Proceedings ISES 2005, Solar World Congress, Aug. 6-12, 2005, Orlando, USA.

JAPANESE MANUFACTURERS' 'COST-PERFORMANCE' MARKETING STRATEGY FOR THE DELIVERY OF SOLAR PHOTOVOLTAIC HOMES

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ABSTRACT

Japanese housing manufacturers claim that they have been producing higher-performance houses for *about* the same price as conventional ones. They give their factory-built or industrialized housing the higher levels of amenities that make their residential construction a living environment, whereby room temperature, air-cleanliness and soundproofing in the house are well controlled. Today, manufacturers compete to produce homes equipped with photovoltaic (PV) electric power generating systems. These manufacturers use *value-added production* as well as *mass custom design* approaches to produce 'mass custom homes' equipped with PV systems that correspond with the wants and needs of both individuals and society. Their design and production approaches reflect the manufacturers' 'cost-performance' marketing strategy, which can be considered the *essence* of their business success in producing *marketable* PV solar homes. Thus, this paper identifies the 'cost-performance' marketing strategy and suggests some opportunity for future research.

1. INTRODUCTION

Japanese housing manufacturers have been gaining a worldwide reputation for their unique design and production approaches to producing 'innovative' industrialized housing, which is often equipped with PV systems today. Their homes are produced based on their 'cost-performance' marketing strategy that helps them to address the wants and needs of individuals as well as society. In general, today's consumers are looking to purchase a 'customizable' house at an affordable price that adapts to the demographic changes of our society with regard to socio-economic profiles. In order to satisfy consumers' demand for reasonably priced, customizable housing, the manufacturers might be urged to apply a new *design* approach. On the other hand, as the global awareness of sustainable development, which was first advocated by the World Commission on Environment and Development (commonly known as the Brundtland Commission) in 1987, are elevated, today's society needs to encourage the production of sustainable housing. The use of industrialized building techniques that help to reduce the total amount of wastage at the construction stage, and the clean, renewable energy technologies (such as PV systems) that contribute towards reducing carbon dioxide (CO_2) emissions, when a house is occupied, can be considered to be effective in meeting such societal need for green homes. Some leading Japanese housing manufacturers developed their own high-tech, quality-oriented *production* approach that fully relies on computerized design and inventory control systems, assembly-line production, robotics, and research and development. Their prefabricated homes are no longer merely repetitive, mass-produced housing that the public came to associate industrialized houses with 'low quality' during the 1970s and 1980s; rather, their interior and exterior design compositions as well as the space arrangements are well customized by the end users themselves. Today, the manufacturers tend to produce 'customizable' prefabricated homes equipped with PV systems, which are reasonably priced, in response to both consumer and societal demands for new housing [1].

In 2004, total 1,160,083 houses were newly built in Japan. Among them, 159,224 houses were prefabricated [2]. These results indicate that 13.7 % or roughly one out of seven newly built houses can fall into prefabricated homes in Japan. Their prefabricated housing industry has been bolstered by the government support. In 1963, in order to improve the public image of prefabricated homes, Japanese Prefabricated Construction Suppliers and Manufacturers Association was established by the Ministry of Construction and the Ministry of International Trade and Industry. In 1976, the government proposed a nation-wide competition called "House 55" project to encourage manufacturers to

improve the quality of their industrialized housing and to demonstrate to the public that prefabricated homes need not be of low quality and could meet the consumer demand for quality homes [3]. Today, in response to the societal demand for sustainable housing, the government implements some promotional programs that aim to support the installations of PV electric power generating systems particularly in residential construction—e.g. the research program "New Sunshine Project" initiated in 1993 and the incentive program "Residential PV System Dissemination Program" (as well as its predecessor "Residential PV System Monitoring Program") [4]. According to the National Survey Report 2003, issued from the International Energy Agency (IEA) Photovoltaic Power Systems Programme, the subsidy per 1 kW in 2003 was estimated at 90,000 yen (US$ 871) in Japan [5]. In the same year, the companies manufactured over 60% or 400MW of global PV module production, 55% of which was destined for the local market [6]. The target market segment is the residential PV systems with 85 % of the share [7]. The number of houses equipped with PV systems has been on the rise in Japan; in fact, between 1994 and 2003, the residential PV installations drastically increased from 539 to 52,863 houses (Table 1) [5].

