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Sustainable Building in Japan – Observations on a Market Transformation Policy

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ABSTRACT
Despite the lack of mandatory thermal requirements in the housing sector, an average Japanese household consumes around one-third of the energy for heating and cooling compared with a UK or German household. Based on a policy analysis and interviews, this paper identifies the concept and policies for sustainable building in Japan considering the characteristics of the building stock and household energy use behaviour. Energy and housing policies are described in terms of regulations, fiscal instruments and labels, and visualized in the context of a market transformation. The research shows that the Japanese policy has a clear preference for market-based instruments. Thermal regulations are limited to large developments only (over 300 m^2) and exclude most of the residential sector. The market transformation is likely to work with appliances, and the Top Runner programme has proved to be an effective policy in making a current market leader a future standard, but the 'scrap and build' housing policy leaves little incentive for energy investments in the building sector; in 24 years the resale value of a Japanese home declines to almost zero and the payback time of most environmental measures exceeds the life-cycle of a building. As the implementation of environmental policies is voluntary, and the insulation levels low, the low heating demand per household seem to be due to different behavioural culture. The research concludes the necessity of introducing mandatory thermal regulations in housing in addition to market based instruments in order to gain further savings in the housing sector. Copyright © 2011 John Wiley & Sons, Ltd and ERP Environment.

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Introduction

THE INTRODUCTION OF BUILDING ENERGY SIMULATION TOOLS AND SUSTAINABLE BUILDING POLICIES IN EUROPE HAS NOT generated a revolution in energy efficiency on the ground. Technology for sustainable building exists, the benefits of insulation have been known since the 1970s and energy prices continue to increase, but in practice the progress has been slow (Boardman *et al.*, 2005; Sunikka, 2006; Meijer *et al.*, 2009). This will become a critical issue under legislation for zero carbon buildings and achieving the carbon reduction targets in

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the EU. One reason for the lack of progress is that environmental policy making seems to be based on images (often on as yet unbuilt reference projects), feelings and politics – not on the evidence of the existing policy programmes. Furthermore, although there is an agreement that occupant behaviour and consumer choice are major determinants of energy use in buildings, the potential reduction of CO_2 emissions with non-technological options is not much assessed and the potential leverage of policies over these is not well understood (Levine *et al.*, 2007). Despite the fact that the ways in which buildings are operated are as or more significant in determining their energy use than the initial design, European policies tend to focus on the uptake of energy efficiency measures, and what happens once these measures are adopted is often ignored (Bergman *et al.*, 2009; Tambach *et al.*, 2010). Furthermore, appliances are often ignored in European sustainable building policies, although the electricity use of consumer appliances is the fastest growing share of household energy consumption for example in the UK (Boardman *et al.*, 2005); in Japan, 41 % of household energy use is used for lighting and appliances (Murakami *et al.*, 2009).

Arising from the points mentioned above, this paper presents observations on the Japanese policy for sustainable building and appliances. Based on a research visit to Japan, a policy analysis and expert interviews carried out at the Ministry of Economy, Trade and Industry (METI), the University of Tokyo and practitioners, the research discusses the effectiveness and limitations of Japanese housing and energy policy considering the characteristics of the building stock. The paper aims to answer the following questions. What are the characteristics of the sustainable building concept and the energy use behaviour in Japan? How is the market for energy efficient buildings and appliances transferred in terms of regulations, fiscal incentives and voluntary measures such as labels? How can the Japanese policy be improved to further reduce energy consumption?

The following section presents the research methodology and the theoretical framework. The next section introduces the concept of sustainable building in Japan. In order to understand the user behaviour, the fourth section describes the characteristics of household energy use in Japan. Regulatory and fiscal instruments are discussed in the fifth and sixth sections. Conclusions are drawn in the final section.

Methodology

The research takes the market transformation strategy as a starting point for the policy analysis because previous research has demonstrated the preference for market led instruments in government policies for sustainable building (Sunikka, 2006; Klinckenberg and Sunikka, 2006). In a market transformation strategy, subsidies are limited to innovations only, regulations are gradually used to eliminate the worst performing stock and the main market is directed by taxes and knowledge dissemination, namely labels. The EU aims to improve the market demand for sustainable buildings with the energy certificates of the Energy Performance of Buildings Directive (EPBD) (EC, 2003). The European Parliament requires the member states to make national plans for increasing the number of (labelled) zero emission buildings and setting the targets as a minimum percentage of the total stock by 2020 (EP, 2009). This makes a study of market transformation policies for energy efficient appliances and buildings in other countries relevant. Market transformation is defined as 'the reduction in market barriers due to a market intervention, as evidenced by a set of market effects that lasts after the intervention has been withdrawn, reduced or changed' (Meyers *et al.*, 1996). The theory is adopted in order to visualize the Japanese policy approach.

The Japanese government policy was studied in 'as is' policy analysis and verified in the expert interviews (see the references for the list of interviewed people). The research in Japan was funded by the Daiwa Anglo-Japanese Foundation. It should be considered that the policy developments described in this paper are subject to change and based on the situation in 2009/2010.

