ENHANCING SUSTAINABILITY PRACTICE THROUGH ICT-ENABLED INNOVATION KNOWLEDGE MANAGEMENT

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Currently, in Malaysia sustainability issues are still very much underlined by the scope required under Environmental Impact Assessment (EIA) approvals and the Environmental Management Systems (EMS) requirements based on the demands of the Department of Environment (DOE). Additionally, the MS 1525:2007 on the practice of energy efficiency and use of non-renewable energy for new construction projects as well as the acquisition of green rated designed buildings are not mandatory. The focus of such requirements are seen as being minimalist, and can only serve to ensure limited negative effects on the immediate project environment. Taking the case of Malaysia as a developing country, the level of awareness regarding the impacts of unsustainable practices in the construction sector is noticeably significant, however the efforts towards sustainability attainment is rather low. Taking the view that developing countries have a greater possibility to shift towards the implementation of a *new development model* based on higher innovation capability, this paper outlines a sustainability capacity model to be implemented for new residential developments based on a proposed Innovation Knowledge Management Methodology (IKM^2). A key feature of this initiative is the open-source characteristic component. The argument towards this principle is based on neo-Schumpeterian economics, and the notion that innovation is a key enabler for sustainability attainment. Here, innovation competition is seen to take the place of price competition as the coordinating mechanism of interest.

Keywords: sustainability, knowledge management, innovation, sustainability indicators, neo-Schumpeterian economics.

1. INTRODUCTION

Sustainability in the Construction Industry

Due to the wide variety of issues related to delivering sustainable construction, in 1994 Charles J. Kibert, founder of CIB Task Group 16 for Sustainable Construction, noted that “a *major challenge* for the [construction industry] is establishing the principles of sustainable construction and creating a common vocabulary that can be used to exchange information, define methods, create appropriate materials, transition technology, and accomplish other related activities”. He defined sustainable construction as the creation and responsible management of a healthy built environment based on resource efficient and ecological principles. There are many definitions of sustainable development (Shelbourn et al., 2006). The term ‘sustainable development’ is considered to be an “essentially contested concept” (ECC). ECCs cannot be managed in the deterministic sense that “management” implies, and hence ‘sustainability’ is viewed as a more general concept than is implied in its use as an adjective within the existing extant literature on sustainable development (see Ehrenfeld, 2008). Sustainable development is a continuing process, it cannot by definition, be ever achieved. An example of the adjectival use

of the term is described by Gibberd (2005) as a "state in which humankind is living with within the carrying capacity of the earth" (p. 300). According to Ehrenfeld (2008), "virtually everything that has been done in the name of sustainability is rather an attempt to reduce unsustainability".

According to Wetherill et. al., (2007), "there are still barriers preventing sustainable construction from gaining ground in mainstream building processes". They attribute this to the following:

- Sustainability knowledge in construction is fragmented, diverse, embedded in various documents, and developed in a non concerted and integrated way across geographical boundaries.
- Lack of sharing, exploitation, and reuse of isolated sustainable practices and principles acquired through practice across the industry.
- Lack of education and awareness across key construction stakeholders and building end-users.
- Lack of access to value-added sustainability information.
- Unclear links between sustainability principles and current construction regulations and standards.

The construction industry is concerned with the design, planning, production, alteration, maintenance, and demolition of the built environment. It is noted by Wetherill et. al., (2007) that in the contemporary world this industry is facing pressure to increase the sustainability of its practice. This pressure is understood to imply significant changes in the industry's understanding of the demands of society and of its clients, as well as its own sense of corporate social responsibility. Hence, it is an unavoidable fact that major changes are required in its work practices. According to Kibert (1999), the aims of such a sustainable practice in construction can be summarized through the following principles: (i) minimization of resource consumption; (ii) maximization of resource reuse; (iii) use of renewable and recyclable resources; (iv) protection of the natural environment; (v) creation of a healthy and nontoxic environment; and (vi) pursuit of quality in creating the built environment.

Aligning to the Global Sustainability Agenda

The biophysical considerations in the built environment have not been clearly articulated beyond the impact on environmental health and the construction industry does not pay adequate attention to its broader environmental impact. Besides, the lack of appropriate legislation/incentives and capacity for implementation has led to a construction industry with very little regard for environmental considerations. Whilst, it is noted that in both cases of developing and developed countries, there is a need to completely reinvent our built environments; however, this is seen to be hampered by there being no clear understanding yet of the tremendous innovation in building materials, service systems and construction processes that will be required.

