were only used to a limited extent; Skanska, for example, used Anavitor to extend their in-house knowledge. LCI data was collected at an early stage for all the tools, but IVL (the research institute behind Anavitor) was the only institute in Sweden updating data for building LCA from this period on. Their database was originally only used in-house. In 2018 the BM tool was developed through a project funded by the Swedish Energy Agency and a number of property developers and municipalities, and at this point parts of the IVL database became openly available. During the 2000s, individual industry actors made attempts to start introducing LCA and embodied carbon assessments, but without access to updated, representative data, their arguments had little power either within in-house business development or with clients and changing opinions.

During this period, other than energy performance regulation, the political discourse was to avoid regulation and instead promote dialogue and market-driven voluntary commitments; these were dominated by the large umbrella initiative Bygga-bo-dialogen, launched by the Government in 1998. Through dialogue and joint projects, agreements were reached between the Government and more than 40 industry partners, aimed at paving the way to action beyond regulation. The focus however was mostly on indoor environmental quality and energy-saving in buildings, with little mention of embodied carbon. This focus can be traced back to the Eco-cycle council, working here as an “issue network”. The focus was also very clear in government initiated investigations about the need and possibilities for introducing voluntary or mandatory building declarations at the time [27]. One particular outcome was the development of the national environmental certification tool for buildings, Miljöbyggnad [28], the leading certification scheme in Sweden. The inclusion of an indicator for embodied impacts was discussed, but was considered too demanding by the majority of participating industry stakeholders.

A broader interest in LCA and embodied carbon has been shown over the last few years in Sweden. A series of missions initiated by the Swedish Government and Boverket (the national board for building, planning and construction) resulted in a proposal for a new regulation, and a mandatory climate declaration for all new buildings in Sweden from 2022 [29]. This was initiated in September 2015 when Boverket was commissioned by the Government to “investigate the research and knowledge status concerning climate impact of buildings from a life-cycle perspective” [30]. The report concluded that “there is a need that the state takes lead in the climate work if the pace of this work shall enhance in the building and construction sector...One tool to analyse climate impact is life cycle assessment, LCA” [32]. This remit was in turn a direct result of a report from the Royal Academy for Engineering (IVA), also representing powerful industry stakeholders [31]; the development of this report is the subject of the first case study in the subsection below. Boverket continued with a self-initiated mission to further investigate the need for regulation, including for climate impact/LCA [33]. The recommendations however proposed sector dialogues and voluntary guidelines rather than regulation, while stating, “if

sector dialogues and a book of ideas are not enough, then Boverket shall further investigate regulation about LCA for buildings” [33].

The political concern about the need for integrating embodied carbon reduction in regulation had meanwhile grown rapidly, and by 2017 was seen as a priority. The Building Rules Modernisation Committee was therefore asked in February 2017 to “investigate the need for policy tools to reduce environmental impact... during the construction process” [34]. The Committee started with the intention of proposing rules on embodied carbon. Just after the start of the Committee work, during autumn 2017, Boverket was however again commissioned by the government, this time to “propose a method and regulations for climate declaration of buildings, taking into account a lifecycle perspective”, more or less the same task as that of the Committee. At this point, the need for regulation was embraced and was also actively promoted by the building and construction sector in their road-map for a fossil free sector by 2045 [35]. The issue was also picked up as one of the 73 points in the government negotiations that followed the complicated election result in 2018.

### 5.2 Swedish case studies

*Sweden CS1:* The first Swedish case deals with the IVA report, mentioned above and launched in 2014 [31]. This report played a significant role in the shift in interest in embodied carbon reduction and of the following increase in activities in this area. The main message of the report was that annual greenhouse gas emissions from construction operations in Sweden were of the same order of magnitude as those from all car journeys in the country. The report was based on the results of a research study which showed that half of the whole life greenhouse gas emissions from new multifamily buildings came from the product and construction stages, and were no longer dominated by the operational energy use, and further pointed out that there was no regulation steering the reduction of these emissions [36].