The research builds on the previous research on the effectiveness of policy instruments (see for example Beerepoot and Sunikka, 2005; Levine *et al.*, 2007; Koeppel and Ürge-Vorsatz, 2007; IEA, 2008; Meijer *et al.* 2009; McGilligan *et al.*, 2009), which enables a rough comparison between sustainable building policies and in Japan and the EU states. It is recognized that there are great national differences in the EU countries (for example Germany versus the new member states), but contrasting the approaches in order to highlight the characteristics of the Japanese policy was considered feasible.

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The pressure–state–response (PSR) model is an internationally recognized framework used to provide a core set of indicators for environmental performance reviews (OECD, 1993). Previous research by the present author modified the PSR model to identify two kinds of response to environmental pressure: policies (output) and actions taken as a result of these policies (outcome), to reflect better the situation in housing, where environmental pressure is determined by the actions of landlords as well as the behaviour of tenants; tenants can only maximize their energy saving behaviour if landlords invest in energy efficiency measures, or create conditions for the tenants to do this (Sunikka, 2006). As expressed in the model, a behavioural response is an essential parameter in studying the policy impact.

The study on energy efficiency measures is primarily focused on building level (new construction and refurbishment) and the reduction of energy demand, and secondly on the renewable energy sources. It is very clear that the culture and values of Japanese households versus European ones are very different. The aim of the paper is not to suggest transferring policy measures as such but to describe and understand the Japanese policy approach and suggest how it could be further improved.

Japanese Concept of Sustainable Building

Sustainable building is a fairly new concept is Japan, reflected by the fact that the Japanese Sustainable Building Database website currently lists only 29 projects (Japan Sustainable Building Database, 2010). There seems to be a lack of statistics since the approach is mostly voluntary. The Architectural Institute of Japan (AIJ) defines a sustainable building in Japan as one that is designed 'to save energy and resources, recycle materials and minimize the emission of toxic substances throughout its life cycle, to harmonize with the local climate, traditions, culture and the surrounding environment, and to be able to sustain and improve the quality of human life while maintaining the capacity of the ecosystem at the local and global levels' (AIJ, 2005). The emphasis on energy and materials makes the concept similar to Europe, although the aim to harmonize with the local climate and the surrounding environment is considered as 'good design' in Europe but not included in the definition of sustainable building. The Japanese building stock is characterized by very high density. In this way, Japanese cities are already where the European cities may be in the future; the use of photovoltaic (PV) panels, for example, is limited by insufficient roof-scape, especially in office buildings.

CASBEE, an environmental assessment method for buildings, has become synonymous with the definition of sustainable building and its quality assurance in Japan. Unlike the case of European evaluation systems, the building environmental efficiency (BEE) is addressed in relation not only to the environmental load (*L*) but also to the quality of the building (*Q*) (Murakami *et al.*, 2006). Environmental quality (*Q*) consists of the indoor environment (including acoustics, lighting, thermal comfort and air quality), service quality (including adaptability, flexibility and durability) and outdoor environment. Environmental load (*L*) consists of energy, materials and off-site environment. There are similarities to Western assessment systems such as BREEAM or LEED, although in the energy criteria, for example, a building achieves 'excellent' rating 50% more easily in CASBEE than in LEED (Kawazu *et al.*, 2005). In the context of the outdoor environment, in CASBEE there is an absence of biotopes in the assessment (no compensation for green space) and limitation to urban environment, including a reduction for the heat island effect. The CASBEE assessment for new construction is valid for three years and the assessment for existing buildings is based on operation records a minimum of one year after completion. The use of the tool is voluntary but encouraged in several policy documents, for example the MLIT Action Plan and the Kyoto Protocol Target Achievement Plan (Matsuo, 2006), but the expert interviews indicate that, in practice, use is limited due to the excessive criteria – with its six elements and numerous sub-categories the evaluation takes three to seven days, although a simpler version can be done in two hours. In order to increase the use of CASBEE it has been linked to other policy instruments in local governance. In Osaka City, for example, only buildings ranked above 'A' by CASBEE, based on a self-assessment, can apply for subsidies (Osaka City Planning Department, 2009). In Kawasaki and Sapporo City, a 'B+' assessment may entitle the holder to a lower interest mortgage. In Nagoya City, 'S'-ranked buildings (the highest sustainability performance) are permitted to use a premium extra-floor area ratio and the CASBEE results for residential buildings must be displayed on sales advertisements. METI would prefer a tool similar to the Energy Certificates of the EU

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Energy Performance of Buildings Directive (EPBD) (EC, 2003) that is focused on energy and required in each property transaction in the EU.