It is articulated in the document on Agenda 21 for Sustainable Construction in Developing Countries that in a way, that there is a need for shifting to a *new development model* (Cib, 2001). It is noted in the document that the shift to a new development model would be easier for the developing countries as it is recognized that fundamentally developing countries have not become overly accustomed to the highly unsustainable principles such as overreliance on non-renewable resources

and that they have a strong affinity for traditional innovative practices in relation to sustainable practices. As the state of developmental progress is still at a relatively lower level, it is noted by du Plessis (2007), that it would be easiest for the developing countries to seek out a new developmental model. According to Du Pleissis (2007) the sustainability attainment in developing countries is seen as more challenging due to the following systemic problems:

i. Rapid rates of urbanization;
ii. Deep poverty;
iii. Social inequity;
iv. Low skill levels;
v. Institutional incapacity;
vi. Weak governance;
vii. Uncertain economic environment; and
viii. Relatively higher levels of environmental degradation.

Taking the view that Malaysia is a developing country and that some peculiarities do impinge on the actual practice for sustainability as is proposed under Agenda 21, the focus is on viewing the issue of sustainability for the construction industry as a form of *challenge* requiring a knowledge management oriented approach on a global scale, involving the bringing down of not only barriers but also boundaries. The rationale for such an approach is that innovation is key in driving the agenda for sustainability.

It is noted by Du Plesis (2002) that the differences between the developed and developing nations sustainability agenda lie in the scope of the Agenda and the context within which its recommendations have to be applied. This paper argues for a concerted effort towards developing knowledge management infrastructure that can be designed for an improvement-based concept for sustainability. A key argument for forwarding the innovation capacity building model, known as the Innovation Knowledge Management Model (IKM^2), is that the current landscape on sustainability transition is being hampered by current solutions that are being secured by the existing dominant socio-technical landscape comprising Local authorities and other governmental agencies in developing countries. These are seen as not viable mechanisms for innovations, as they are far from practising KM oriented approaches to sustainability as an alternative to their primary aim of being governing authorities for policy-driven initiatives. According to this paper, KM is a predominant characteristic for enabling a transformation to sustainability. The IKM^2 proposed is to be utilised for the development of new residential buildings, and this agenda can best be undertaken by individuals and private developers who are able to generate a symbiotic relationship to develop innovations for sustainable development.

2. KNOWLEDGE MANAGEMENT AND INNOVATION PRIORITIZATION IN CONSTRUCTION INDUSTRY SUSTAINABILITY PRACTICE

Wetherill et. al., (2007), draw on the work of McGee and Prusak (1993); Laudon and Laudon (1998); Rezgui (2001); Asprey (2004);and Sor (2004) in arriving at the conclusion that “despite the recognition of its value, the practice of knowledge management in the construction sector is still considered to be immature and underutilized” (p. 79). They argue that although the construction industry strives to innovate and utilize best practice, methods and materials, its sustainability goals can

only be realized if its activities are informed by new resources of knowledge and expertise. This is very much influenced by the recognition that "whilst this new resources of knowledge and expertise are available in the traditional codified form, most of it continues to be in the form of less easily codified expertise, lessons learnt etc. that often exists within the confines of particular projects, organizations or professions. Hence, following Laudon and Laudon (1998) and Sor (2004), they emphasize that this knowledge has to be created, captured and disseminated both within and across contextual and situational boundaries. Hence, in order to be of the greatest benefit, a *knowledge management environment* must take account of codified "hard" information and knowledge, but it must also support, foster, and promote the social processes and interactions in which knowledge is inherent.

Khalfan et. al., (2003) note that despite the interest and the effort put into knowledge management by many leading companies, the discipline is still in its infancy. Davenport and Prusak (2000, p. 173) argue that KM is substantially a human interaction exercise with information and communication technologies (ICT) as providing a supportive and facilitative role and suggest the ratio of one-third technology two-thirds people-related issues as being a useful guideline. Following the argument of Maqsood et. al., (2007), it is important to note that KM allows organisations to devise mechanisms that could bring them closer to knowledge communities generating new knowledge and producing innovations. This interaction can allow a flow of knowledge between internal and external knowledge communities so that instead of an organization responding reactively to knowledge-push it can pull that knowledge into itself, adapt it and effectively use it. However, as noted by them whilst KM research has significantly grown since its inception in the 1990s, researchers and the academic community struggle to explicate a realistic KM philosophy that can be readily put into practice and successfully implemented. From a practice perspective, it is evident that KM has moved from being technology dependent in the mid 1990s to a greater emphasis on socialisation in the late 1990s and early 2000s. Culture, leadership, and vision issues are becoming more important to KM philosophical underpinnings.

