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Towards Zero Energy Mass Customized Housing Delivery

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Editorial

Homes need to be socially, economically, and environmentally sustainable in response to societal pressure on our common future. The concept of 'Sustainable Development' was first advocated by the World Commission on Environment and Development, dated back to 1987, and it was considered as 'a process of change in which the exploitation of resources, the direction of investments, the orientation of technological development, and institutional change are all in harmony and enhance both current and future potential to meet needs and aspirations.' In 1992, this notion was given additional impetus at the United Nations Conference on Environment and Development (or the Earth Summit) held in Rio de Janeiro where an initial international treaty on environment was produced; however, this had neither limits on greenhouse gas emissions nor legal enforcement provisions for individual nations. In 1997, the text of the Kyoto Protocol to the United Nations Framework Convention on Climate Change was adopted eventually at the 3rd Conference of the Parties held in Kyoto, Japan. As of April 2008, 178 states signed and ratified the Protocol; in consequence, most industrialized nations and some central European countries agreed to legally binding the reductions of greenhouse gas emissions of an average of 6 to 8% below 1990 levels between the years 2008 and 2012.

In response to growing global warming issues and the constant increase of energy prices, house-builders and housing manufacturers today are becoming more responsive to the delivery of net zero energy and carbon dioxide (CO2) emission sustainable homes than ever. Within this context, the sustainability may embrace housing economy and adequacy beyond the legitimacy in which the quality barely coincides with individuals' dynamic various needs, desires and expectations. Nevertheless, the industry's business operation tends to follow routines and the close system mode of operation often hinders the enterprises from adopting unfamiliar innovations which may be inevitable in realizing the delivery and operation of socially, economically and environmentally sustainable homes. In theory, homebuilders and housing manufactures are sensitive to societal needs and demands. Yet, in reality, traditional builders generally tend to follow routines in their way of doing business and cut down information search for determining whether or not to adapt unfamiliar design challenges, and innovative building materials and systems. Nonetheless, to build zero carbon mass custom homes that aim to satisfy the wants and needs of individual consumers as well as society may require the use of innovations. Then, how can such conventional house-builders and housing manufacturers be adapted to new business operations required for the delivery of zero carbon mass custom homes, whose design, production and marketing approaches may not be akin to those to which they are accustomed?

'Mass customisation' is a paradoxical concept. The notion was anticipated in 1970 by Alvin Toffler in his book entitled 'Future Shock.' In 1987, the term was eventually coined by Stanley M. Davis in his book entitled 'Future Perfect.' Furthermore, in 1993, Joseph B. Pine II profoundly systematized the general methods of mass-customizing products and services in his book entitled 'Mass Customization.' In 2009, Frank T. Piller and Mitchell M. Tseng edited a 'Handbook of Research in Mass Customization and Personalization' and compiled the R&D activities and outputs delivered by a variety of industries across the globe. Nonetheless, the idea could date back to the 1950s as the gravity became explicit in Walter Gropius' book entitled 'Scope of Total Architecture.' The essence of mass customisation applied to housing was speculated as he emphasized the need for 'standardising and mass-producing not entire houses, but only their component parts which can then be assembled into various types of houses.' In fact, housing is a system of energy and environment, composed of a number of parts and components indeed. The choice of the housing design elements need to be made carefully with due consideration of the project's initial and operational cost, quality, and time. Moreover, the location factor cannot be less of a consideration as it encompasses geographical and topographical conditions and local regulations. Location and orientation of housing help secure the optimum use or prevention of sunlight and wind and this affects the building's operational energy consumption and generation which correlate with CO2 emissions and utility costs.

In fact, housing is a system of energy and environment, composed of a number of parts and components indeed. The choice of the housing design elements need to be made carefully with due consideration of the project's initial and operational cost, quality, and time. Moreover, the location factor cannot be less of a consideration as it encompasses geographical and topographical conditions and local regulations. Location and orientation of housing help secure the optimum use or prevention of sunlight and wind and this affects the building's operational energy consumption and generation which correlate with CO2 emissions and utility costs. The total number of possible ordered pairs (or combination) of given standard housing components can be quantified. In the approach, the mass customization (MC) has been systematised and visualised simply by making use of a conceptual analogue model as follows: MC= f (PS). In this model, the service sub-system (S) concerns communication platforms that lead the users to participate in customizing their design output while the product sub-system (P) covers production techniques that aim to encourage the standardization of housing components for mass production and dissemination. Standardisation of building components seems to be a limited hindrance to design customisation if communication platforms are well developed. Design-consulting staff and appropriate communication interface are required to facilitate user choice of standard design components. These fundamental design service factors can also be integrated into a comprehensive model: S=f (l, p, t). In this model, the service sub-system (S) is supported by the existence of the location (l), personnel (p) and tool (t) factors and they

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are necessarily interrelated. Basically, building components can be divided into three categories: volume, exterior and interior. These can be considered the main elements of the product sub-system (P) which can be explained by the following conceptual model: P=f (v, e, i, o). The volume (v) components are used to configure the building's internal space that determines the size and location of each room while the interior (i) and exterior (e) components serve to co-ordinate decorative and functional elements that customize a building. In addition, 'o' denotes other optional features such as building amenity and security systems, inclusive design components and renewable energy technologies. In general, fabric and ventilation heat losses are associated with building volume and envelop exposures while thermal transmittance links up with materials applied to exterior and interior components. Energy monitors may fall into the category of optional features.

Most of the net zero-utility-cost housing manufacturers typically in Japan have begun to install a number of renewable energy technologies as standard features rather than options based on their value-added, high cost-performance marketing strategy. The strategy itself is far from new having been applied to a variety of end user products around the globe. For instance, although today's automobiles can be produced with lower production costs than those in the past, their selling price does not seem to be affected dramatically by higher productivity. New cars are still generally regarded as expensive; nevertheless, the list of items now offered as standard 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 housing industry in Japan. Quality-oriented production contributes towards the delivery of high cost-performance housing in which high-tech modern conveniences that are installed as options in conventional homes are available as standard equipment (Se). In this context, the product subsystem (P) can further be modified into the following conceptual model: P=f (v, e, i, o)+Se. In fact, Japanese housing manufacturers mass-produce net zero-utility-cost customizable homes in which a variety of housing amenities and renewable energy technologies such as PV, air source heat pump, micro combined heat and power systems are installed as standard features rather than options. Despite the reduction of equipment choices, volumetric, exterior and interior design components still remain substantial options from which the users can choose so as to customize the end product.

In order to deliver a marketable and replicable net zero energy/emission mass custom homes or ZEMCH, the strategic balance between the optional and standard features seems to be critical. The optional features may be provided with the aim to enhance design quality (or customizability) that helps contribute to satisfying desires and expectations of individual stakeholders. The standard equipment, on the other hand, needs to be installed in buildings as it aims to exceed product quality whose levels can be adjusted in conjunction with societal demands and requirements.