Kobunaki Ecovillage in Omihachiman City, Shiga Prefecture, is a demonstration project that is an example of the Japanese concept of sustainable building in practice. The starting point of Kobunaki is that sustainability cannot be achieved by environmentally friendly buildings and products only, but a lifestyle change is needed. The project started as a non-profit organization (NPO) and is now managed by a developer (G-Project). The main demographics in the area are young families and the mainstream market – a good environment for children is also used as the marketing strategy. The land prices are estimated to be around 10% above the market average. The Japanese government promotes the life-cycle targets for new houses of 200 years (compared with the average of 24 years in Japan) and some houses in Kobunaki have adopted the target. All new houses fulfil the 'Next Generation Energy Saving Standard for Construction', meaning around 160 mm insulation in walls, the thickness depending on the insulation material. Most homes have passive solar strategies (sun shading), natural ventilation, individual heat pumps, high efficiency appliances and rain water tanks, and they are earthquake safe. The density is slightly below market average; an average house surface area is 120 m^2 and an average site around 240 m^2. Social sustainability is managed by a civic non-profit organization together with local industries and municipalities, aiming to encourage voluntary projects to cope with challenges and tasks for the community. Growing one's own vegetables seems to be successful, social activities like workshops are held in a common neighbourhood house and there is, for example, construction waste recycled for reuse among the inhabitants.

The interviews in Kobunaki indicate a number of barriers to sustainable building in Japan that may be difficult to address with market based instruments only. First, three levels of bureaucracy (management at government, prefecture and city levels) were a major barrier in the development and changed the master plan during the process. Second, subsidies are limited to information dissemination, with some support for the use of local wood and solar panels. All green areas and vegetable gardens, for example, are private, since the local government cannot afford the maintenance. The local government has introduced public transport in the area, but it is poorly managed, so the households are dependent on private cars. Third, the interviews indicate that the use of sustainable materials is limited by the liability issues of the construction industry – if local materials and craftsmanship are used, there is a risk of complaint, making a contractor use standardized products.

Large contractors that dominate the (mostly prefabricated) housing market in Japan seem to be interested in the market potential of sustainability, although it is too early to speak of a large scale implementation. Examples of sustainable homes launched to the market are, for example, the Carbon Neutral House by Sekisui House, or a large housing development by Toyota. These sustainable buildings often use PVs, passive solar strategies, natural ventilation and intelligent home energy management systems (HEMS). According to METI, large architect offices like ARUP understand sustainability as a business opportunity but the knowledge is more limited in smaller practices.

As a demonstration project on the urban scale, the government initiative on Eco-Model Cities (EMC) aims to place leadership on local governments. 15 EMCs were selected in 2009 and ambitious targets were set for them, such as a 50% or more reduction in carbon dioxide emissions from the current level and improvement in energy efficiency by 30% or more by 2020 (Murakami, 2008).

It should be considered that Japanese buildings have a very short life span. The average life span of a Japanese home is 26 years, compared with 44 years in the US and 75 years in the UK (Ministry of Construction, 1996). The preference for newly built homes and the high turnover rate of the Japanese building stock makes embodied energy very important – although the turnover is slowing down with less than 1 million starts per year, compared with 1.5 million in 1970–1990 (Ministry of Construction, 1998a). The renovation rate remains low: the ratio of home renovation to housing investment is 11% in Japan, compared with 65% in the UK and 41% in the US (Kuraishi, 2003), this despite the fact that, according to the Housing Demand Survey, 48% of Japanese families are not satisfied with their home; a majority (58%) is not satisfied with the energy efficiency and sound proofing in particular (Ministry of Construction, 1998b). Compared with most European countries, maintenance has traditionally not been in a Japanese ownership culture, but the DIY stores are slowly increasing their popularity. The lack of maintenance is a threat to sustainable building, not only in terms of environmental sustainability (waste and the use of new resources) but also economic (lack of incentives regarding long payback times that often exceed the life cycle of a building) and social sustainability (low levels of insulation as a health risk for the elderly). Furthermore, the used house market is very limited (Iwafune *et al.*, 2006); 12% of the annual home transactions are existing houses

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compared with 81% in the US (see Figure 1). Urban regeneration, supported by the introduction of the Special Law on Urban Renaissance and Community Renovation Grants, could offer cost-effective intervention points for sustainable renovation. There are further synergies with making housing accessible and safe for the ageing population and earthquake safety; 82% of the buildings built before 1980 (when the first thermal regulations were introduced) are judged dangerous in the case of an earthquake, compared with 33% of the houses built after 1981.

Energy Use Behaviour

It was observed during a visit to Japan, and confirmed by the expert interviews, that there seem to be at least four characteristics typical of household energy use behaviour in Japan that need to be considered in order to understand the energy performance and policies in the housing sector.