Khaflan et. al., (2003), note that in order to attain the goals of sustainable construction, the industry needs to intensify its efforts to move to a knowledge intensive mode, reiterating the call for construction activities to be informed by new resources of knowledge and expertise, mostly located within situated and contextual appreciations of sustainability goals and local practices developed across organisational and professional boundaries. Hence, they proposed that the industry focus on and achieve new modes of knowledge management, including embedded knowledge creation; hence, forwarding the notion for construction industry knowledge creation within a sustainability context.

The emphasis of this paper is to introduce the conceptual model for advancing innovation and knowledge management at the meso-level, working on a transitions approach to understanding the challenges brought upon the industry for achieving sustainability practice. It is important to recognize the current dominance of Neoclassical Economic Theory that has its focus on micro and macro economics. Hence, within the meso-lelvel, the ability to work based on the principle of Neo-Schumpeterian Economics that can allow for innovation and knowledge management to be situated within a Sustainability Attainment phase within the micro-level but structured at the Meso-level is then possible. Macro level innovation theory focuses on organizational adopters, whilst micro innovation level theory

focuses on the individual adoption and meso innovation is classified in between these previous two. Meso innovation focuses on an organization as consisting of series of individual adoptions (see Iivari, 1993). The focus on innovation is with respect to knowledge generation and diffusion.

According to Horning (cited in Mogavero and Shane, 1982), "*innovation is the process by which new knowledge is generated and applied to the material and intellectual operations of society. Thus, innovation is more than discovery and theorizing, more than speculation or invention, and more than engineering design. For until new know-how is incorporated into what is done, innovation has not occurred*" (p. 10). The basis for using neo-Schumpeterian Economics emphasizes on observing and controlling inflationary tendencies and focusing on long-term orientation that makes it possible for entrepreneurial business formation with regards to the concept of IKM and the technical, physical and material aspects of the construction industry. This is notwithstanding current major barriers for uptake of sustainable practice in the form of increased upfront project cost, increased technical and material specification considerations etc. Neo-Schumpeterian Economics has now moved on from the notion of a representative agent to that of a heterogeneous agent (see Hanusch and Pyka, 2006) and this fits with the notion of fringe actors within developing niches, as is perceived in the case of sustainability considerations. As the sustainability agenda within the construction industry is seen as a developing niche supported by fringe actors from multi-disciplinary disciplines.

This paper focuses on using Haxeltine et. al.'s (2008), conceptual framework for transition modelling in order to develop a 'use-inspired' basic model for KM for enhancing sustainability practice. The approach is centred on socio-technical transitions that highlights the technical, physical and material backdrop that sustains society within processes and patterns of competition among established and novel solutions. This paper, proposes the concept of innovation knowledge management for enhancing sustainability practice based on sustainability being an 'essentially contested concept' (ECC), and noting the contrasting processes and patterns of competition among established and novel solutions existing within the construction industry, that is in the transition phase of sustainable construction practice. Here, the notion of solutions, is deemed as being viable alternatives notwithstanding their sustainability attainment levels. The sustainability transition, as state, is conceptualized as arising out of a dynamic interplay between a dominant regime and a set of competing niches that exist within a background socio-technical 'landscape' (see Haxeltine et. al., 2008). Regimes and niches are conceptualized as interacting sub-systems, and a socio-technical transition is defined as a fundamental change in the socio-technical regime, that involves radical shift in a system's dominant structure, actors and practices. Here, KM is seen as a mechanism for sustainability attainment. KM is seen as being part of the societal process (enabled by ICT) and being triggered by internal dynamics of the Sustainable Construction Agenda. Hence, the KM mechanism is able to transform a Niche (N) to an empowered niche (EN) and then into a New Regime (NR) (which is still within a dynamic state, and is also reversible).

