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Life cycle thinking toward sustainable development policy-making: The case of energy retrofits

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ABSTRACT

Viable implementation of building energy-efficiency policies is inevitable to mitigate climate change, above all as buildings account for around 40% of the world's energy consumption. Although some 75% of all buildings in Europe are energy-inefficient, only 0.4–1.2% of the whole stock is renovated each year. The greatest challenge for the coming decades is to increase the rate, quality and effectiveness of building renovation. The overall goal of the present article is to illustrate the key role to be played by Life Cycle Thinking in sustainable development policies and its implementation in the design of optimal retrofit solutions. The main housing renovation policies implemented in Spain were submitted to analysis using the focus of Life Cycle Approaches. Representative case studies were selected based on the analysis of 3245 real renovation solutions funded by policy programmes in the period between 2010 and 2014. Current solutions were assessed and compared to other retrofit scenarios that a priori might seem more desirable when striving for energy-efficient buildings. Multi-criteria assessment results reveal that the current renovation strategies applied in Madrid and Seville are, by no means optimal solutions, while only a small additional cost could produce significant performance improvement in Bilbao. The Passivhaus standard that offers the greatest reduction of energy consumption in all three cities would appear, however, not to be the solution of choice for any of them. These findings demonstrate the need to integrate Life Cycle thinking into the building process to identify the most sustainable energy pathways.

1. Introduction

1.1. Addressing the root: a systems approach to sustainability

There is a limit to what can be achieved when using an approach that basically takes existing consumption patterns as a given benchmark and thus concentrates solely on reducing the present impacts. The Sustainable Development Goals provide evidence of a growing consensus that sustainable development must be considered in a holistic manner: there is an urgent need to explore radically different ways of providing large-scale utility or wellbeing (UN, 2017). Essentially, a systems approach, such as is posited herein, means looking at the broader picture of any one issue (Bai et al., 2016). It constitutes an attempt to identify and deal with the deeply-ingrained roots of a specific problem rather than to merely attempt to alleviate the most immediately apparent symptoms (Missimer et al., 2017). It also implies an awareness of, and attempt to avoid any burden displacement or shifting that may occur, that is, it offers an understanding of the possible side-effects of any proposed solution (Mangoyana et al., 2013). This is what Life Cycle Thinking (LCT) is all about (Sherli and Kani, 2018). Life Cycle Approaches have emerged as a promising framework within which to measure sustainability full cycle, from “the cradle to the grave” based on a systems approach that provides a long-term perspective of the multiple primary and secondary impacts (Azapagic, 2017).

Environmental life cycle assessment (LCA) (Chang et al., 2014; Laurin, 2017) has developed briskly over the last three decades. In the last decade alone, LCA broadened to include life-cycle costing (LCC) (Swarr et al., 2011) together with social LCA (SLCA) (Grubert, 2018), in line with the ‘triple bottom-line’ model of sustainability. In

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2011, the Life Cycle Sustainability Assessment Framework (LCSA) (Cinelli et al., 2013; Ekener et al., 2018) that included these developments was presented to experts in various different disciplinary fields for them to discuss and thence develop a holistic approach to effective sustainable development and sustainability decision-making. Unfortunately, the result has been scant development in the field of back-up for effective decision-making (Gbededo et al., 2018; Zamagni et al., 2013).

1.2. Strategic opportunities for policy action to apply life cycle thinking (LCT)

What is considered a policy issue is "not self-evident", it may be contested, subjective and socially constructed (Wolman, 1981), whilst public policy formulation is notoriously inscrutable (Wu et al., 2012). Public policy development is the result of many factors that influence decision making (John, 2013) and multiple stakeholders with different values, perceptions and preferences, thereby resulting in a complex and unpredictable process (Cairney, 2015). However, policy development, if effective and efficient, if designed effectively and efficiently, delivers the greatest benefit at the lowest cost and allows the stakeholders to focus on the "real" issues. Public policy decisions vary greatly, from narrow mandates to broad policies, and involve a wide range of institutions, from local municipal departments to federal agencies (Seidel, 2016a). As a result, the way Life Cycle Approaches are applied within the public policy process can, and should be different in each case, varying from qualitative perspectives (life cycle thinking), to quantitative evaluations (comprehensive life-cycle assessment).

The use of life cycle concepts and tools can bring together scientific and policy-making communities to strike an appropriate balance between economic, environmental and social considerations, by moving outside a framework pieced together from fragmented end of life approaches toward more holistic decision-making. From an environmental perspective, LCA can play an important role in the legislative policy process by contributing toward identifying problems and instating policy evaluation and implementation (Reed, 2012; Seidel, 2016b).

