Author/s:
Wu, H;Crawford, RH;Warren-Myers, G;Dave, M;Noguchi, M

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CONCEPT AND BARRIERS FOR THE ECONOMIC VALUE OF LOW-ENERGY HOUSES

Hao Wu[1], Robert H. Crawford[1], Georgia Warren-Myers[2], Malay Dave[3], Masa Noguchi[1]

[1] *EDBI Research Group, Faculty of Architecture, Building and Planning, The University of Melbourne*
[2] *Faculty of Architecture, Building and Planning, The University of Melbourne*
[3] *Built Environment, University of New South Wales*

ABSTRACT

This study explores the market revealed price of low-energy residential buildings and why the economic value of low-energy housing products is less transparent in active residential markets. It explores Australian and Japanese conditions and examines the proposition by using embodied energy, operational energy and market price data of selected housing stock in Australia. The study aims to examine a new perspective towards understanding the barriers to ascertaining the economic value of low-energy buildings. In particular, the study examines the composition of energy consumption associated with the residential property life cycle. Operational energy is linked to consumer preference by its inter-temporal value estimate of future expected utility or benefit flow. A 'low' embodied energy house is an environmental construct, which does not appear to currently link to short-term market value perception. It does not strongly link to an expected (intuitive) benefit. This 'gap/disconnect' creates a barrier to estimating a holistic economic value of low-energy residential property.

Keywords: Embodied energy, operational energy, market value, low-energy house

INTRODUCTION

A house is a form of productive capital: it is productive or performance-valued and typically considered as durable capital. A low-energy house can be defined as a house that uses little or no non-renewable energy over its life. In its most holistic sense, this includes both energy required for operation (operational energy) and embedded in the materials used in its initial construction and on-going maintenance and repair (embodied energy). There are different approaches to analysing energy use, which may be associated with 'capital' or with 'cost or income'. Understanding the economic value of built structure may involve its production cost, value depreciation, and value appreciation – embodied energy is directly relevant to capital formation and durability where operational energy is associated with maintaining productivity of capital. The capital cost should capture all information about house-production-associated energy ideally including the value of 'embodied energy' (EE), i.e., the full value of energy resources involved in the formation of the capital. A life cycle approach suits, at least conceptually, the evaluation of total cost of capital formation and total operational cost during the life cycle of a built structure. The challenge lies in ascertaining the *market value,* whereby the fundamentals is highly dependent on an informed purchaser, their requirements, desires and willingness to pay for the dwelling given a broad range of criteria for preference.

Operational energy (OPE), on the other hand, relates to running costs that facilitate the 'services' that the capital asset provides – it may be considered to be transparent and easy to measure. In this study, the OPE related arguments are based on data collected by means of visiting Japanese housing manufacturers' sales and production facilities (Noguchi 2011). Research and practice have traditionally focused on operational energy (operational cost) to assess investment values, which, unfortunately, does not assess or fully capture the social value of capital good. Given the capital formation cost relating to embodied energy is not well understood, one question emerges: is the economic value of low-energy house fully appreciated in current market valuations? The question relates to the broad debate of the economic value of 'sustainability' where a 'conceptual tension' currently exists. An effective approach to the question demands specific examination of the value base of the two components of energy cost, i.e., operational cost and capital formation cost.

Price inconsistency exists between capital formation and estimation of market values for a house (Ball 2003). This value gap tends to change over time, which suggests barriers, changes in consumer choice, or market inefficiency in costing and valuing the full capital/operational cost of a house. Whipple (2006) describes value change as 'departure of present value and replacement cost', which is distinct from depreciation analysis used in accounting. Time-discounting model excludes detail about production capital in its current market valuation, which may or may not include full information of all resource (i.e. embodied energy) consumed. This paper explores and identifies important barriers to help understand the conceptual dilemma of the measurability and the economics of low-energy houses being built today. The study further aims to explore a coherent valuation framework of operational and embodied energy of real estate capital production. It uses OPE and EE cases, respectively, to discuss the difference in their values, valuation conflict and challenges. This paper is structured as follows: conceptual conflict and barriers, the OPE case, the EE case, value and valuation issues, condition and formation of market prices. The study leaves formal empirical testing and surveys to future research.