TABLE 1: NUMBER OF RESIDENTIAL PV INSTALLATIONS IN JAPAN: 1994-2003

YEAR	ANNUAL NUMBER OF HOUSES EQUIPPED WITH PV SYSTEMS	ANNUAL INSTALLED CAPACITY (MW)
1994	539	1.9
1995	1,065	3.9
1996	1,986	7.5
1997	5,654	19.5
1998	6,352	24.1
1999	15,879	57.7
2000	20,877	74.4
2001	25,151	91.0
2002	38,262	141.4
2003	52,863	201.4
TOTAL	168,628	622.8

Japanese housing manufacturers have benefited from the governmental PV deployment support. In fact, Sekisui Chemical Co., one of the largest PV housing manufacturers in Japan, reports that the production of energy-efficient houses contributes to the growth in sales and orders, and between 2002 and 2003, they increased the delivery of their PV solar homes from 32% of the total housing sales to 46% in response to the market demand for high-quality, sustainable housing [8]. Furthermore, the company, which already marketed over 30,000 solar homes equipped with PV systems, also reports that they began to install the solar electric system as *standard equipment*—rather than *options*. In general, Japanese housing manufacturers emphasize the distinguishing features of their high 'cost-performance' industrialized (or factory-built) housing, in which a variety of amenities (including the PV rooftop systems today) are installed as standard equipment, while they do not try to reduce the selling price. In other words, their quality-oriented production for the delivery of industrialized housing reflects their 'cost-performance' marketing strategy [9]. However, their marketing strategy itself is *not* clearly understood today. Thus, this paper aims to identify the manufacturers' 'cost-performance' marketing strategy that might make them successful in producing *marketable* prefabricated homes that are often equipped with PV systems.

2. 'COST-PERFORMANCE' MARKETING STRATEGY

According to a housing survey conducted in 1997 by the Government Housing Loan Corporation in Japan, the construction cost of a conventional home was estimated at 175,404 yen (US$1,698) per square meter [10]. A prefabricated home was at 190,033 yen (US$1,840) per square meter [11]. These results indicate that Japanese manufactured housing is about 8% more expensive than the conventional one. There is a tendency for the manufacturers to compete to improve the housing quality rather than reduce the selling price of their products.

The Japan Prefabricated Construction Suppliers and Manufacturers Association conducts an annual survey of consumer preferences in the purchase of factory-built homes [2]. Their survey carried out in 2003 shows that the perceived 'high quality' of prefabricated housing was the most significant factor attracting potential homebuyers. In fact, 23% of the homeowners surveyed preferred to purchase industrialized housing because of the higher levels of product quality regarding the durability, insulation performance, and air-tightness—this result somewhat suggests that today's homebuyers regard *housing sustainability* as important in the buying decision-making process. The second most significant factor was the 'reliability' of the large-scale company, which somewhat reflects the 'brand name' effect on the sales, as 15% of the purchasers replied to this survey. Ranking next to them, 9% of the homeowners responded that they preferred to purchase industrialized housing, whose selling price is 8% on average more expensive than conventional one, because they were convinced by the sales staff's explanation of their product and service. These results indicate that homebuyers tend to consider the *quality* of housing, which may affect both the amenity and the life cycle cost, to be the top priority, while the selling price is less of a consideration. In other words, today's consumers venture to purchase a reasonably priced *innovative* product, if convinced of the superior quality.