Hence, from an innovations perspective, the current innovations within the transition state of sustainability within the construction industry are best understood as niche-innovations, carried out and developed by small networks of dedicated actors often as fringe actors within the mainstream practice. Hence, this paper proposes an Innovation Knowledge Management Methodology (IKM^2) that focuses on categorizing knowledge according to the development of a New Regime (NR). A

'regime' is understood as a constellation of key practices, rules and shared assumptions, actors and structures associated with the dominant set of practices. As such, the methodology proposed is for the setting up of a Knowledge Management System (KMS), a class of information systems for managing organizational knowledge developed to support and enhance the organizational processes of knowledge creation, sharing, transfer and retrieval in relation to developing NRs related to sustainability (see Figure 1). It is proposed that this KMS be structured and maintained by current set of 'fringe actors' as an open-source platform. In fact, it is observed from current developments within the sustainable construction agenda in Malaysia that this is the current scenario with regards to the existing Green Building Index Sdn. Bhd.'s initiative, which is a private initiative supported by the government. However, within the developing countries context, a notable difference is that there is the lack of a multi-disciplinary composition amongst the niche fringe actors; as well as the pursuit and development of technical and material knowledge that is lacking in strong fundamentals for developing innovation knowledge related to sustainability. Hence, it is proposed that that these two key issues can be rectified by implementing the Innovation Knowledge Management Model structured and maintained by the fringe actors themselves, aimed at developing a new Regime.

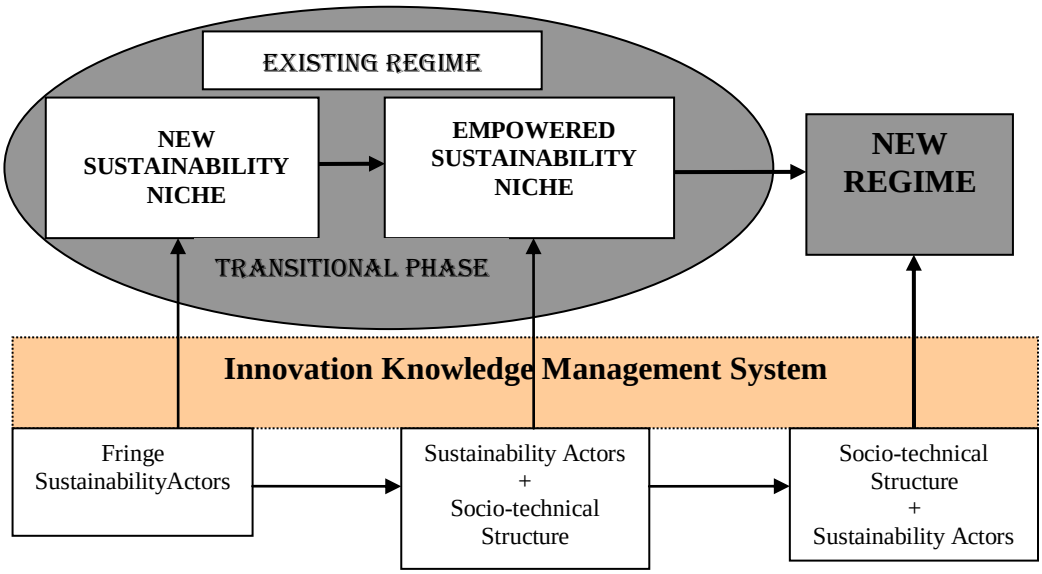

Figure 1: The IKMS Framework for Sustainability Attainment

It has been previously proposed by researchers from the sustainability science community that 'sustainability' or 'sustainable development' is an 'essentially contested concept' (ECC). Additionally, based on qualitative research findings of the C-SanD research team members (Khalfan et. al., 2003) , there was a consensus regarding the necessity to have sustainability 'built-in' onto a project and not 'bolted-on' in terms of the 'degree' of emphasis for sustainability attainment. It is argued by Kemp and Martens (2007) that sustainable development requires learning that feeds into decision making. Noting that learning on many fronts is needed; such as learning how to make products more ecofriendly, about new socio-technical systems for the delivery of goods and services, new business models based on sustainability and about how existing systems of governance can be made more reflexive, and various ways for meeting our 'real' needs in more sustainable ways. It is proposed

that one approach that encourages reflexive governance is transition management. The notion of transition management has been developed within the field of sustainability science, which initially focused on seeking to understand the fundamental character of interactions between nature and society (Kates et. al., 2001).