CONCEPTUAL CONFLICT

A literature search of 'value of embodied energy' shows few directly relevant studies. It is worthwhile to ask why this is the case. Crawford (2011a) explores the concept of zero-emissions housing in Australia. The 2015 special edition of Building Research and Information (43(1)) explores net-zero and net-positive energy buildings and value, including the conflicting concepts between operational and embodied energy. For Cole (2015) and Mang and Reed (2015) this conflict "highlights the radically different ways of defining value within 'mechanistic' and 'ecological' worldviews." The mechanistic view is in line with business investment linked to operational energy in the private ownership domain, whereas the ecological view is more closely linked to the embodied energy, largely on values that are left in the public domain. Relative to operational related energy, it is much more difficult to measure and estimate the market value of embodied energy. In order for users, traders, government and other actors to measure and analyse low-energy houses as productive capital, knowledge, learning (i.e. obtaining knowledge), and information (availability/quality) are critical.

The subjective theory of demand implies different consumer preferences, knowledge and saving behaviors for operational energy and embodied energy. For example, saving behaviour for OPE is closely linked to individual/group interest. Contrasting this, saving behaviour for EE and the existing user/owner is considerably less obviously linked to economic agent's interest in a complex market economy. Capital theory suggests a 'trade-off' between embodied energy and operational energy. It concerns stability of consumer behavior, e.g., trader (builder) through learning by processing and absorbing new information and the use of new technology. The barrier involves solving the complex monetary vs. non-monetary values. The market value of privately owned houses does not capture EE is because EE contributes little to the short-term market-based investment worth (or 'utility'). This is treated as capital value. The worth of the property to the investor, which then includes their acceptance of the value including social costs (e.g. taxation), may capture the EE. However, ascertaining what proportion, if any, the purchaser has attributed to EE will be inherently difficult to identify and will depend greatly on their knowledge and engagement. Furthermore, to identify and extrapolate the 'market value' of EE will require broader acceptance and demand from market participants, in addition to the valuers' understanding and interpretation of this change of preference towards EE in private home investment preference and decisions.

A third barrier is due to an inactive market for production-related energy within which the demand for EE is openly traded. For example, the markets for such natural resources as oil, natural gas, or minerals have never fulfilled the neoclassical assumption of a perfectly competitive market. How much do we understand the nature of EE regarding cost, estimated value and market prices? Some natural resources (e.g. public goods) do not have short-term scarcity, hence no active market for measuring demands or consumer choice. OPE cost is publically recognisable e.g., building operational expense analysis or green energy certification, and there are active markets to assist organisations or households to estimate market value, making it easier for empirical analysis. Market valuation theory is built on a motivation of consumer choice (e.g. willingness to pay), but also decrees a number of other factors crucially important to the concept of market value, primarily the knowledge and information available to the buyer. The active housing market reveals an agents' motive to realise a built structure (e.g. capital cost) and to use the structure (e.g. operational cost). The economic value of low-energy housing needs to be estimated by the joint-analysis of operational and embodied energy through the structure's life cycle (time). There are two key challenges for this: (1) the asymmetric information of OPE cost and EE cost; (2) user's different expected value of short and longer term cost and benefit. Users often discount expected benefits using time-varying discount rates.

Capital cost captures 'all energy'. Whether energy cost is rightly priced, measured by consumption or environmental impact, is an empirical question to market efficiency. However it is hard to test non-market pricing such as government-led schemes. Likewise, given politico-economic uncertainty, the creation of a new 'embodied energy market' is more a price control question. Embodied energy is defined as 'cost' but lacks active markets to trade the 'cost'. From a consumer perspective embodied energy and operational energy have quite a different conceptual basis: one being more ecological, the other being more rational. It brings two further questions: (1) what differentiates operational energy and embodied energy in the valuation of residential buildings? (2) How are OPE and EE treated in the low-energy housing sector?