First, the Japanese traditionally prefer to heat one room rather than a whole house. Heating the whole house is considered as wasting behaviour – and considering the low insulation levels it is. The Japanese often use appliances such as convectors or the traditional *kotatsu* heating (a low table with an electric heater under the table covered with a kilt), whose use was estimated to be 76% in 2004 (Murakami *et al.*, 2009). Air-conditioners are installed in 87% of the houses in Japan and an average household owns 2.3 units (Murakami *et al.*, 2009) but house-wives who are at home in the daytime would not use the air-conditioning for themselves but only put it on in the evening when the whole family is at home. The difference in energy use patterns between Europe and Japan could be described as the concept of person heating (Japan) versus space heating (Europe). Second, greater fluctuations in comfort levels are accepted. Indoor temperature is kept between 18 and 20°C, and the night-time room temperatures can be as low as 10°C, although in colder climates such as Hokkaido higher average temperatures are common. Lowering the indoor temperature has a great impact on energy consumption, In Britain, for example, for every degree that the thermostat is turned down, the heat loss decreases by about 10%, and turning the thermostat down from 20 to 15°C would nearly halve the heat loss (MacKay, 2009). Energy use behaviour is notoriously difficult to address in government policies, but in the commercial sector in Japan the acceptance of greater fluctuation in comfort zone is encouraged by the 'Cool Biz' program. The voluntary demonstration campaign encourages setting the air-conditioning to 28 degrees in the summer and casual clothing in the commercial sector, as a part of the 'team minus 6% campaign' that aims at moderating temperature settings for space heating and cooling and reducing the duration and frequency of use of appliances. The program is estimated to result in a saving of 460 000 tons of CO_2 and a public awareness of 96% has been reported (Murakami *et al.*, 2009). The policy has recently been adopted by the United Nations.

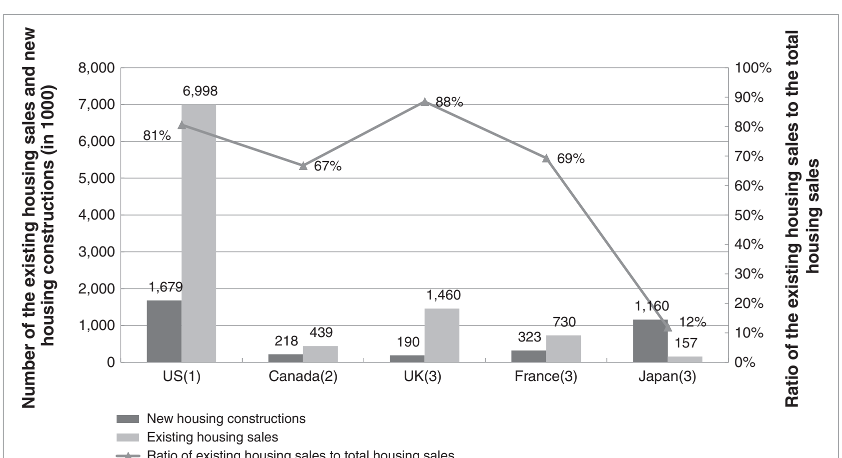

Figure 1. Ratio of existing housing sales to total housing sales in Japan in comparison with other countries. References: (1) USA: U.S. Census Bureau, Statistical Abstract of the United States (2004-2005), (2) Canadian Housing Observer, Housing Data Tables (2004), (3) White Paper on Land, Infrastructure and Transport in Japan (2003)

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Third, there is a strong culture to turn off heating/cooling (and lights) when it is not necessary. Research comparing energy use patterns in Norway and Japan found out that Japanese heating behaviour is more disciplined than in Europe (Wilhite *et al.*, 1996).

Fourth, in general the Japanese (especially women) seemed to have a better grasp of energy consumption compared with Norway (Wilhite *et al.*, 1996). This may be due to a monthly billing system that can give a better grasp of the actual energy consumption – instead of having an annual energy bill based on predictions.

The share of hot water consumption is remarkable in Japan due to bath culture (also washing dishes under running water). Most dwellings have both bath and shower, although the bath water is often reheated among family members. There is potential for solar energy in heating hot water: 8% of energy for residential hot water supply in Japan came from solar water heaters in 1990 (Murakami *et al.*, 2006). In contrast, hot water is not always used in doing the dishes or washing clothes. Another difference is that fluorescent light is preferred in Japanese homes instead of incandescent light as in Europe (feeling of warmth and the atmosphere is regarded to come from materials not incandescent light) and ceiling lighting instead of lighting spots.

The focused heating concept has been supported by the communal way of living but the lifestyle is in flux and has become more individual – now more rooms are heated or cooled because members of the family do different things by themselves and go to bed later. Furthermore, the average floor area of a new dwelling has increased to $107\,m^2$ (still modest compared with $211\,m^2$ in the US), which together with a decrease in household size are a factor for increased energy consumption. The number of households in Tokyo, for example, is expected to increase by 31% compared with the 1990 level by 2005 (Murakami *et al.*, 2006). If it is presumed that a person in a single-person household consumes energy with a factor of around 1.4 compared with a person living in a four-person household (Boardman *et al.*, 2005), this will have drastic implications for energy consumption figures in the household sector.

