Challenges in Framing Building Energy Research

(white paper)

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November 2017

Abstract

This paper discusses the framing of work on the energy efficiency of buildings (and more in general, energy efficiency of the built environment) in writings by students, scholars, policymakers and other stakeholders. It addresses various types of '*tunnel vision*' that are becoming increasingly widespread in the field. It argues that:

1. studies of energy efficiency may be worthwhile but do need to acknowledge that the performance aspect of 'energy efficiency' interacts with other performance aspects such as 'thermal comfort'.
2. the problem of 'energy efficiency' itself is complex, and deals with a range of underlying problems such as limited resources, economic factors such as peak oil, political drivers such as (in)dependency of foreign producers, climate change, damage to local ecosystems, and others.
3. derivative terminology such as 'energy efficient design' reinforces the tunnel vision and needs to be used with extreme care.

The paper includes a discussion of what level of framing should be expected from various types of contributions, and concludes with some general recommendations for the best way to position a contribution to the field.

Introduction

Research into the energy efficiency of buildings is a buoyant field. In the UK, the EPSRC (Engineering and Physical Sciences Research Council) alone supports academic research efforts in this area of well over £ 5m per annum, with further investments by InnovateUK and the European Research Council. In the European Union, research funding on building energy efficiency is in the order of €5b per annum; in the USA the Department of Energy (DOE) invests in the order of $100M per year in energy efficiency research. There are many conferences on the subject, such as COBEE (International Conference on Building Energy and Environment), PLEA (Passive and Low Energy Architecture), CISBAT (Solar Energy and Sustainability in the Built Environment) or SEB (Sustainability in Energy and Buildings). More advanced work is published in a range of peer-reviewed academic journals, such as *Energy and Buildings*, *Energy Policy*, *Advances in Building Energy Research, Facilities*, *Building and Environment* and *Applied Energy*, and a range of books dedicated to the subject.

While many authors contribute excellent work on the subject, there is an increase of manuscripts that lacks critical reflection on the challenges underlying the need to study energy efficiency of buildings. Some introductions are becoming almost verbatim copies of the same simplified line of reasoning. References, when provided, often point to other papers that voice a similar approach, rather than to underlying data. This way of framing building energy research is problematic and carries significant risks. It opens the work being presented up to easy criticism of the premises underlying of the research effort, even if the research itself is worthwhile. Incomplete discussion and shortcuts in reasoning will raise doubts about the quality of the further methodology of the research. And in the end, using an introduction that repeats what others have already said and offers nothing new is a waste of space, and may put the readers off before they get to core of the work. Simplified introductions also set authors up for problems when they come to the discussion and conclusion sections of their writing, as this makes it much harder to include a critical reflection on the impact and reach of any contributions made. The lack of critical reflection creates barriers for students to gain good coursework marks, barriers for scholars to get their work accepted in academic journals, and barriers for researchers to gain grants from funding agencies. On the other side, lecturers and reviewers are becoming increasingly impatient with reading the same story again and again, and having to repeat the same constructive feedback.

This white paper is an call to arms for more diligent framing of research contributions in the area of building energy research. It describes a number of 'tunnel visions' encountered in student work, scholarly work, governmental reports and consultancy recommendations, and suggests levels of awareness that may be expected from various authors.

Categories of building energy tunnel visions

There are different types of building energy tunnel vision. As with most problems these come in gradations, from subtle confusion to grand oversights.

(1) "Energy only" tunnel vision

This type of tunnel vision assumes that energy use is a performance aspect that can be studied in isolation. It ignores the fact that buildings are never designed, constructed and operated with only energy use in mind; in real life buildings respond to a need to provide living accommodation, working space and similar. A simple thought experiment is as follows: if buildings would not need to provide suitable conditions for the occupants and processes, one could simply turn of all systems and have a zero-energy solution. The fact that life is not as simple as that shows that energy use is balanced with other requirements. An extension of 'energy only' tunnel vision is the concept of energy efficient design. By nature design requires an intricate trade-off between various requirements and design solutions; the idea that 'energy' could be a single driving factor for the design process is clearly out of touch with reality. For some deeper insights into the balancing of thermal comfort requirement with efficient building operation, see for instance Killian and Kozek (2016). To add further complexity, a deeper and often overlooked debate exists about the trade-off between operational energy use and embodied energy, as explored by Iddon and Firth (2013).