BARRIERS TO VALUING EMBODIED ENERGY

The value of OPE is easier to measure than that of EE as OPE can be captured through the market price as on-going cost. Cost- benefit analysis (CBA) is typically used for this. EE that suffers from asymmetrical information is less understood by and inferred to consumers. The ignorance and lack of information in EE valuation is similar to the DEWHA (2008) observation that visible building features (e.g. window) had greater impact on house price than invisible features (e.g. roof insulation). This ‘problem’ may be reduced through education or ‘learning-by-doing’. For example, Japanese cost data show the importance of education and experience in altering expectation and the ethics of saving. This is a highly important consideration in the concept of identifying market value.

There are a number of potential barriers for the valuing of EE: (1) information scarcity of building embodied energy demand leads to a high price premium for low-energy houses. A high price or expected rate of return becomes a barrier, (2) ethics and belief shape value e.g. ideology and learning. These forces are essential to form the value of low-energy houses in inactive markets, (3) human preference to value perception of short-term vs. long-term benefits, (4) market competition – the embodied energy component may lose ground in market value due to its weak link to market competitiveness. It has higher relative prices with similar short-term utility, (5) price premium a barrier to efficiency and trade/circulation, (6) availability of reliable modelling tools, historical statistical and case specific data.

One fundamental question of inter-temporal differentiation of value and cost is clearly documented by building cost and price indices e.g. AIQS index and REIA house price index. However an apparent challenge in examining value-cost consistency is that those market value indexes contain land and structure values, furthermore in markets like housing, calculating value through the addition of building costs and land do not equate to the *market value*. It is arguable that energy may be a more suitable unit of comparison than prices as it allows proper comparison of building structures without taking into account the land component. The approach used by Lutzkendorf *et al.* (2015) may be inspiring, as they consider full life cycle resource use efficiency and environmental impact reduction of housing projects. Georges *et al.* (2015) adopt a holistic approach that includes building OPE and EE. Coles (2015 pp.4) points out: “both studies advocate reducing energy demand, increasing onsite renewable energy and minimizing the initial and recurring embodied emissions”. Given the apparent challenge in treating value of low energy houses, the OPE and the EE cases are discussed.

THE OPE CASE IN JAPAN

The ultimate low-energy house, i.e. a zero-energy house, falls into two categories: self-sustainable or net zero-energy (Noguchi 2008). The former is a standalone house whose OPE relies solely on its own power generation and storage. It is independent from a commercial grid or power from external sources. The latter means the energy ‘use’ becomes net zero over a fixed period of time. Moreover, domestic OPE can further be classified into two sources: primary and delivered. The primary energy is considered as energy before it is transported from production plants, while the delivered energy is energy imported from the grid. Generally, the distinction of such energy sources affects the level of domestic carbon dioxide (CO_2) emissions; it widens the definition of net zero energy houses. ‘Net zero *source* energy’ is based on the net zero balance of primary energy use; therefore, transport loss of energy delivered from power plants, for instance, is taken into consideration (Aelenei et al. 2013). ‘Net zero *site* energy’ means that the annual balance of operational energy use is based on the grid interaction at the boundary of the building site. A house whose energy cost is net zero under the same conditions is termed a ‘net zero-energy-cost’ house. To achieve net zero-energy-cost, a house needs to be connected to a commercial grid where electricity can be exported and imported between the energy user and the supplier under a net metering arrangement. The notion of 'zero carbon house' is from time to time likened to these abovementioned homes; perchance, the performance may entail the further steps to cover CO_2 emissions from not only operation but also construction and end of life demolition or recycling—i.e. over the full life span (Dave 2014).