Japanese research results indicate that lifestyle changes are more effective than increasing the thickness of thermal insulation (Murakami *et al.*, 2006, 2009). In a study by the University of Osaka, energy consumption in a case study was reduced with energy-saving behaviour by 38% (relative to the baseline case), compared with 8% reduction if all buildings were brought up to the 1999 standards. There is not much research on the culture and the motivation behind the disciplined energy use of Japanese households. A monthly energy bill may be an essential factor supporting the disciplined energy saving behaviour: in Europe the impact of monthly feedback has been estimated at up to 10% (Darby and White, 2005; Darby, 2006). Japanese survey results have shown that electricity use can be reduced by about 10% by visualizing energy consumption (Ueno *et al.*, 2005). Yamatake Corporation, for example, has developed a web-based building energy monitoring and control system that allows owners to estimate heating, ventilation and air-conditioning (HVAC) energy use for an individual tenant. The Energy Monitoring System by Misawa Homes is capable of displaying information on room-by-room energy consumption (including CO_2 graphs), including electricity, gas and water and home appliances, plus PVs or fuel cells; as part of the energy management system lithium batteries can store cheap night-time electricity or solar surplus power. The use of the system, however, is at present limited by its costs (USD 2,500).

The results of the study by Gatersleben *et al.* (2002) suggest two measures of environmentally significant behaviour: an intent-oriented and an impact-oriented measure. An intent-oriented measure focuses on behaviours that an actor considers as environmentally significant but that do not reflect the actual environmental impact of behaviour patterns; a low correlation between pro-environmental attitudes and household energy use has been reported (Gatersleben, 2000). Household energy use is primarily related to determinants such as income and household size. Considering the not particularly sustainable waste and water consumption habits, and the relatively new concept of sustainability in Japan, the disciplined behaviour is likely to be attributable to culture rather than particularly pro-environmental attitudes or policies.

Regulations for Sustainable Building

According to the IEA (2008), environmental policy measures that have had a strong impact in Japan have been regulatory. The policy overview shows, however, that the impact of legislation on the building sector is limited.

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The Energy Conservation Law was introduced in 1979 and revised in 1999, with major consequences for new construction and appliances that are aimed at Canadian standards (Matsuo, 2006). As a result of the ratification of the Kyoto Protocol in 2002, the Kyoto Protocol Achievement Plan was published in 2005 (revised in 2008), putting more demands on the construction sector. Despite the 6% CO_2 reduction target, however, the emissions in Japan increased by 6% between 1990 and 2006; industry reduced its CO_2 emissions by 5% but the housing sector increased its emissions by 31% (EU–Japan Centre for Industrial Cooperation, 2008a, 2008b). Further pressure to save energy is expected as the residential/commercial sector accounts for 30% or more of final energy consumption and has grown remarkably compared with the industrial and transportation sectors (Sakamoto, 2009), in a situation where 95% the Japanese energy supply is exported. The housing sector is prioritized as one main area of the national energy policy, but complex energy saving performance metrics, high costs, insufficient knowledge and a lack of incentives have been identified as main barriers in the building sector.

The Energy Efficiency Standard for buildings was introduced in Japan in 1980. In two decades, the thermal requirements have been sharpened. In the Tokyo region, for example, the heat loss factor 5.2 W(m^2/K) in 1980 was reduced to 2.7 W(m^2/K) in 1999 (Hirano, 2008). Thermal insulation specifications were set from 30 to 100 mm (walls) and 40 to 180 mm (roof). Since 1999 double glazing is expected in new construction. Thermal regulations are based on performance based standards for an annual heating and cooling load, and prescriptive standards and performance based standards for thermal loss coefficients, and they include a formula for passive solar systems. Despite the revisions of the Energy Saving Law regarding buildings and appliances, however, the impact of the thermal regulations is limited by the fact that buildings less than 300 m^2 are exempted. Considering that 50% of the stock consists of individual houses, in practice most thermal regulations do not apply for residential buildings. The lack of thermal regulations in the housing sector means there is a huge renovation potential in the existing stock. The government aimed to increase the compliance with the 1980 energy efficiency standard (29% of the stock in 1996) to 67% of the total building stock by 2004, but how the policy will be applied to private housing is ambiguous. The interviews indicate that there seems to be an ideology that private parties cannot be regulated and requirements should be limited to industrial parties only. Furthermore, discussions with practitioners indicate that there are many exemptions in practice and a lack of monitoring regarding any building regulations and compliance.

During the research visit to Japan it became clear that the passive house concept, soon to be driven by regulations in Europe, has not reached Japan in full force. 25 000 solar houses (based on passive solar and collected warm air) have been built (Murakami *et al.*, 2006) but they rely on passive measures without elimination of a heating source. According to METI, due to the hot and humid climate it is hard to eliminate the cooling need that makes a building without any energy supply very hard to implement. A zero energy building (ZEB) concept launched in 2009 by METI allows on-site energy supply. By definition, a ZEB achieves a 100% reduction in energy use through energy efficiency and the use of local renewable energy sources on site (Sakamoto, 2009). The ZEB measures include passive solar energy, PV, use of natural energy and ventilation, high efficiency heating, high efficiency lighting, low energy equipment, use of intelligent technology to control lights and the encouragement of sharing energy facilities (heating cooling) among buildings and the potential of urban thermal energy. The ZEB program targets new public buildings to be zero carbon by 2030 with an economic stimulus package, even though, as recognized at METI, its impact is limited as it is a policy not a strict regulatory mechanism.