This message was already a well-known fact for the researchers participating in the study, but earlier studies had received very little attention outside academia. However the disproportional impact of this new report related to the actors involved in the study and the effective communication of key messages. The project had been initiated by a retired enthusiast with long experience in the construction industry and a well-developed network of strategic leading professionals. He set the stage with the Swedish Construction Federation as the official project leader and funding from the construction industry's R&D fund (SBUF), to balance the diverging business interests of the sector. This would also ensure results uptake by the industry, since SBUF projects often generate a more direct communication path to the construction industry stakeholders compared to academic research funded by national research councils. The study was undertaken by experts from the university KTH and the research institute IVL, both seen to have a high level of expertise (expert power), which would thus reduce the risk of questioning of results by powerful business interests. An active steering committee and reference group, based on the enthusiast's strategic network, also played important roles. The head of the reference group, a retired CEO of a large construction company, continually emphasised the urgency of taking climate action in the meetings, while the steering committee produced reviews of the report texts which provided reassurance that the messages were entirely neutral to business concerns. The fact that the experts at KTH and IVL also collaborated and communicated the same message also played a role for increasing the accountability of the study. The results were reported and discussed for the first time in July 2014 at a crowded seminar in the largest contemporary national arena for the development of political ideas, Almedalen, in which the housing ministry also participated. The project attracted considerable attention in the media, while key messages also reached policy makers through the political networks of both the enthusiast and the representative of the Swedish Construction Federation (who also had a political career), forming the path forwards for subsequent policy initiatives, as described in the previous section.

*Sweden CS2:* The second Swedish case is about the development of a new-build multi-family building which is one of the few examples so far in Sweden in which embodied carbon assessment has been used to support a low-carbon design. It was initiated before the concern about embodied carbon had become widespread. With this demonstration case with a very high sustainability profile, the developer meant to scale-up solutions developed as part of this project in forthcoming developments. At the time the developer had a sustainability manager competent in LCA, and with a seat on the executive board, who

proved very effective in developing the company's profile as a front-runner in sustainability. In 2014 the sustainability manager decided to launch an LCA study of the structural solutions considered at the early design stage of the project [37]. The results of this study suggested that, under certain defined conditions of use, a concrete solution could have lower embodied carbon than the timber concept studied. These defined (and rather specific) conditions were 1) results were calculated for a reference study period of 100 years (based on client requirements), 2) that the timber solution had a timber façade as well as a (high embodied carbon) rubber cover on all balcony floors, both of which had to be replaced three times over the 100 year lifetime, 3) the concrete was climate optimised. The conclusions encouraged the developer to continue developing a concrete solution for the project. In further collaboration with researchers, they specified procurement requirements ending in a product with 30% lower embodied carbon compared to the product they would have used [38]. It is significant that the sustainability manager, a charismatic person with a powerful position at the company, could recruit an environmental manager with research experience of building LCA, who could drive the concrete procurement process. This case demonstrated that it was possible for a client to set up procurement requirements which could really lead to product development. The close collaboration with concrete and cement binder producers was also important in order to specify requirements.

The case is also interesting from a social power perspective. The concrete and cement industry, completely dominating multi-family building construction, could already see that they risked losing power in terms of market share, from the political and industry moves described in CS1. Therefore, there was a clear incentive to demonstrate the potential for low embodied carbon concrete. The study in CS2 proved an opportunity to claim this new and still forming expertise. The study, even though performed by a research institute and involving both concrete and timber industry representatives, displays that industry interests had a clear role in how the study was designed. The study has become a well-used debate tool for the concrete and cement industry, displaying Scott's [18] competition of "rights over a particular sphere of activity".

## **6. Analysis: UK**

### **6.1 Historical narrative**

Meanwhile in the UK separate initiatives were following a fairly similar timescale. In 1996 the Building Research Establishment (BRE), still at that point a UK Government research agency (and therefore with a powerful monopoly which exists, to a lesser extent, today), introduced the first version of the Green Guide, which rated different construction materials for their environmental sustainability; LCA was one indicator which supported the ratings, but was not visible to the end user. While the BRE was privatised in 1997, it continued to remain closely aligned with Government.