Japanese manufacturers are at the forefront of commercialising mass-customisable homes to correspond with market demand for low (zero) operational CO_2 emissions, affordability and design customisability (Noguchi 2013). They compete to produce net zero-energy mass-produced custom homes equipped with renewable energy technologies—e.g. a solar photovoltaic electric power generating system, an air source heat pump, a micro combined heat and power system, and a hydrogen fuel cell. Under the Kyoto Protocol, Japan is assigned the target to reduce its emissions of CO_2 by 6% from the 1990 level from 2008-2012. In Japan, PV systems rated at 3 kW or less use to be common. Today, the high-capacity systems at power levels of 5 kW are being installed to houses. Some leading manufacturers have created a new sector for residential PV systems, developing all-electric houses whose energy can be fully or partially supplied by the micro-power generation systems. In early 2004, Sekisui Chemical Co. (2004a) launched a new zero-energy-cost home "Parfait AE" with zero utility expense specifications. It includes thermal barrier-free systems applied for the foundation and floors, passive ventilation heat-blocking system for high heat dissipation skylight and heat-blocking screens to control sunlight intake. In collaboration with Sumitomo Trust and Banking Co., they jointly developed a new home loan to assist in the purchase of a house equipped with high-capacity PV systems. "The higher the power generating capacity of the photovoltaic generator, the lower the loan's interest rate." (Sekisui Chemical 2004b). The rate was estimated at as low as 2.8%, comparing favourably with long-term fixed-rate bank loans. Such partnership enhances the economic appeal of low-energy PV solar technology.

Japanese manufacturers tend to install costly renewable technologies as standard features rather than optional (Noguchi 2011). To initiate and maintain the sales of their low-energy houses, they bring into effect their quality-oriented production and user-oriented services, which reflects their cost-performance marketing strategy. They have succeeded in developing a good reputation for their net zero-energy-cost product. This is also to show the distinguishing features of high cost-performance house products where a variety of amenities including renewable energy technologies are treated as standard features. According to a 1997 housing survey by the Government Housing Loan Corporation, the average initial cost of a conventional home was estimated at 175,404 JPY/m^2 and a prefabricated home was at 190,033 JPY/m^2 (Noguchi and Collins, 2008). These results indicate that the price of a pre-fabricated house in Japan is 8% more expensive than that of conventional site-built ones, though manufacturers argue that they have been producing better quality homes for about the same price as conventional ones. The manufacturers' way to commercialise new innovative products is a cost-performance marketing strategy, which is applied in other industries e.g. automobile. Although today's automobiles can be produced with lower production costs than those in the past, their selling price does not seem to be heavily affected by productivity. Consumers may still regard new automobile models as expensive. The list of items now offered as standard features in new cars, such as air conditioning, a stereo set, airbags, remote-control keys, power steering, power windows and adjustable mirrors, were offered only as expensive options in older models. Clearly, the quality of newer models is much higher than that of older models. The same is true for the Japanese housing industry where quality-oriented production contributes to deliver high cost-performance houses (e.g. renewable energy technologies), active markets and market values.

Value assurance helps reduce buyer risk via ‘follow-up’ services and warranties. In order to assure homebuyers of product quality, post-purchasing services are of high importance in reducing perceived risks during home buying decision-making. Most manufacturers provide a ten-year warranty and reassure their clients with free post-purchase services based on the warranty. They also keep in contact with their clients post sales to offer periodic product inspections with information update on maintenance and renovation. Such long-term post-purchase services assure potential homebuyers of product quality throughout the product life cycle. It helps anchor and elevate the customer’s trust on company product reputation. The 2007 market survey of Japanese prefabricated housing, which was conducted by Japan Prefabricated Construction and Suppliers and Manufacturers Association (2008), indicates that 2% of the homebuyers who preferred to purchase a prefabricated home, considered the selling price as reasonable despite the fact that the initial cost is 8% more expensive than that of conventionally built housing. Homebuyers may be well convinced of both the superior quality and the economic value of net zero-energy-cost homes.