However, following Clark (2007), the work outlined in this paper concurs with current practice, noting that sustainability science has reached out with focused problem-solving efforts targeted to urgent human needs. In this sense, sustainability science is usefully thought of as neither "basic" nor "applied" research, but considered to be an enterprise centred on the "use-inspired basic research" contributing to and learning from the world of applied problem-solving across a range of disciplines. Fundamentally, a transition can be conceptualized as arising out of a dynamic interplay between a dominant (or 'incumbent') regime and a set of competing niches (Haxeltine et. al., 2008). According to Martens (2006), sustainability science is an integrative science, a science that sets out to break down the barriers that divide the traditional sciences. This new type of science is seen as being able to deal with complexity, uncertainty, and legitimate multiple viewpoints. Hence, allowing for mutual learning, integrated assessment, and conflict resolution. In terms of science, it demands what Gibbons et. al. (1994) refer to as mode-2 science that is interdisciplinary and transdisciplinary and promotes a context in which knowledge is coproduced and provisional.

Neo-Schumpeterian Economics emphasises on knowledge, innovation and entrepreneurship at the micro level of economic analysis within socio-economic systems. Notably, innovation characterised by novelties, is the core principle underlying the Neo-Schumpeterian approach. Hence, innovation competition rather than price competition is the key coordinating mechanism of interest. Additionally, uncertainty is considered as an important ingredient alongside the principle of innovation that is viewed within a broad sense, encompassing technological, organisational, institutional and social innovation, has the potential of removing and overcoming the constraints limiting the scope of economic development as has traditionally been the case. Following Hanusch and Pyka (2007) this paper argues for a greater focus on the meso level of the economic system, which is considered to be critical for the development of the decisive structural and qualitative changes within the economic system. Currently, sustainability concerns within the current transition phase are obscured within the mainstream micro and macro economic realm of understanding.

3. SUSTAINABILITY SCIENCE AS THE EPISTEMOLOGICAL BASIS FOR INNOVATION AND KNOWLEDGE MANAGEMENT

This paper takes on the recommendation of Kates and Parris (2003), as being part of the sustainable transition effort, and hence being constitutive of the body of work that is aimed at accelerating the trends that favour a transition towards 'sustainable development' and slow the trends that impede them. The author takes into serious consideration the main outcome of the policy forum on Environment and Development (Kates et. al., 2001), which identified a new emerging field of sustainability science that seeks to understand the fundamental character of interactions between nature and society.

According to Martens (2006), sustainability science is an integrative science, a science that sets out to break down the barriers that divide the traditional sciences. This new type of science is seen as being able to deal with complexity, uncertainty, and legitimate multiple viewpoints. Hence, allowing for mutual learning, integrated assessment, and conflict resolution. In terms of science, it demands what Gibbons et al. (1994) refer to as mode-2 science that is interdisciplinary and transdisciplinary and promotes a context in which knowledge is coproduced and provisional. This form of practice differs from normal academic science which is monodisciplinary and based on peer review by the scientists themselves. In mode-2 science, the scientists interact with practitioners, policymakers, and citizens to produce knowledge for action (Table 1), and no single set of knowledge or view-point is privileged (Wiek et. al. 2005). Hence, sustainability science provides the epistemological basis for understanding the role of fringe actors, consisting of a multi-disciplinary composition producing knowledge that is trans- and interdisciplinary. Hence, the niche is then enhanced to an empowered niche and then possibly become the new regime, i.e. 'dominant practices, rules and shared assumptions'.

Table 1 Properties of mode-1 and mode-2 science (after Kemp and Martens, 2007)

Mode-1 science	**Mode-2 science**
Academic	Academic and social
Monodisciplinary	Trans- and interdisciplinary
Technocratic	Participative
Certain	Uncertain
Predictive	Exploratory

4. CHALLENGE FACING DEVELOPING COUNTRIES

Weinstein (2010) notes that by 2050' approximately 60% of the world's population will be living in urban settings. The Johannesburg Plan of Implementation (WSSD, 2002) arising out of the UN World Summit on Sustainable Development has been instrumental in focusing attention to not just the Green Agenda but also that of the Brown Agenda. The Green Agenda as is now well understood is the response to the impact of ecologically detrimental development whilst the Brown Agenda focuses on the problems of poverty and underdevelopment. The differences between the Green and Brown Agendas are outlined in Table 2. It is noted by Du Plessis (2007) that sustainable development requires both the Green and Brown Agendas. Additionally, she notes that due to the rapid rate of urbanization and infrastructure development currently taking place in developing countries, there is a need for urgency in introducing sustainable construction practices and avoid the problems experienced in developed countries.