The discourse of sustainability grew rapidly during the first decade of the new century under the new Labour Government. Having at first been broadly defined, a focus on 'zero carbon' soon started to emerge. In 2006 a Government consultation was published on the draft document 'Building a greener future: Towards zero carbon development' [39]. The published responses to the consultation, mainly from industry, showed that their principle concern was with the omission of embodied impacts, and a desire to see this included in the definition of zero carbon [40]. However a month after the analysis, the resultant policy document was published, rejecting the consultation responses out of hand: 'We do not believe a full consideration of embodied carbon is practical or realistic in the short-to-medium term' [41]. It seemed that the consultation exercise had been merely a nod to including wider industry views, at least in this matter, and that the 'issue network' of only loosely connected professionals had little power to change the political power.

However the reason for the omission of embodied impacts could be traced to the Government commissioned Callcut Report, published in the same year. Limiting 'zero carbon' to net operational carbon allowed John Callcut, a former housing developer and by then the Chief Executive of the Government regeneration agency, to conclude that: 'the housebuilding industry and its supply chain have the potential to deliver 240,000 new good quality homes a year by 2016 *and to achieve the zero carbon targets.*' [42] (p.9, emphasis added) In effect, this review had already answered the first question of the consultation to 'Building a greener future'. Callcut was a Government appointee and already

close to policy through his role; while representing part of the construction industry, his own professional interests aligned closely with political aspirations. In order to achieve the new homes a new task group, the Zero Carbon Hub (ZCH), was appointed from across the construction industry; the carefully controlled membership and terms of reference closely aligned to Government interests suggested clearly that this was more of a ‘policy community’. Meanwhile a different Government Department also published a new policy statement; the Children’s Plan included the statement that schools, too, would be zero carbon by 2016. The following year another task group, the Zero Carbon Task Force (ZCTF), was set up to work out how this might be done. The terms of reference were again specifically aligned with the definition provided by the DCLG: ‘The Task Force will NOT:... consider carbon emissions beyond those attributable to the energy used within the building’ [43](p.69)

While the multiple consultations and task groups therefore suggested that the Government were keen to be seen to consult, the wider industry stakeholders appeared to have little power over the outcome. In fact, not only were the responses to the ‘Building a Greener Future’ consultation ignored, so were some of the recommendations of the directly appointed task groups; one member of the ZCTF explained ‘You know we make a whole lot of proposals, a whole load of recommendations, they [the Government] decide which ones they want to include and what ones they don’t.’ [40](p 106) The choice of industry appointees also differed between Departments, with the DCLG favouring housing developers and contractors. It was perhaps no surprise that their deliberately restricted definition of ‘zero carbon’ was achievable in parallel with their political focus on encouraging more housebuilding.

While embodied carbon was being excluded from the definition of zero carbon in the UK, at Bath University Craig Jones and Geoff Hammond were developing the Inventory of Carbon and Energy (ICE), a database which collated and averaged available data on the impacts of construction materials. The database was published as open access, and rapidly taken up by both industry practitioners and academics around the world. In itself this was a radical move. Knowledge of embodied impacts was highly limited at this point. Rather than restricting access to existing experts, the publication of a free database of materials data allowed power to be widely distributed, while growing the new area of expertise and hence the individual power of the ICE developers.

In 2010 the Government financed Technology Strategy Board (TSB), now Innovate UK (IUK), published a funding competition, for the development of ‘Design and Decision Tools’. A number of industry-led consortia won funding, of which several focused on the whole life impact of buildings; one of the resultant tools was Butterfly, which (with several others) included a detailed section on calculating whole life embodied carbon and energy [44]. In the same year the UK Green Building Council ran an event on embodied carbon in London which was attended to capacity by 200 industry leaders and designers, showing the growing level of powerful interest across industry. It was of particular relevance that this event was chaired jointly by the chairs of the ZCH and the ZCTF, showing again that the exclusion of embodied impacts from their task groups had come from their powerful political appointees.

While the tools developed through the TSB competition mainly remained in-house, industry interest in embodied impacts continued to grow. In April 2014 the country-wide ‘Embodied Carbon Week’ offered a series of well-attended events which identified the need for better knowledge sharing, more data, and an agreement on a methodology. Later the same year a new funding competition, ‘Building Whole Life Performance’, was held by IUK. One winning consortium had originally come together during the Embodied Carbon Week. Led by Simon Sturgis, the head of a carbon consultancy, they proposed to iron out any discrepancies in different calculation methods and write a definitive guide to LCA of buildings for industry practitioners with the RICS. This is reported as the first case study in the section below.