(2) "Carbon reduction" tunnel vision

The use of fossil fuels to operate buildings is linked to the emission of greenhouse gases. A key greenhouse gas that gets a lot of attention is carbon dioxide (CO_2), leading to shorthand discussion of 'carbon reduction' as an equivalent to efforts to reduce greenhouse gas emissions. Unfortunately, the real situation is more complex. Beyond carbon dioxide, there are other greenhouse gases such as methane (CH_4), nitrous oxide (N_2O), various chlorofluorocarbons (CFCs) and hydrofluorocarbons (HFCs). Some natural elements of the atmosphere, such as water vapour (H_2O) and ozone (O_3) also cause greenhouse effects. For the sake of comparison, it is possible to equate emissions of other greenhouse gases to carbon dioxide emissions. However, such conversions rest on significant assumptions. Conversions of energy use to carbon emissions are even more subtle, as they are based on a specific local energy mix; by way of example, a building that is only supplied by renewable energy sources will not cause any emissions. For deeper discussions, see for instance Budischak *et al.* (2013) or Ozturk *et al.* (2016).

(3) "Climate change" tunnel vision

One of the environmental problems connected with the use of fossil fuels is climate change, as a long-term effect of the emission of greenhouse gases. This is undoubtedly a serious challenge. However, work that focuses only on climate change overlooks other energy problems, such as the fact that many sources are finite, the local implications of gathering fuel, and economic and political dimensions. Expanding on some of these issues: nuclear energy is sometimes argued as a solution that is good as it does not cause climate change, yet it still depends on finite natural resources of uranium and involves other risks (Vainio *et al.*, 2017). Mining of tar sands and hydraulic fracturing (fracking) are accessing new supplies of fossil fuel but at significant environmental cost which are outside the climate change discussion; see for instance Meng (2017). The arguments of 'peak oil', which links availability of fossil fuels to serious price consequences (Brecha, 2012; Chapman, 2014), and of dependency on foreign imports (Winzer, 2012; van Moerkerk and Crijns-Graus, 2016), also fall outside the climate change scope.

(4) "Global warming" tunnel vision

Climate change in itself is a complex process. Some authors simplify this to a straight cause-effect relation where greenhouse gas emission lead to a higher average temperature. In reality the relation is more complex; human-made and natural drivers may interact, and the impact is not just an average temperature rise, but a range of issues such as increase in frequency and severity of extreme weather events such as hurricanes, sea level rise, and others. For a deeper discussions, see for instance de Wilde and Coley (2012) or Held (2014).

(5) "Magic bullet" delusion
Buildings are complex, bespoke 'systems of systems'. The energy required to operate buildings is not only a function of the systems that make up the building, but also highly dependent on the load imposed by the climate and occupancy, as well as the control regime that has been set. In this context, it is highly unlikely that a single novel technical system, design approach, construction or operation method will be generally applicable across all situations. Unfortunately some authors fail to reflect properly on the limitations of their contributions. Deeper exploration of some solutions may reveal unexpected consequences and paradoxes; see for instance Copiello (2017).

(6) "Scientific greenwash"
For actual buildings, 'greenwash' relates to efforts where a building is deceptively made to be perceived as environmentally friendly, for instance by the use of renewable energy systems (Patience, 2011). The principle of greenwash is based on creating an association with a positive environmental aspect, even if in fact a product has no such positive aspects itself – for instance through naming that includes eco, green, imagery, and vague correlations. A weak form of this marketing plot may be present in the framing of building energy research. In authoritative writing about energy efficiency of buildings, it is thus important to critically reflect on claims for the need of green buildings, sustainable buildings, eco-buildings and similar, and to prevent blindly following one-sided argumentation.