In fact, Japanese housing manufacturers produce quality products and offer extensive customer services, having succeeded in developing a good reputation for their products. The manufacturers attempt to educate their clients to appreciate the distinguishing features of their high-cost and high-performance (i.e. high 'cost-performance') housing, in which a variety of amenities including the PV systems are installed as *standard equipment* rather than *options*. The manufacturers emphasize that they have been producing better-quality homes for *about* the same price as conventional ones. In short, the housing manufacturers' quality-oriented production reflects their 'cost-performance' marketing strategy, which can be also seen in the automobile industry. 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, and new cars are still generally regarded as *expensive*. However, 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. In fact, Sekisui Chemical Co., which already marketed over 30,000 solar homes equipped with PV systems, began to install the renewable solar electric system as *standard equipment*. In their 2004 annual report, Sekisui Chemical Co. clearly explained that the production of energy-efficient houses contributes to the growth in sales and orders, and between 2002 and 2003, they increased the delivery of their PV solar homes from 32% of the total housing sales to 46% in response to the market demand for high-quality, sustainable housing.

Japanese housing manufacturers tend to use the money saved from lowering production costs through mass-production to equip homes with more standard housing components of high quality—this, in turn, upgrades the product quality and distinguishes their industrialized houses from conventionally built ones. In general, marketing strategies considerably influence product development processes. Thus, the following sections discuss Japanese housing manufacturers' *design* and *production* approaches that may reflect their 'cost-performance' marketing strategy.

2.1. Value-added Production

Japanese housing manufacturers often acquire ISO 9000 and 14000 accreditations that certify the quality control of their products, as well as the companies themselves. They set up higher standards than ordinary building regulations, maintaining uniform product quality by strict control over their products [12]. In particular, most Japanese manufacturers establish their own quality standards in order to improve structural resistance, durability, and amenities. In terms of the structural resistance, their quality standard is based on the Great Kanto earthquake that destroyed houses with horizontal force of approximately 9 tons. Basically, structural resistance is a matter of utmost concern in housing quality in Japan; for instance, on January 17, 1995, a gigantic earthquake with a magnitude of 7.2 battered Kobe, Japan's sixth largest city (1.6 million populations), destroying a number of houses, buildings, bridges, port facilities and other urban infrastructures [13]. The 20-second quack killed over 5,500 people, becoming the worst in Japan since the Great Kanto earthquake in 1923 when 142,807 people lost their lives. A house must protect not only the homeowners' lives but also their property. For instance, Misawa Homes Co., which obtained the 2004 Good Design Award issued by Japan Industrial Design Promotion Organization, produces modular homes that can resist 1,000 gal (28.7 tons) in horizontal force. As well, Sekisui Chemical Co., another large-scale modular housing manufacturer in Japan, recently introduced a new commodity, called "GRAND TO YOU," which uses 2 x 6 in. studs for the exterior wall framing, rather than 2 x 4 in. and the house is designed to resist even 1,600 gal of peak in horizontal force [14]. Most leading housing manufacturers reported that none of their houses built in Kobe were fatally destroyed by the 1995 Hanshin Great earthquake [15][16][17][18].

2.1.1. Housing Sustainability

Japanese housing manufacturers adapt resource-saving strategies. Toyota Motor Co., which also produces modular homes in Japan, advocates that the durability of housing should contain structural durability, design durability and flexibility that help adapt to the changes in homeowners' lifestyles, while Misawa Homes Co. attempts to produce homes that can be used by several generations over 100 years. Surprisingly, the lifespan of housing in Japan is regarded as shorter than in other advanced nations [19]. In 1993, there were in total 45,940,000 houses, and of this number, only 2,150,000 were pre-war houses. The legal lifespan of wood-frame housing is said to be 30 years in Japan; however, 10% of wood-frame housing statistically vanish within 18 years after the home is newly built and almost half of wood-frame houses are destroyed within 33 years. Japanese manufacturers have been aware of the short durability of their older housing stock, educating the public that newer factory-built homes are structurally, environmentally and economically durable—or *sustainable*.