THE CASE FOR VALUING EE

Placing an economic value on the energy embodied in a building is difficult as there is a distant connection between the building owner/purchaser and the actual energy expended. In contrast, building users are typically provided with operational energy data as part of their energy bills. Home owners and users also have much less control over embodied energy demand once a house is built as opportunities for intervention such as renovation occur less frequently.

An increasing number of studies show that embodied energy can be just as, if not more, significant than the operational energy demand of housing. This is even more pronounced for low-energy buildings where the focus tends to be on lowering operational energy demand. This becomes all the more relevant for houses that are self-sufficient or autonomous by being off-grid as such buildings require larger-than-usual energy generation and storage systems and this further exacerbates the embodied energy debt (Dave 2014). However, providing an economic value for the embodied energy aspect of low-energy housing may still be possible. It is critical that this occurs on a life cycle basis, just as operational efficiency upgrades are typically considered. A low initial embodied energy house may result in a low upfront capital cost for the user/owner, but will often result in a high demand for recurrent embodied energy and on-going costs through the more frequent replacement of materials throughout the life of the house. In this sense, durability of materials is critical. Higher embodied energy materials that will last longer and minimise the frequency of material replacement will be more highly valued. As the on-going energy cost of housing from an embodied energy perspective is its recurrent embodied energy, this is the component that will be of most interest to a user/owner in placing a value on a ‘low embodied energy house’. Assessing the economic value of recurrent embodied energy should be based on the service life remaining for the main materials and components as well as the embodied energy that is required to produce the replacement materials.

As for the value placed by owners and users on the potential cost savings of operationally energy efficient housing, the embodied energy invested in more durable, longer-lasting materials must ideally result in an equal or greater reduction in on-going recurrent embodied energy demands compared to business-as-usual. This embodied energy saving can easily be translated to economic value, as a reduction in recurrent embodied energy resulting from a reduced demand for materials should lead to lower replacement costs for the house owner. Just as is the case for a low operational energy house, a low 'life cycle' embodied energy house has the potential to be highly valued in an economic sense, especially as energy and thus material replacement costs (which are intrinsically linked) rise over time. Determination of life cycle embodied energy demands for a house provides information that can then be used to inform a homeowner or potential home purchaser of expected future costs.

There is an expectation that any additional materials and systems invested in a building to reduce operational energy demand will result in a net life cycle energy and cost saving. While it is beyond the scope of the current study, the typical embodied energy increase associated with these energy efficiency-related upgrades is usually not included in this analysis, resulting in what is usually an overestimation of the net energy benefit of these efficiency improvements. Consideration of the value of a low embodied energy house must therefore also be made in the context of its operational energy demand. A house with a low embodied energy, even over its life cycle, may result in a higher demand for operational energy, especially if less insulation materials, lower performance windows or less thermally efficient envelope materials are used.

VALUE AND MARKETS FOR RESIDENTIAL OPE AND EE

Valuation of green buildings has attracted major attention over the past decade, however is plagued by a multitude of issues in both process and practice (Warren-Myers 2012, Warren-Myers 2013). The focus has been on the investment value and private benefit or the OPE analysis and modelling. The consideration of OPE analysis in actual market valuation is limited to broader overview of operational expenditure that affects the net income of the commercial property. Time-discounting price model used primarily in real estate valuations and hedonic price model used to ascertain economic value analysis are utilised to analyse OPE scenarios. EE is rarely if ever explicitly defined in the valuation process, reflected by a lack of explicit treatment of EE in production function and cost accounting of building, as well as formal building regulations concerning EE assessment in Australia. (See www.nather.gov.au)