Meanwhile the UK Government was running a public consultation on alternative routes to achieving ‘net zero carbon’ for future amendments to the Building Regulations. There were a number of responses from industry, requesting again that embodied carbon be included. However, in the Government’s response there was no mention of embodied carbon. Following the change of Government in May 2015, the aim to achieve ‘zero carbon’ was quietly dropped.

Industry nevertheless continued to push. In 2017 following the outcome of the Sturgis IUK project, the RICS published their Professional Statement on Whole Life Carbon in Buildings [45]. This was followed in 2018 by a publication from the RIBA, also authored by Sturgis, advising architects on embodied carbon calculations. In 2018 the BRE introduced full LCA as an option within BREEAM. In 2019 the new draft of the London Plan included for the first time statements about reducing carbon dioxide emissions from construction as well as operation and minimising the ‘embodied carbon in construction.’ However, as of yet there is no indication that embodied carbon will be included in regulations.

## 6.2 UK best practice case studies

*UK CS1:* The first UK case studies the development of the RICS Professional Statement [45]. This was based on the work of the industry-academia team led by Simon Sturgis, funded through the IUK. Sturgis ran a ‘carbon consultancy’ which was subcontracted to undertake detailed embodied carbon calculations for projects. The project was originally envisaged as demonstrating and implementing an (assumed already agreed) whole life carbon methodology, with the academic partner (Moncaster) seen as an arbiter to ‘regulate potential differences’. However it was clear early on that industry methods were in fact very varied, both in general [16] and within the team [46]. The original lack of awareness of this led to time delays. While the collaborative nature of the regular workshops appeared to offer power sharing between the different professionals, such detailed input also led to both meetings and the project running out of time. Time and budget pressures meant that the meetings stopped in January 2017. Sturgis had meanwhile separately entered into discussions with BRE on ‘possible implications for the next version of BREEAM’, signing a non-disclosure agreement; this private relationship with BRE, and the cessation of the meetings, meant that the power returned in this final stage to Sturgis. His relationship with both RICS and the BRE, and the alignment of his own interests with theirs, meant that the final text of the RICS Statement aligned with his interpretation, and cemented his expert power and his business interests.

*UK CS2:* The second UK case study is of two new school buildings designed and constructed between 2008-2012. As with the Swedish study, these were an early example in which embodied carbon calculations were used to support decisions. The initiative came from the structural engineers, who proposed replacing the planned steel frame in this case with cross laminated timber (CLT) as a ‘truly sustainable’ solution. They firmly equated sustainability with embodied carbon, and felt that BREEAM (required on the project) failed to demonstrate this: ‘the embodied carbon.. to me is what BREEAM should be about.. sustainability, embodied carbon, in terms of the actually tangible thing.’ [40](p192). Not by coincidence, they were also starting to carve out a niche of expertise in CLT design. It was therefore worth them spending considerable extra resources on this project, including conducting a small research project with Cambridge University. Their expert knowledge of both CLT and of embodied carbon, and their development of a partial LCA model as a specialised tool, paid off in persuading the lay client of their expertise.

However the project documents showed overt conflict with other professionals on the team, including in particular the services engineer, who went as far as emailing the client to warn him that timber construction was unsafe. The previous definition of sustainability as solely about operational energy and carbon reduction, as had been implied by the UK Government in their description of ‘zero carbon’, had meant that services engineers had been able to rebrand themselves as ‘sustainability experts’; indeed their report on the services strategy for this project was entitled ‘Sustainability Report’. Now, however, the structural engineers were competing for rights for that powerful new form of expertise. The Quantity Surveyor (QS) was also unhappy about the proposal, in his case because he was unsure as to how to cost this new material. The result was that the structural engineers calculated the costs themselves, through direct discussion with the supplier, again offering a challenge to the expert power of another professional on the team.