Japanese housing manufacturers have been producing better products with higher levels of amenities that make the home not only just a mere shelter, but also a living environment, where room temperature, air-quality, and soundproofing are well controlled. Air-tightness is considered an effective measure to reduce operating costs for cooling and heating rooms, since it improves insulation. Indeed, most manufacturers have become increasingly aware of the benefits of energy efficiency. Misawa Homes Co., for instance, demonstrates that the high insulation properties of prefabricated homes is more cost-effective, producing homes whose air-leakage is 67% less than that of conventional homes [20]. As a result, the annual heating and cooling costs are reduced by 32%.

Ventilation is also necessary to achieve a healthy living environment. When the house lacks ventilation, uncomfortable indoor air conditions, caused by humidity, condensation, and the accumulation of gaseous toxic substances (i.e. volatile organic compounds) may cause illness. Toyota Motor Co. is one of the pioneers who developed artificial ventilation systems in housing, introducing the light cleaning ventilating fan [21]. This fan consists of ultraviolet catalytic filters that decompose gaseous toxic substances such as nitrogen oxides and formaldehyde. In addition, National House Industrial Co. developed an air-conditioner that senses CO_2 levels in the residential environment and cleans the air automatically [22].

Noise is another concern that may reduce the comfort levels in the home. Many housing manufacturers try to reduce the noise from outside of the home, as well as inside, by using soundproofing techniques to alleviate sound due to air vibrations and floor impacts. For instance, National House Industrial Co. designs steel-framed external walls that can reduce sound levels by 43%, and floors by 64%, using rubber-soundproofing devices that alleviate light- and heavy-weight impact sound [22].

2.1.2. PV Rooftop Systems

Under the Kyoto Protocol, Japan is assigned the target of reducing its emissions of CO_2 by 6% from the 1990 level between 2008 and 2012. Today, a growing number of PV systems is being installed in Japan for residential use, as described above, and helps to ease the environmental impact of producing energy for homes. PV systems rated at 3 kilowatts (kW) or less used to be common in the past, but the high-capacity systems at power levels of 5 kW are beginning to be used [23]. There is a tendency for the society to demand the production of energy-efficient homes from housing producers in response to the increasing global awareness of the depletion of the earth's natural resources. In addition to the improvement of product durability and housing amenities, Japanese housing manufacturers began to install renewable solar electric generating systems, producing PV solar homes in 1994 (Fig.1).

Fig. 1: Misawa Home Z
(Source: Misawa Homes Co., Ltd)

In fact, residential PV systems were installed to 168,628 houses in Japan, in which the cumulative installed capacity reached 622.8 MW at the end of 2003, as shown in Table 1. Today, the leading manufacturers create a new market for residential PV systems, developing all-electric houses equipped with PV systems. In their 2004 annual report, Sekisui Chemical Co. explained that the production of "zero utility expense" homes equipped with PV systems helped to increase their total housing sales and the orders grew 7% in comparison to those in the last fiscal year [24]. Also, the company indicates that they began to install PV systems (as well as a hot water unit with CO_2 heat pump) as standard equipment rather than options. In April 2004, Sekisui Chemical Co. launched a new zero utility expense home, called "Parfait AE," which further expand their zero utility expense specifications with features including "thermal barrier-free systems" applied for the foundation and floors and "passive ventilation heat-blocking system" for the high heat dissipation skylight and heat-blocking screen that controls the amount of sunlight [24]. Furthermore, in collaboration with Sumitomo Trust and Banking Co., Sekisui Chemical Co. jointly developed a new housing loan, which helps homebuyers to purchase a house equipped with high-capacity PV systems. The company explains that "the higher the power generating capacity of photovoltaic generator, the lower the loan's interest rate. Going as low as 2.8%, this compares favorably with long-term fixed-rate bank loans, further enchanting the economic appeal of our products" [24].

In order to upgrade the product quality of industrialized housing, the manufacturers' 'cost-performance' marketing strategy encourages them to install a number of standard features, which may be offered as options in cheaper site-

built homes, while helping them to maintain the higher selling price. In addition to their value-added production for the delivery of today's high-performance PV solar homes that reflect the societal need for sustainable housing, the manufacturers have also been practicing a unique *design* approach that meets the diverse demand of homebuyers.