Perfunctory introductions
Apart from succumbing to tunnel vision, many dissertations, conference papers, journal articles and policy documents start with some variation on the following simplified argumentation:

- buildings are responsible for something like 30 to 40% of energy use and related greenhouse gas emissions, depending on whether one takes a national or international view;
- climate change is a global challenge, with dire consequences in terms of overheating, heat-related death, and flooding;
- there is a need or agreement to reduce greenhouse gas emissions by some percentage by some date in the future;
- the work reported in this piece of writing is important because it helps reducing greenhouse gas emissions through some sort of effort such as the development of new systems, software, or policies.

The reasoning is often supported by large number of references to other papers following the same line of thought.

This line of reasoning has the following shortcomings

a. Obviously, the argument suffers from energy and climate change tunnel vision.
b. The figure of 30% to 40% is very generic, and is of limited use unless overall energy use and greenhouse gas emission figures are included. Percentages reflect on the balance between energy use in the built environment and other sectors of the economy, such as transport and manufacture, so high values are not necessarily bad when overall use is low. Furthermore, conversion of energy use to carbon emissions is not straightforward, and is highly dependent on the local fuel mix, which renders some numbers questionable for some countries.
c. Political aspirations in terms of energy and climate change may be used to indicate the perception of decisions makers. However, actual targets must be viewed with some scepticism. For a recent example, see the discussion on 'zero carbon homes' in the UK. Building up a scientific argument on the basis of political assumptions thus carries risk of the argument becoming outdated. Some research is identifying underlying agendas in energy research, see for instance Diedrich *et al*. (2011).
d. The argumentation fails to mention the complexity of the global climate, and the time it takes for interventions to have an impact. The global climate depends on many factors, and even if reductions in emissions can be achieved, some change is already locked into place and inevitable.

e. The line of reasoning says little, if anything, about the importance for research activities that will be the core of the contribution. Even if these are a valid work that reduces energy use and/or reduces greenhouse gas emissions, there still is a need to position the relative importance of this contribution to the overall situation.
f. Reference of sources that present the same line of thought does not validate the argumentation. Proper scientific work should cite underlying sources that present and confirm underlying assumptions, which typically is much harder to do.

Expectations

Writings about energy efficiency come at different levels, and hence cannot all be judged in the same manner. However, the following may be expected from different key contributions:

- Student work at BSc level (reports and dissertations) should demonstrate a general understanding of the complexity of the energy use of the built environment. This typically will require a positioning of a topic of study within the wider energy context, discussing various interactions and using a good spread of references.
- Student work at MSc level (reports and dissertations) should demonstrate advanced understanding of the complexity of energy and buildings. Beyond the positioning of a topic of study in the wider context, this level may be expected to reflect on cause-effect relations in some depth.
- Scholarly contributions by PhD-students, professional researchers and academics typically claim to make a contribution to knowledge. This is especially true where manuscripts are submitted to peer-reviewed archived journals. In this context one may expect authors to quantify the contribution of their research efforts, and to reflect on their importance in the wider context.

Recommendations

This paper points out some of the problems found in the framing of building energy research. It points out some of the problem areas encountered frequently when reviewing student work, journal submissions and funding applications.

Further suggestions for better framing of building energy research are as follows:

- Students should make use of the many resources that help to guide them in critical thinking, such as Biggam (2011), Greetham (2014) and Phillips and Pugh (2010). A more general guidebook for academic writing is Johnson (2011).
- All authors should make an effort to cite original sources. In terms of data on energy use in the built environment, this means accessing national statistic reports; an authoritative international context is available in the annual *World Energy Outlook* published by the International Energy Agency.
- Where the context of a publication already is clearly energy use of the built environment, for instance when a manuscript is submitted to a journal like *Energy and Buildings*, there is no need for extensive framing and it is better to come straight to the main point of the contribution.
- Finally, there needs to be a balance between the introduction and conclusions in a manuscript. Where the introduction starts from a wide perspective, the conclusions need to reflect back to this wider context; writing that starts broad but ends narrow is unbalanced.

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