The contractor appointed to build the first school had not used CLT previously, but found it to be quick to erect with low site waste, saving time and money. In addition it offered a far more comfortable environment [40](p172). The second school building was won by this contractor through a different, contractor-led, procurement process. Here the contractor took the unusual step of replacing their original



highly regarded structural engineering firm with the structural engineers from the first school, and co-opting their expertise to help sell a CLT solution to the client. This second project therefore demonstrated the successful increase in power of the structural engineers through their development of a specific expertise, including both practices and language.

### **7. Discussion and conclusions**

These short histories and indicative case studies do not claim to offer a complete picture of what has happened in the UK and Sweden over the last 25 years. However they have shown some of the ways in which social power has worked through projects, industries, and policy formation to gradually allow embodied impacts of buildings to become accepted as a valid concern. In doing so a new form of expertise, and new experts, have been created, leading to shifting power structures. Expertise, and its associated power, is often perceived as a zero sum game in which one person's gain is another's loss. Therefore any new fields of expertise are likely to result in direct or indirect conflict, and examples of Lukes' first and second 'dimensions' of power are both visible in the analysis. Other examples from both countries have demonstrated the ways in which power works through policy formation, and the differing powers of both loose 'issue networks' and more controlled 'policy communities'. The most effective relationships here are seen to be those where interests are closely aligned between industry and political actors; however the more indirect but longer-term power of the looser issue networks has also become apparent within the changes over two decades.

In the Swedish case this was demonstrated by the very direct uptake of embodied carbon on the political agenda commencing in 2014, due to a less than a handful industry representatives with powerful political networks. The opposite result was seen in UK in the early years of the century- here embodied carbon was specifically omitted from the Zero Carbon definition (Lukes' second dimension of power, in which the option was kept 'off the table'), with the Government position shored up by an influential industry actor whose business interests were also aligned.

The critical issue of accessibility to reliable data, as a means to drive embodied carbon reduction through sharing expertise is also revealed in both countries. It was not until the University in Bath in UK and later the IVL research institute in Sweden released open data, that a broader and more egalitarian uptake and competence building about embodied carbon impacts in buildings could take place in the two countries. In the UK it was a move made by two individual researchers; however in Sweden, it was a difficult step to take since the research institute was very aware of the competitive power such data represents. In Sweden, the government is therefore currently standing behind the development of a database to be used for developing the forthcoming mandatory climate declarations for buildings.

A further difference in the two countries is that in UK embodied carbon has been an issue of, at least some, consideration as far back as the launch of the BRE Green Guide in 1996. In Sweden, the issue was raised by individual researchers in academia occasionally from that time and on, but since industry was opposed to introducing LCA it was omitted in the nationally adapted certification schemes of buildings until 2017. Despite (or perhaps because of?) this difference, embodied carbon is now in the process of becoming regulated in Sweden, while the UK regulations still omit it.

The literature review described three causes for variation in embodied carbon calculations as 'temporal', 'spatial' and 'physical' [14]; the power struggles described within this paper demonstrates a fourth reason, which we have termed 'social'. It is clear from this short paper that extending this social power analysis might hold the key to the more effective introduction of embodied carbon across Europe. This work will therefore be extended further within the Annex 72 project.