Table 2: Difference between the Brown and Green Agendas

	Brown	Green
Key Concern	Human well-being	Eco-systemic well being
Timeframe	Immediate	Delayed
Scale	Local	Think global, act local
Concerned about	Low-income groups	Future generations
View of nature	Manipulate and use	Protect and work with
Environmental services	Provide more	Use less

Source: McGranahan and Satterthwaite (2000)

Currently, in Malaysia sustainability issues are still very much underlined by the scope required under Environmental Impact Assessment (EIA) approvals and the Environmental Management Systems (EMS) requirements based on the demands of the Department of Environment (DOE). Additionally, the MS 1525:2007 on the practice of energy efficiency and use of non-renewable energy for new construction projects as well as the acquisition of green rated designed buildings are not mandatory. The focus of such requirements are seen as being minimalist, and can only serve to ensure limited negative effects on the immediate project environment. It is noted by Zainul Abidin (2010), that many developers in Malaysia are aware of sustainable construction, but generally they are not willing to push the boundaries and take on the challenge of implementing the concepts favouring sustainable development. Hence, taking the case of Malaysia as a developing country, the level of awareness regarding the impacts of unsustainable practices in the construction sector is noticeably significant, however the efforts towards sustainability attainment is rather low.

Taking the view that developing countries have a greater possibility to shift towards the implementation of a *new development model* based on higher innovation capability, this paper outlines a sustainability capacity model to be implemented for new residential developments based on a proposed Innovation Knowledge Management Methodology (IKM^2). A key feature of this initiative is the open-source characteristic component. The argument towards this principle is based on neo-Schumpeterian economics, and the notion that innovation is a key enabler for sustainability attainment. The rationale for proposing innovation as being a viable approach for developing countries is linked to the notion of understanding sustainability from a transitions perspective, and not just based on the notion that developing countries are used to innovation as proposed in the Agenda 21 Report (Du Plessis, 2002). Additionally, this paper proposes the adaptation of the concept of innovation competition based on the principle of neo-Schumpeterian economics. Here, innovation competition is seen to take the place of price competition as the coordinating mechanism of interest.

It is evident that the developing world is not a homogenous entity, as there are many stark differences between the regions, and different countries within those regions experiencing different challenges whilst being at different stages of development. Hence, in order to seriously pursue the sustainability agenda in Africa, a special discussion was held at the SB04 Africa Conference (2004) to develop a Regional Action Plan for Sustainable Development within the African context. It is noted by Du Plessis (2005) that a need for a regularly maintained, easily accessible source of information (termed Knowledge Foundation) that can be used by practitioners, educators, and other interested parties such as clients, local government and funding agencies was found to be necessary. This suggested portal however was to provide inter alia:

. access to tools, guidelines and Best Practice examples relevant to Africa
. regional database of accredited 'green building' practitioners'
. information about funding opportunities and programmes
. news about training courses, events and new publications
. network of related information sources within other developing countries and countries with similar climatic conditions

Hence, this proposal for *a new development model* is focused on addressing the issues highlighted by Wetherill et al., (2007) and Du Plessis (2005) using knowledge management as a *mechanism* and sustainable construction agenda as the niche to be possibly realized as a new regime organized within the concept of a new

development model structured on an open-source platform underlined by the principle of 'innovation' at the meso level. Innovation, that has its basis on Neo-Schumpeterian economics that allows for curbing inflationary tendencies within the sustainable construction industry through purposeful intervention and promoting innovation competition with regards to sustainable development to be the key consideration in evaluating architectural bids and not just contractors' tenders.

5. DISCUSSION AND RECOMMENDATION: USE-DRIVEN APPROACH FOR SUSTAINABILITY ATTAINMENT IN HOUSE-BUILDING

In Malaysia, a house-building project (with individual land titles) is a multi-stage process, where developers acquire land, consultants or in-house professionals carry out design and cost management; and as often is the case, contractors execute the construction. Others involved in the housing development process are subcontractors, manufacturers and suppliers. However, developers and contractors are generally the main actors in house-building. The traditional work flow, for housing development is shown in Figure 1. However, it is recommended that the approach towards sustainable house-building can be achieved based on providing an innovative sustainable options approach, as shown in the Figure 2.