Pan and Ning (2015) pointed out that human behaviour is poorly understood in building energy, design and construction research. Behaviour assumptions of time discounting include, firstly, given stable preference/taste, people tend to demonstrate time-varying value (discounting) choice, e.g., heavily discounting more recent or immediately relevant events, measured by inter-temporal variation of time discounting behaviour or inter-temporal discount rates. Behavioural economics implies that people allocate lower value to less certain or more distant future or less immediate needs. Climate change or embodied energy belongs to this category of very long-term discounting. But it seems to be in conflict with the empirical evidence of lower-rate discounting for long-term cash flow observed in the case of leasehold vs. freehold housing markets, e.g., Giglio *et al.* (2014) and Wong *et al.* (2008). Cochrane (2011) explains time-varying valuation through a rational choice perspective. Secondly, given asymmetrical information and capability to learn, people tend to establish time varying valuing (discounting) choices, which suggests time-varying preference through knowledge accumulation or change of perception/belief. This implies the possibility of counteracting the time-preference discounting behaviour by learning. Education, environmental awareness programs and growth of wealth e.g. the Environmental Kuznets Curve would vary time-discounting behaviour under rational choice theory.

This is consistent with the long-term discounting behaviour, which is against the Keynesian long run decision assumption. However from an individual decision-making perspective, certain long-term matters are irreversible. Time, in the human context, heads one direction only. OPE, although human (owner) benefit oriented, can be influenced by social value-driven saving behaviour. EE, due to measurement difficulty, demands higher social value-driven motives.

CONCLUSIONS

This paper concerns the economic value of energy performance of houses. Humans adding value to the ecological system remains a much-debated topic, requiring critical discussion. This paper compares building embodied energy and operation energy by relating their relevance to the concept of market value. Either lower EE or lower OPE may be a 'positive' value creator. They, however, have different 'market derived values'. Being less costly to measure, OPE is typically valued more highly by markets than embodied energy. Does the view above provide anything potentially different from the all-in-one low-energy approach to the cost-value relationship? One could look at either EE or OPE separately, or both together in a more holistic sense. This research as well as that by Crawford (2011b) argues for a 'life cycle' approach to these types of considerations when attempting to reduce energy demand (also consider capacity to supply, or, scarcity) in houses, so it makes sense to take similar approach when valuing the energy performance of a building.

The discussion covers several aspects of valuing EE for the consumer: (1) the purchase and construction implications of using higher EE materials, especially if there is a price on carbon. This would be a solid reason for people to purchase/build a low EE building; (2) valuing the life cycle EE implications would be important to future-proof the investment. This is where the life cycle approach becomes important. A building with a low EE to build is no good if it requires substantial investment of materials/EE over its life (much akin to high on-going maintenance costs). This is similar to purchasers/occupants being more inclined to lease/buy a property with low on-going operational energy demands as it will cost them less in the long run, if they are aware of these benefits and these align with their own values, behaviour and attitudes. However, the preference for low ongoing energy and/or low embodied energy is going to be balanced with a range of other criteria (e.g. size, comfort, layout, location) in the process of purchasing a house.

The discussions on OPE and EE over the building life cycle show distinctive potential in built-environment research. It helps inform the question how to define and measure the "plus" of a future energy plus house. It may also help pave the way for measuring economic value of low- and zero-energy buildings. The study may be connected to such areas as collective buildings or 'net-positive approach' to energy efficiency (e.g. Hamilton *et al.* 2010 and Cole and Fedoruk 2015).