In the commercial sector, the revision of the Energy Conversation Law in 2006 set more obligations for building owners and ESCOs to inform consumers about operational energy use and energy saving measures in their estates. The mandatory sustainable building reporting scheme requires owners of residential buildings over 2000 m^2 to report energy conservation measures to local authorities in new construction and large-scale refurbishment. If the energy use is considered excessive after an inspection, improvements are suggested (ordered). If no action is taken at this stage, the name of the building owner is published (a 'name and shame' policy) with a risk of a sanction of USD 11 000 (one Million yen). According to METI, no actions were necessary for non-compliance until now.

The market transformation strategy on energy efficient appliances plays a key role in the Japanese energy policy. In the Top Runner program, an energy performance target for each appliance is set based on the most energy efficient device in the market; usually a time frame of eight years is given for the manufacturers to maximize the energy efficiency, after which non-compliant appliances are not allowed in the market. There are sanctions for non-compliance, for example setbacks in shipping values, and research and marketing assistance for forerunners. With the Ecodesign Directive (2005/32/EC, revised in 2009), the EU aims to implement a similar policy and

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information concerning the product's environmental performance and energy efficiency must be visible if possible on the product, but there is no direct provision for mandatory requirements, making the Directive more of a communication than a regulatory tool.

Figure 2a visualizes the objective of the Japanese market transformation policy for energy efficient appliances in terms of energy performance (*x*) and the market share (*y*). The first curve presents the current market; most appliances have a moderate energy performance but there is a great deviation in energy performances. The most energy efficient product in the market is identified as the Top Runner. The second curve presents the market after eight years; the Top Runner has become a minimum energy standard for all products in the market and most products go beyond it. In order to transfer the first curve to the second one, and decrease the variation of energy performance in the market, mandatory energy performance requirements are used to eliminate weak products from the market. The mainstream market is greened with energy labels and eco-action points. Since 2009, Japan has been one of the first countries to test eco-action points for consumers (Kutsukake, 2009). When a consumer makes an energy efficient purchase (refrigerators, air conditioners or TV sets that are verified by a simple voluntary energy