2.2. Mass Custom Design Approach

Buying a new home is a significant investment usually undertaken only once or twice in lifetime in Japan; therefore, consumers are cautious and selective when buying a house, because it must satisfy their personal requirements in view of the demographical changes of today's society. In other words, today's consumers are no longer satisfied with monotonous products, even though the products themselves are reliable enough in terms of the product quality. Houses must be responsive to individual requirements, particularly when they are relatively costly. Japanese manufacturers' design process for the creation of customizable homes reflects the advantages of industrialization of housing, in which mass-production of the components helps reduce the design and production costs, while in-factory production ensures a steady supply of quality products. The design approach, which the manufacturers have applied for the delivery of customizable homes, does not fit into the well-recognized design approaches of today—i.e. speculative (or production), semi-custom, and custom design [25][26]. Rather, with consideration of the emerging concept of mass customization, it should be termed "mass custom design" that results from the combination of three basic design elements of housing: the volume, exterior and interior. As well, the manufacturers usually provide optional equipment, in order to improve housing amenities [27].

Mass Customization is a seemingly contradictory term, for how can one combine mass production and customization? As a technological capability, mass customization was anticipated in 1970 by Alvin Toffler in his book entitled *Future Shock*—"Uniformity will give way to diversity" [28]. Toffler also asserted that maximum "individual choice is regarded as the democratic ideal" and expressed anxiety at the emergence of more standardized mass culture and lifestyles in the future. In 1987, the term was actually coined by Stanley M. Davis in his book entitled *Future Perfect* and he delineated the concept as follows: "The world of mass customizing is a world of paradox with very practical implications. Whether we are dealing with a product, a service, a market, or an organization, each is understood to be both part (customized) and whole (mass) simultaneously…For mass customizing of products, markets, and organizations to be possible, the technology must make it economically feasible in every case" [29]. In many industries, this innovative concept has been applied to product design in order to satisfy the unique demands of each consumer. The housing industry is no exception. Japanese housing manufacturers have already succeeded in mass-customizing their industrialized housing [27][29][30].

To bring the concept of mass customization into full play, Japanese manufacturers have been practicing a total coordination approach to their design, production and marketing. In particular, their design techniques are well integrated into a system that is composed of two design-support sub-systems: product and service [31]. In general, a "mass customization system" (MC) that helps to mass-customize housing has been translated into the following conceptual model [26][32]:

$$\mathbf{MC = \mathit{f}\,(PS)}$$

In this model, the 'service sub-system' (S) concerns communication techniques that lead users to directly participate in customizing their new home, while the 'product sub-system' (P) covers production techniques to encourage housing suppliers to mass-produce housing components. Both sub-systems can be considered as the indispensable functions of mass-customizing homes. In general, mass production of housing components is regarded as an effective method of reducing production costs [30][32][33]. Moreover, the higher the rate of in-factory completion of housing components, the more the product quality can be maintained under optimum conditions inside the factory, where materials are not exposed to adverse outside climate [34]. Moreover, the elapsed time for the production, which influences the product's costs, is fully controlled [35].

In mass-customizing products, user participation is considered important, and therefore housing producers need to provide design support communication services for their clients. In fact, during the design stage, Japanese housing manufacturers encourage clients to participate in customizing their home in three ways: by giving catalogues to the client, by visualizing the client's image of the house, and by estimating the product's costs [31]. Before actually making a contract with the client, manufacturers offer these services as part of their design consultation process, which normally takes place in the company's display house located in the Housing Park or in the salon of the Housing Information Center [9].