One of the major benefits of LCT lies in its ability to change actors problem perception (Lazarevic et al., 2012; Thabrew et al., 2009). LCT may also be helpful when establishing implementation procedures and educating people with respect to the possible outcomes a policy decision will produce as well as when promoting sustainable lifestyles (Kikuchi-Uehara et al., 2016). Last but not least, during policy evaluation, LCA affords a comparative tool whereby to measure policy effectiveness. Indeed, the life cycle perspective and the systemic approach to the evaluation of options add crucial value (Reale et al., 2017).

LCT and LCA are increasingly mentioned as essential in holistic and comprehensive decision-making in both business and policy contexts (Lehmann et al., 2015; Manda et al., 2016; Reimann et al., 2010). The European Union and its member states are leaders in the use of Life Cycle Approaches in public policies and programmes (Hellweg and Canals, 2014; Walser et al., 2017). The building and energy sectors, above all, are working within the framework of holistic life cycle considerations for sustainability as promoted in the current legislation (Kylili and Fokaides, 2017). The United States have been relatively slow to integrate LCA into overall policy as compared to Europe, but have also begun to consider life cycle information as essential to policy decisions at both federal and state levels (Reed, 2012). General developments in Asia started in 2010 (Valdivia et al., 2015). The use of Life Cycle Approaches in regulations and programmes in Latin America is an ongoing process, with Brazil and Mexico as representative examples and Argentina, Peru, Chile, and Colombia following close behind (Maia de Souza et al., 2017; Valdivia et al., 2017). In Africa, the Caribbean and Central Asia, Life Cycle Approaches still figure low on the agenda (Sonnemann et al., 2016).

1.3. Energy efficiency retrofit policy

In recent years, the International Energy Agency (IEA) has tried to highlight the importance of energy efficiency and to give it priority as the "first fuel" (International Energy Agency, 2014a). This focus is, in part, due to the perception that the demand-side of energy policy options has been overlooked in favour of the supply-side (Lazar and Colburn, 2013) with a resulting bias toward investment in energy generation as opposed to efforts to reduce energy demand. The IEA estimate that the existing levels of policy support will leave untapped two-thirds of all economically-viable energy efficiency potential by 2035 (International Energy Agency, 2014b).

Activity in domestic buildings is often responsible for a large proportion of national energy use (Kerr et al., 2017). The share of energy consumption by buildings in the EU States indicates that the building sector is one of the major sources of greenhouse gas emissions, thus representing a huge possibility of improving energy efficiency and reducing GHG emissions through energy retrofit (Anisimova, 2011; Buyle et al., 2018). Existing building stocks are to present the bulk of future stock for many decades to come in developed countries (Artola et al., 2016). A significant percentage of these buildings are relatively old and thus offer huge potential in energy saving and reduction of GHG emissions. The studies carried out emphasise the importance of addressing local/regional energy-driven issues and the requirements of any designed policy to improve energy efficiency (Sandberg et al., 2016; Visscher et al., 2016).

Policy instrument is the key to drive improving energy-efficiency in building sectors (Shen et al., 2016). Policies designed at encouraging and supporting energy-efficient renovation include: energy audits and assessment; energy performance certificates or ratings at point of sale; financial incentives and capital support including grants, subsidies, tax credits, low-interest loans, and third-party financing; certification and training of contractors; community or neighbourhood renovation schemes (collective procurement, support for vulnerable or low-income households); and marketing or awareness campaigns. Although these vary considerably in design and implementation, the policies all constitute efforts to promote energy-efficient renovation decisions, whether these be taken in the EU (Grubb, 2014), North America (Dixon et al., 2010), China (Li and Shui, 2015) or in other markets worldwide (International Energy Agency, 2016, 2013; 2008). Kerr et al. (2017) assessed the extent to which the various benefits of energy efficiency formed part of the rationale for energy-efficiency retrofit policies in a selection of varying contexts. In the countries considered, with the exception of New Zealand, the carbon emission benefit was probably the predominant rationale for energy-efficiency retrofit.

The European Union in its Energy Performance of Buildings Directive, EPBD 2010/31/UE (European Commission, 2010), outlined the objectives to increase energy efficiency in the building sector while reducing CO_2 emissions and promoting the use of renewable energies, in line with its commitment to the Kyoto Protocol. After the Paris Climate Conference (COP21) and in accordance with the Paris Agreement and the Europe 2020 strategy (Liobikienė and Butkus, 2017) the European Commission made by the end of 2016 a proposal to update the EPBD 2010/31/UE (European Commission, 2016). Although some 75% of buildings in Europe are energy inefficient, only 0.4–1.2% of the stock is renovated each year (Jäätteenmäki, 2017). The greatest challenge in the