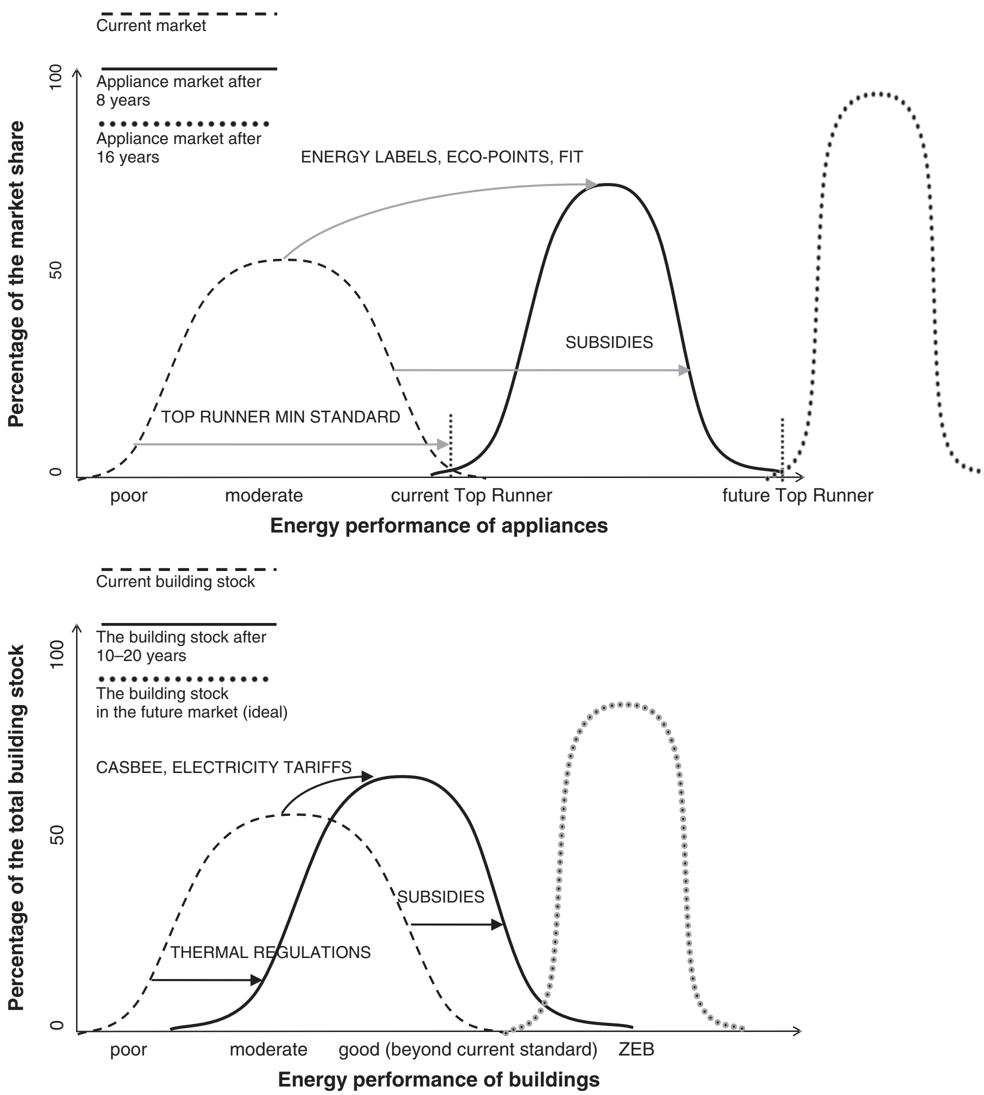

Figure 2. Japanese market transformation strategy for a) energy performance of appliances and b) energy performance of buildings

label expressing in colour whether a product is above/below the Top Runner Standard) eco-action points are received in return. The points can be saved, donated or used for energy efficient appliances or train tickets within three years. R&D subsidies are reserved for the industry to facilitate new high-performance standards. Based on these policy instruments, the market will gradually be transformed to resemble the third curve, where high energy efficiency has become a standard and the deviation of energy performances is small.

The Energy Conservation Centre is responsible for controlling the Top Runner program and the results indicate it has been highly effective; energy efficiency standards have increased for air-conditioning by 70% as a result of the programme and for most other products by 50% (Matsuo, 2006). The total energy savings are expected to reach 0.35 EJ (Exajoules) by 2010, compared with the total annual household consumption of around 2 EJ in Japan (Geller *et al.*, 2006). The annual cost of air-conditioning was estimated to be around USD 1460 before 1980 and USD 570 in 1999 (Hirano, 2008), suggesting a radical improvement in the energy efficiency of appliances. There is a risk, however, that the technological cap of saving potential in the Top Runner program has been achieved: most of the cost effective changes have been adopted already and further improvement in energy performance of the appliances may be costly (Energy and Natural Resources Committee, 2006).

Fiscal Instruments

How does the Japanese government aim to get households to improve the energy performance of housing if buildings less than 300 m^2 are exempted from thermal regulations? Energy saving measures in buildings often have a low cost-effectiveness compared with those for other sectors, and there is a lack of incentive to invest in energy improvements due to the short life-cycle of the buildings. Regardless of the energy prices in Japan, which are among the highest in the world (but so is the income level), most houses do not last long enough to make the investments worthwhile. The land prices are very high in Japan compared with the value of the houses, leaving little space for anything extra such as environmental measures (an average the price of a new house including land is around USD 350,088 compared with USD 207,000 in the US) (Ministry of Construction, 1996). Moreover, the housing market is dominated by the owner-occupied sector (60% of the tenure) and there is a very small percentage of social housing, so the target group of sustainable building policy is the notoriously difficult private sector with little capital to invest. The government housing loan company (GHLC) has been privatized, limiting the possibility to influence housing with long-term low-interest loans, with advantageous loans for better thermal performance.

The Japanese government has recognized these gaps and introduced fiscal measures to facilitate CO_2 reduction in buildings. Between 1999 and 2006, USD 49.8 million was allocated to home-owners for energy efficient improvements (excluding social housing), and USD 2.90 million for renovation (IEA, 2008). The 'Leading project for CO_2 emission reduction from housing and building' – a subsidy program – started with a budget of USD 50 million in 2008. The new energy and industrial technology development organization (NEDO) allocates subsidies for new energy and technologies in new construction and the existing housing: most cover roughly one-third of the costs of energy efficient appliances or renewable energy technologies such as PVs (Kutsukake, 2009). PVs, for example, are subsidized around USD 2692 per household (USD 769 per kW) or there is a possibility of a reduction of tax income (10% of the installation costs of a PV system). Despite the USD 150 billion spent in the previous subsidy package, however, there have been just 21 653 applications, whereas no less than 35 000 were expected (Japan Photovoltaic Energy Association, 2010). This may change in the near future resulting from the feed-in tariffs (FITs). In 2009, METI launched a New Solar Power Purchase System that requires ESCOs to purchase at fixed prices surplus electricity generated by PV panels installed for household use. The purchase price of electricity from solar power home owners will be double the current price at USD 0.53 per kWh during the contract period of 10 years (the price is reviewed on an annual basis and is expected to be lowered when PV generating costs drop with the widespread use of PV generation). The FIT scheme supports the government's market-oriented plan to expand the PV generation to 20 times the current level by 2020.

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At the moment, heat pumps seem to be a more successful renewable strategy in new housing than solar power. Heat pumps are subsidized by USD 770 per unit (the full costs are USD 6600 per unit), improving the 10year PPT period. Cheap night-time electricity tariffs are used to support subsidies and are in reality a more important incentive.