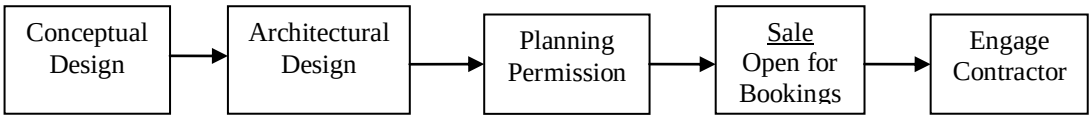

Figure 1: Conventional Upstream Building Stages

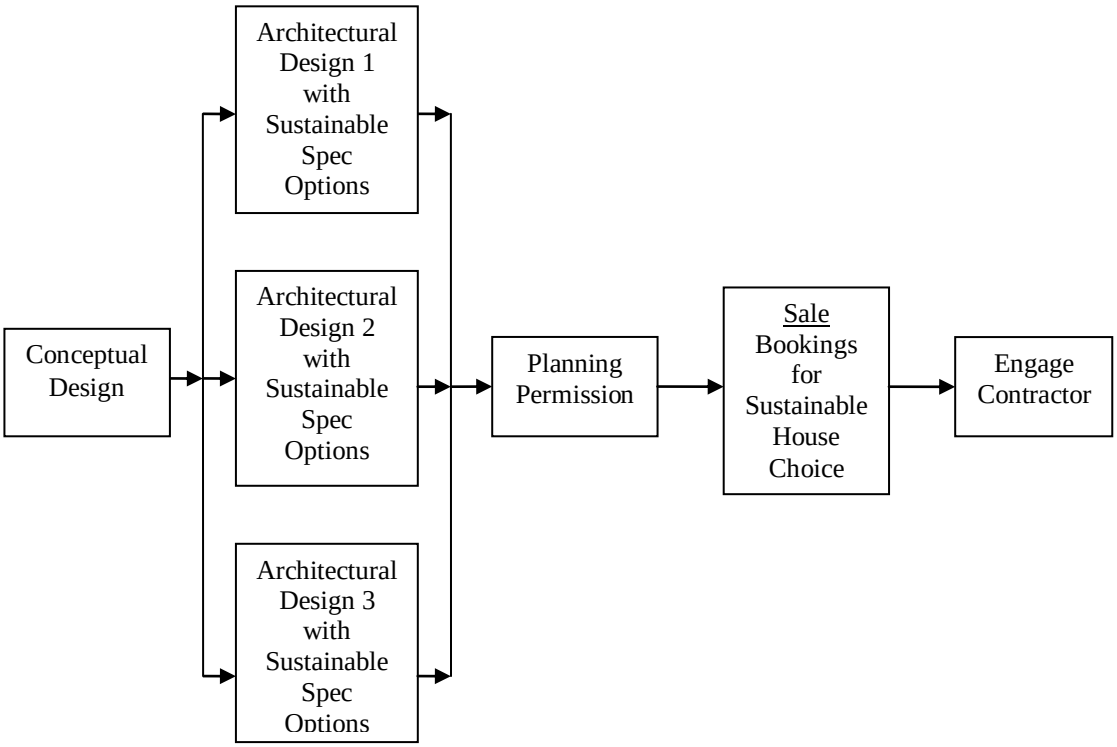

Figure 2: Upstream Building Stages for Sustainable Design and Construction

This recommendation for sustainable construction for house –building is to be based on the developers providing sustainable options based on knowledge procured through the IKMS that is developed as an open-source vehicle for generating and diffusing knowledge. Hence, the following enablers for this process are identified as:

I. Use the Sell-then-Build (STB) concept
II. Local authorities to provide initial planning approvals and final sustainability spec planning confirmation approval
III. Developers to provide architectural options that allow for the possible incorporation of individual sustainable housing-buildings supported by knowledge readily available on IKMS open source site

Current trends towards incorporating sustainability in a more pervasive manner is very much influenced by policy, and this often does not allow for innovation that is critical to the sustainability transition agenda; as well as such implementations often are driven by transaction cost theory based on neo-Classical Economics, and hence the notion of price competition dominates often allowing only for the achievement of minimum requirements.

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