In general, the manufacturers provide the client with four types of catalogues that concern the company's commodities, specific housing types, technology, and component selection. The first three catalogues are usually provided during the marketing stage, while the component selection catalogue is used during the design consulting stage. The housing component selection catalogue corresponds to the housing styles, and helps the client choose the standard components for

the exterior and interior arrangements of the home. The catalogue describes the material, size, color, texture and functions of each component; however, it does not include any prices. In addition, manufacturers use a computer-aided design system for the creation, modification, analysis and optimization of a design. Furthermore, as the virtual image of the house is erected, based upon the housing components selected by the client, the manufacturer provides a cost estimate. Once the client is satisfied with the plans, the manufacturer will finalize the design and, at last, enter into a contract with the client [36][37].

An important part of the mass custom design approach is that the user directly determines the configurations from choices given as client input during the design stage. This could hardly be achieved without the standardization of housing components for the structural, exterior and interior arrangements. The concept of component standardization can be illustrated with Lego® building blocks. A number of simple, modularized blocks can be connected in a variety of ways, because of their interlocking tabs and holes. Likewise, Japanese housing manufacturers offer a variety of housing components to their clients and then encourage them to participate in combining the components to design their new home. These are visually arranged in a component selection catalogue to enable clients to easily choose from the many options. Housing components can be divided into three categories: structural, exterior and interior. The structural components are used to construct the housing models that determine the number and size of each room, while the interior and exterior components serve to coordinate both the decorative and functional elements that help mass-customize housing (Fig. 2).

Figure 2. Logia-Type E
(Source: SANYO Homes Co., Ltd.)

The application of the mass custom design approach may have potential to reduce production costs by achieving the *economies of scope* (based on standardization of housing components), while helping totally customize homes in response to the wants and needs of homebuyers [26]. The existing elements (i.e. parts of a whole) can be standardized, while the myriad combinations of these standard parts still provide great scope for creativity. Thus, a homebuyer can directly choose the standard housing components, while the combinations of the users' direct choices of these *mass-produced* components make their house *customized*—viz. these homes have been termed "mass custom homes" [32]. Mass custom homes may theoretically achieve a high level of standardization of all housing components that homebuyers can directly select in customizing their new home, while user choices of the mass-produced, standard components paradoxically increases the level of customization in housing design (Fig. 3).

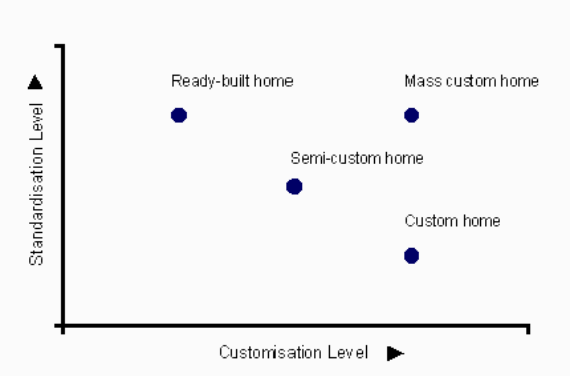

Fig. 3. Standardization-customization relationship compared by housing type

Japanese manufacturers have been producing mass custom homes that are often equipped with PV systems today. The manufacturers' 'cost-performance' marketing strategy considerably affected their design and production approaches for the delivery of marketable PV solar homes that correspond with the wants and needs of individual homebuyers, as well as society.

3.CONCLUSION

This paper described Japanese housing manufacturers' 'cost-performance' marketing strategy that influenced their *production* and *design* approaches. This marketing strategy can be considered as the *essence* of their business success in producing '*marketable* PV solar homes' (i.e. *mass custom homes* equipped with PV systems) that correspond with the wants and needs of individuals as well as society.

However, it can be argued that their quality-oriented production approach alone resulted in successful commercialization of innovative housing. Nevertheless, other parameters might come into play along with the marketing strategy. For example, their communication (or *marketing*) approach that helps consumers to understand the added *value* of packaged innovations, rather than the *cost*, might greatly contribute to commercializing their PV solar homes. Thus, their communication approach should be examined further.

4. ACKNOWLEDGMENTS

Financial support for this research project was provided in part by Natural Resources Canada through the Innovative Research Initiative and the Technology and Innovation Program as part of the climate change plan for Canada.

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