Figure 2b describes the market transformation of buildings in the context of the Japanese policy, energy performance of buildings (x) and the total building stock (y). The ideal of transforming the building stock is similar to that for appliances (see Figure 2a). Compared with appliances, however, a market transformation of buildings (especially housing) is complicated and slow due to high capital costs, fragmented tenure and a distorted market where the demand exceeds the supply. It will take decades to eliminate the worst performing stock either by refurbishment or demolition – and the decision will be difficult to force on private households. The first curve visualizes the energy performance of the current stock: due to the lack of thermal regulations until 1980, a majority of buildings have a low or moderate thermal performance, below the current thermal regulations. The second curve anticipates the ideal development as a result of the government policy consisting of thermal regulations (currently applied on large projects and the commercial sector only), subsidies and labels (such as CASBEE or a Housing Performance Indication System as a part of the Housing Quality Assurance Act). There could be stronger fiscal incentives in the future: the Tokyo local government is planning a CO_2 cap for buildings and emission trading is being discussed by local governments. An ideal future market is presented in the third curve; a good thermal performance has become a standard and the deviation in energy performance is small. This situation, however, would require an elemental reorientation of the policy. If the government does not want to impose mandatory requirements, such as thermal regulations, on private households to reinforce the market-based instruments, how the mainstream market can be moderated to become more sustainable is a key question not yet resolved in Japanese policy and (considering the barriers) seems to call for a regulatory approach.

Conclusions

Based on a policy study and interviews, this paper has discussed the characteristics and the effectiveness of the concept and policies for sustainable building in Japan, considering the characteristics of the building stock and household energy use behaviour. The CASBEE environmental assessment system for buildings gives a good overview of the holistic concept of sustainable building in Japan and the principle of considering environmental quality versus load instead of focusing on the environmental load only.

The differences in the Japanese and EU energy consumption policies are summarized in Table 1 in relation to legislation, economic instruments and voluntary actions, such as labels and demonstration projects.

The analysis shows that the Japanese energy and housing policy has a clear preference for market-based instruments. The research concludes the necessity of introducing mandatory thermal regulations in housing in addition to market based instruments. The market transformation is likely to work with appliances (Figure 2a) but improving energy efficiency of the existing stock will be more complex and take longer (Figure 2b). Regulatory instruments are also needed due to the fact that in 24years the resale value of a Japanese home declines to almost zero; in reality the payback time of most environmental measures exceed the life-cycle of a building, even with subsidies for PVs and heat pumps, supported by electricity tariffs and the FIT scheme. The 'scrap and build' housing policy leaves little incentive for energy investments.

If the implementation of environmental policies is voluntary, and the insulation levels low, as concluded in the previous sections, the low heating demand per household seem to be due to different behavioural culture rather than technical innovations. There were no thermal regulations for building in Japan before 1980 but recently the legislation has caught up; in the commercial sector thermal requirements have been sharpened by 50% in the past two decades, and reporting systems and sanctions introduced. Thermal regulations, however, are limited to large developments only (over 300 m^2) and exclude most of the residential sector. There seems to be reluctance by the government to address private households or disadvantage the construction industry, unlike the case in Europe, where regulations and subsidies for sustainable building have been strongly oriented towards insulation and operational energy.

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		Common priorities in Japan/EU countries	Japan
The concept of sustainable building	Concept	Focus on energy performance (driven by Kyoto) and RES (e.g. PVs, heat pumps), secondarily on materials, waste and water management.	Emphasis on air-conditioning, embodied energy, intelligent home energy management systems (HEMS).ZEB (allows on-site RES) instead of the 'Passivhaus' concept.'Harmonization with nature' and flexibility.
	EIA tools	EIA methods for buildings and energy labels still little used in practice, unless required.	CASBEE (quality/load), no official energy label for buildings.
	Demonstration projects	A large variety of demonstration projects emphasizing energy efficiency and solar power.	Little public support for demonstration projects (market led), green spaces private, lack of public transport (e.g. in Kobunaki).
	The existing stock	Great energy saving potential, sound insulation and accessibility as further challenges.	Average life span 24years, only 12% of the annual transactions existing homes (earthquake safety as a further challenge).
	Barriers	Long PPT, low WTP and a lack of market demand, liability issues in the construction industry, the capture of benefits between a landlord and a tenant, lack of regulations etc.	
Policies	Policy approach	Apart from few regulations, voluntary and market-led.	Clear preference for market instruments (good examples: FIT, electricity price structure).
	Regulations – buildings	Mandatory thermal requirements and reporting system in the commercial sector.	No thermal regulations for housing, unless exceeding 300m^2, reluctance to address private households, problems with compliance reported.
	Regulations – appliances	Mandatory energy labels for appliances (information on energy consumption).	The Top Runner standard setting the future standard in collaboration with the industry (minimum energy performance requirements).
	Fiscal	Subsidies for consumers (e.g. PVs) and R&D, tax breaks (e.g. UK), the introduction of FIT (e.g. Germany in the EU), electricity tariff structure, energy taxes.	Emphasis on electricity tariffs and FIT.

Table 1. Characteristics of the Japanese concept and policy for sustainable buildings in relation to the EU countries.

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