## 8. References

- [1] Moncaster, A. M., Nygaard Rasmussen F., Malmqvist T., Houlihan Wiberg A. and Birgisdóttir H. (2019) Widening understanding of low embodied impact buildings, *J. Cleaner Production* 235, 378-393
- [2] R.J. Cole, P.C. Kernan (1996) Life-cycle energy use in office buildings, *Building and Environment* 31 (4) 307–317
- [3] Treloar, G., Fay, R., Ilozor, B. and Love, P. (2001), "An analysis of the embodied energy of office buildings by height ", *Facilities*, Vol. 19 No. 5/6, pp. 204-214
- [4] Devi, PL and Palaniappan, S (2014) A case study on life cycle energy use of residential building in southern India, *Energy Build.* 80 (2014) 247–259
- [5] Dixit, M.K. (2017) Life cycle embodied energy analysis of residential buildings: a review of literature to investigate embodied energy parameters, *Renewable Sustainable Energy Rev.* 79 (2017) 390–413
- [6] Evangelista, PPA, Kiperstok, A, Torres, EA, Gonçalves, JP (2-18) Environmental performance analysis of residential buildings in Brazil using life cycle assessment (LCA). *Constr. Build. Mater.* 169, 748–761.
- [7] Pomponi F and Moncaster A.M. (2016) Embodied carbon mitigation and reduction in the built environment: the evidence, *Journal of Environmental Management* 181 pp 687–700
- [8] Anand, CK and Amor, B (2017) Recent developments, future challenges and new research directions in LCA of buildings: a critical review, *Renew. Sustain. Energy Rev.* 67 (2017) 408–416.
- [9] Lavagnaa, M, Baldassarrib, C, Campiolia, A, Giorgia, S, Dalla Vallea, A, Castellani, V and Sala, S (2018) Benchmarks for environmental impact of housing in Europe: Definition of archetypes and LCA of the residential building stock, *Building and Environment* 145 260–275
- [10] Ibn-Mohammed, T, Greenough, R, Taylor, S, Ozawa-Meida, L and Acquaye, A (2013) Operational vs. embodied emissions in buildings: a review of current trends, *Energy Build.* 66, 232-245.
- [11] Frischknecht, R, Wyss, F, Knopf, SB, Stolz, P (2015) Life cycle assessment in the building sector: analytical tools, environmental information and labels. *Int. J. Life Cycle Assess.* 20, 421-425
- [12] Soust-Verdaguer, B, Llatas, C, García-Martínez, A (2016) Simplification in life cycle assessment of single-family houses: a review of recent developments, *Build. Environ.* 103 215–227.
- [13] Rasmussen F., Malmqvist T., Moncaster A., Houlihan Wiberg A. & Birgisdóttir H. (2018) Analysing methodological choices in calculations of embodied energy and GHG emissions, *E&B* 158, 1487-1498
- [14] Moncaster, A. M., Pomponi, F., Symons, K. E., and Guthrie, P. M. (2018) Why method matters: temporal, spatial and physical variations in LCA, *E&B* 173, 389-398
- [15] Häkkinen, T., Kuittinen, M., Ruuska, A. and Jung, N. (2015) 'Reducing embodied carbon during the design process of buildings', *J. Building Engineering*, 4, 1–13.
- [16] De Wolf, C., Pomponi, F. and Moncaster A.M. (2017) Current industry practice in embodied carbon calculation, *Energy and Buildings*, 140 (1) 68-80
- [17] Jusselme, T., Rey, E. and Andersen, M. (2020) 'Surveying the environmental life-cycle performance assessments: Practice and context at early building design stages', *Sustainable Cities and Society*, 52
- [18] Scott, J (2001) *Power*, Oxford and Malden, USA, Blackwell.
- [19] Lukes, S. (2005) *Power: A Radical View* Second edition. Basingstoke, Palgrave Macmillan.
- [20] Dahl, RA (1957) The concept of power. *Behavioral Science*, 2: 201-215.
- [21] Bachrach, P and Baratz, MS (1963) Decisions and Non-Decisions: An Analytical Framework, *American Political Science Review*, 57, 632-42.
- [22] Laumann, EO and Knoke, D (1989) Policy networks of the organisational state, in Perrucci, R & Potter, HR (eds.) *Networks of power*, New York, De Gruyter
- [23] Assefa G, Glaumann M, Malmqvist T, Kindembe B, Hult M., Myhr U and Eriksson O 2007 Environmental assessment of buildings properties – where natural and social sciences meet: the case of EcoEffect Build. *Environ.* 42 1458-1464
- [24] Brick K 2008 Barriers for implementation of the Environmental Load Profile and other LCA-based tools (Stockholm: KTH Royal Institute of Technology)
- [25] Forsberg A 2003 Environmental Assessment of the Urban Environment – Development and First Application of the Environmental Load Profile for Hammarby Sjöstad (Stockholm: KTH)
- [26] Erlandsson M, Jönsson, J-A, Enström, D 2007 Räkna med livscykelns miljöprestanda – Anavitor IVL report B 1709 (Stockholm: IVL Svenska Miljöinstitutet)
- [27] Boverket 2001 Deklaration av bostäder, skolor, förskolor. Regeringsuppdrag M1999/3328/Hs (Karlskrona, Sweden, Boverket)
- [28] Malmqvist T, Glaumann M, Sundqvist Å, Carlsson P.-O, Erlandsson M, Andersson J, Wintzell H, Finnveden G, Lindholm T, Malmström T.-G 2011 A Swedish Environmental Rating Tool for Buildings, *Energy* 36 1893-1899