References

Aelenei, L., Aelenei, D., Gonçalves, H., Lollini, R., Musall, E., Scognamiglio, A., Cubi, E, and Noguchi, M. (2013) Design Issues for Net Zero-energy Buildings, Open House International, 38(3), pp.7-14

Ball, Michael (2003) is there an office replacement cycle? Journal of Property Research, 20(2), pp.173-189

Cochrane, J H (2011) discount rates, the Journal of Finance, 66(4), pp.1047-1108

Cole, J Raymond (2015) net-zero and net-positive design: a question of value, Building Research & Information, 43(1), pp.1-6

Cole, R J and Fedoruk, L (2015) shifting from net-zero to net-positive buildings, Building Research and Information, 43(1), pp.111-120

Crawford, R H (2011) towards a comprehensive approach to zero-emissions housing, Architectural Science Review, 54(4), pp.277-284

Crawford, R H (2011) Life Cycle Assessment in the Built Environment, Taylor and Francis

Dave, M. (2014) Chasing ZED – Once the holy grail, but are ‘zero carbon’ homes enough? In: Clarke, D. (ed.) How to Rethink Building Materials: Creating ecological housing for the designer, builder and homeowner. Australia: CL Creations, pp.80-81

DEWHA (2008) energy efficiency rating and house price in ACT, Department of the Environment, Water, Heritage and the Arts, Australian Government

Georges, L., Haase, M., Wiberg, A., Kristjansdottir, T and Risholt, B (2015) life cycle emissions analysis of two nZEB concepts, Building Research and Information, 43(1), pp.82-93

Giglio, S., Maggiori, M and Stroebel, J (2014) very long run discount rates, NBER Working Paper Series, w20133, pp.1-29

Hamilton, G., Summerfield, J., Steadman, P., Stone, A., & Davies, M (2010) Exploring energy integration between new and existing developments, Building Research and Information, 38(6), pp.593–609

Japan Prefabricated Construction and Suppliers and Manufacturers Association, 2008, Prefab Club, <http://www.purekyo.or.jp/3-1.html> retrieved on 13/03/2008

Lutzkendorf, T., Follente, G., Balouktsi, M and Wiberg, A (2015) net-zero buildings: incorporating embodied impacts, Building Research and Information, 43(1), pp.62-81

Mang, Pamela and Reed, Bill (2015) the nature of positive, Building Research & Information, 43(1), pp.7-10

Noguchi, M. (2008) Editorial: The Quest for Zero Carbon Housing Solutions, Open House International, Vol. 33 (3), pp. 88-95

Noguchi, M. (2011) Enhancement of Industry Initiative through the Zero-energy Mass Custom Home Mission to Japan experience towards commercialisation, International Journal of Mass Customisation and Personalisation, 4(1/2), pp.106-121

Noguchi, M. (2013) Commercialization Principles for the Low-Carbon Mass Customized Housing Delivery in Japan, In: Piller, F. T. et al., Mass-Customisation & Personalisation in Architecture and Construction, London: Routledge Architecture, pp.164-173

Noguchi, M., Collins, D. (2008) Commercialisation Strategies for Net Zero-energy-cost Housing in Japan, Open House International, 33(3), pp. 96-104

Pan, W and Ning, Yan (2015) a socio-technical framework of zero-carbon building policies, Building Research and Information, 43(1), pp.94-110

Treloar, G., Love, P and Holt, G (2001) using national input-output data for embodied energy analysis of individual residential buildings, Construction Management and Economics, 19(1), pp.49-61

Sekisui Chemical Co., Ltd. (2004a) 2x6 Grand to You; Technology Catalog, Sekisui Chemical, Co, Tokyo

Sekisui Chemical Co., Ltd. (2004b) Annual Report 2004, Sekisui Chemical, Tokyo

Warren-Myers, G (2012) the value of sustainability in real estate: a review from a valuation perspective, Journal of Property Investment & Finance, 30(2), pp.115–144

Warren-Myers, G (2013) is the valuer the barrier to identifying the value of sustainability? Journal of Property Investment & Finance, 31(4), pp.345-359

Whipple, T (2006) Property Valuation and Analysis, 2nd edition, LawBook Co, Sydney

Wong, SK., Chau, KW., Yiu, CY and Yu, MKW (2008) intergenerational discounting: a case from Hong Kong, Habitat International, 32(2), pp.283-292