- [29] Boverket 2018 Klimatdeklaration av byggnader. Förslag på metod och regler. Slutrapport. Rapport 2018:23 (Karlskrona, Sweden: Boverket)
- [30] Socialdepartementet 2014 Uppdrag angående byggnaders klimatpåverkan utifrån ett livscykelperspektiv Regeringsbeslut IV:11 (Stockholm: Regeringen)
- [31] IVA 2014 Klimatpåverkan från byggprocessen (Stockholm: IVA and Sveriges Byggindustrier)
- [32] Boverket 2015 Byggnaders klimatpåverkan utifrån ett livscykelperspektiv Forsknings- och kunskapsläget report 2015:35 (Karlskrona: Boverket)
- [33] Boverket 2016 Miljö- och klimatanpassade byggregler – Förstudie report 2016:14 (Karlskrona: Boverket)
- [34] SOU 2018 Resurseffektiv användning av byggmaterial SOU 2018:51 (Stockholm: Norstedts juridik)
- [35] Fossilfritt Sverige 2018 Färdplan för fossilfri konkurrenskraft Bygg- och anläggningssektorn [http://fossilfritt-sverige.se/wpcontent/uploads/2018/01/ffs\\_bygg\\_anlaggningssektorn181017.pdf](http://fossilfritt-sverige.se/wpcontent/uploads/2018/01/ffs_bygg_anlaggningssektorn181017.pdf)
- [36] Liljenström C, Malmqvist T, Erlandsson M, Fredén J, Adolfsson I, Larsson G and Brogren M 2015 Byggandets klimatpåverkan - Livscykelberäkning av klimatpåverkan och energianvändning för ett nyproducerat energieffektivt flerbostadshus i betong (Stockholm: Sveriges Byggindustrier)
- [37] Kurkinen E-L, Norén J, Peñaloza D, Al-Ayish N, During O 2015 Energi och klimateffektiva byggsystem – Miljövärdering av olika stomalternativ SP Report 2015: 70 (Borås, Sweden: SP Sveriges tekniska forskningsinstitut)
- [38] Kurkinen E-L, Al-Ayish N, Brick K, Rönneblad A, Brunklaus B, During O, Larsson Ivanov O 2018 Kriterier för resurssnålt byggande i praktiken. Report 2018:18 (Eskilstuna: Energimyndigheten)
- [39] Department for Communities and Local Government (2006) Building A Greener Future: Towards Zero Carbon Development - Consultation. Rotherham, Communities and Local Government Publications
- [40] Moncaster, A M (2012) Constructing sustainability: connecting the social and the technical in a case study of school building projects. PhD thesis, University of East Anglia
- [41] Department for Communities and Local Government (2007b) Building a Greener Future: policy statement. Rotherham, Communities and Local Government Publications
- [42] Department for Communities and Local Government (2007c) The Callcutt Review of Housebuilding Delivery. Rotherham, Communities and Local Government Publications
- [43] Department for Children, Schools and Families (2010) Road to zero carbon: Final report of the Zero Carbon Task Force. Annesley, Notts, DCSF Publications
- [44] Moncaster A.M. and Symons K E (2013) A method and tool for ‘cradle to grave’ embodied energy and carbon impacts of UK buildings, E&B 66 (11) pp 514–523
- [45] Royal Institution of Chartered Surveyors (2017) Professional Statement on Whole Life Carbon assessment for the built environment, RICS, London
- [46] Pomponi F., Moncaster, A.M. and De Wolf, C., (2018) Furthering embodied carbon assessment methodology: findings from an industry-academia collaborative research project, Special Issue on Embodied Carbon of Buildings, Energy and Buildings 167, 177-186