IEA INTERNATIONAL ENERGY AGENCY

Urban BIPV in the New Residential Construction Industry

PVPS

PHOTOVOLTAIC
POWER SYSTEMS
PROGRAMME

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IEA PVPS Task 10, Activity 3.1

Report IEA-PVPS T10-03:2008

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in co-operation with Task 10 experts

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Contents

Foreword

The International Energy Agency (IEA), founded in November 1974, is an autonomous body within the framework of the Organization for Economic Cooperation and Development (OECD) which carries out a comprehensive programme of energy co-operation among its member countries. The European Commission also participates in the work of the IEA.
The IEA Photovoltaic Power Systems Programme (PVPS) is one of the collaborative R&D Agreements established within the IEA. Since 1993, the PVPS participants have been conducting a variety of joint projects in the application of photovoltaic conversion of solar energy into electricity.

The mission of the Photovoltaic Power Systems Programme is “to enhance the international collaboration efforts which accelerate the development and deployment of photovoltaic solar energy as a significant and sustainable renewable energy option”. The underlying assumption is that the market for PV systems is gradually expanding from the present niche markets of remote applications and consumer products, to the rapidly growing markets for building-integrated and other diffused and centralised PV generation systems.

The overall programme is led by an Executive Committee composed of one representative from each participating country, while the management of individual research projects (Tasks) is the responsibility of Operating Agents. By the end of 2007, 12 Tasks were established within the PVPS programme

The objective of Task 10 is to enhance the opportunities for wide-scale, solution-oriented applications of photovoltaics (PV) in the urban environment as part of an integrated approach that maximizes building energy efficiency and solar thermal and Photovoltaics usage. The Task’s long-term goal is for urban-scale PV to be a desirable and commonplace feature of the urban environment in IEA PVPS member countries.

This technical report has been prepared by David Elzinga of Natural Resources Canada, Ottawa, Canada under the supervision of PVPS Task 10 and in co-operation with Task 10 experts.

The report expresses, as much as possible, the international consensus of opinion of the Task 10 experts on the subjects dealt with.

Further information on the activities and results of the Task can be found at:
http://www.iea-pvps-task10.org and http://www.iea-pvps.org

Executive Summary

The new residential construction building industry can play a significant role in deploying BIPV technology. The best methods to encourage this industry to participate in the use of BIPV technology have not been significantly studied by the BIPV and PV industry.

The study of innovation literature has shown that there are many aspects that must be considered when making an effort to accelerate the adoption and diffusion of innovative technologies. The aspects most relevant to a specific industry must be determined and then focused upon to make best use of any policy, market approach and market structure. The innovation literature that was investigated indicated that the construction industry is as innovative as many other industries in terms of localized innovation, but can be considered a “laggard” in systemic type innovation that requires multiple firms to change their processes. The adoption and diffusion of BIPV can be considered a localized innovation and therefore the focus on “early adopter” residential building companies can result in higher adoption and diffusion rates of BIPV rather than a generalized approach to the building industry.

Different building types require different approaches to BIPV due the respective dimensions and geometry, associated construction business and typical ownership structure of the homes or units. Based on the feedback provided from housing surveys by Task 10 participants, the three building types discussed are single family detached, attached and multi-unit housing. Consideration of the differences in each of these building types will allow for creative technical, policy and marketing solutions to encourage increased deployment of BIPV.

Several solutions are proposed to encourage the adoption and diffusion of BIPV by the new home residential building industry. The solutions proposed were divided into PV industry based approaches and policy based solutions. The PV industry based solutions discussed are:

- End customer focused policies must continue to provide customers for the building industry.
- Effort to identify and target early adopter builders must be undertaken to provide focus in the development of both policies and market structure.
- Manufacturers must create product solutions that meet the needs of the building industry such as meeting regular buildings standards.
- Manufacturers must also approach the residential building industry directly to provide increased margin and technical support.
- The construction industry must be engaged in the design and planning stage of the residential building or development.

Policy based solutions discussed are:

- Policies should be developed that focus on the residential building industry to provide incentives directly to them in order to encourage them to offer this product to their customers.
- Demonstration projects offer value by engaging the building industry in the deployment of BIPV. A planned approach to the demonstration of BIPV can have significant positive affect on encouraging the use of BIPV by the new home building industry.
- Development of BIPV specific policy

The approaches suggested do not negate the requirement of policy and financial support mechanisms at appropriate levels for PV, but rather provides focus to support the development

of financial tools to exploit this one application area for PV and BIPV technology. Without appropriate financial support measures other efforts to increase uptake in the new residential building industry will have little impact.

Data was collected from the Task 10 and PV Upscale countries on the number of dwellings in the residential building stock, the annual dwellings constructed and the IEA PVPS data was used for PV market analysis. The methodology developed compared the technical potential of BIPV in the new residential construction industry at a 1% market penetration with the existing distributed grid-connected PV market in the respective countries.

Installed PV in Distributed Applications and New Residential BIPV Potential at 1% Market Penetration, 2003

	Annual Grid Connected Distributed PV Installed 2003 (kWp)	Annual New Residential BIPV Potential (kWp)	Market Potential Percentage compared to existing market
Austria	1 833	720	39%
Canada	37	3 538	9 563%
Denmark	300	323	108%
France	5 900	7 220	122%
Germany	78 000	4 523	6%
Japan	216 535	19 007	9%
Netherlands	1 547	1 786	115%
Norway	7	333	4 751%
Portugal	33	631	1 912%
Sweden	15	300	2 000%
Switzerland	1 300	540	42%
USA	32 000	33 778	106%

Note: See detailed notes for above table in Section 4

A wide range of market potential percentages exist for the new residential construction market when compared to the existing annual distributed grid-connected PV market. Canada, Norway, Portugal and Sweden have the highest percentages and this is due to the combination of a very small existing annual distributed grid-connected market (mostly due to unfavourable policy and support framework for PV development) and relative to this a strong construction market. Market potential percentages above 25% are considered high since only a 1% market penetration rate is used for this calculation. All other countries fall into this category except Japan and Germany, indicating the significant potential that new residential construction can provide to the overall distributed grid-connected PV market. Japan and Germany have the two smallest potential percentages and this is due primarily to their very large annual distributed PV markets and respective new annual residential construction. In the latest data, Germany no longer breaks out the distributed versus centralised PV installations and therefore it is difficult to analyse its specific context. Japan on the other hand has focused some of its support mechanisms specifically on the residential market and therefore lessons can be learned from their experience if studied in detail

Further work is required to develop an increased knowledge in this area. A detailed analysis of the Japanese home building industry is relevant since the Japanese have shown success in engaging home builders in the deployment of BIPV. Secondly, country specific analysis of how to determine which builders are early adopters will ensure appropriate focus for policies and market development. Lastly, case studies of large scale deployments of PV in the new residential building market will provide significant understanding of what aspects are relevant to the building industry.

Introduction

In the photovoltaic (PV) and building integrated photovoltaic (BIPV) literature that has been reviewed, very little has been written that focuses specifically on the residential construction industry and its potential for the use of BIPV products in its market offering. Significant effort has been placed on the customers of both PV systems and PV electricity. This report will focus on the new residential construction industry and cite some of the few photovoltaic sources that do provide building industry focus. This report will not focus on the retrofit construction market.

The new home building industry has the opportunity to be one of the key deliverers of BIPV systems to customers, especially in the residential urban market. Secondly, although the new residential construction market is smaller than existing housing stock, new residential construction adds to the existing stock each year and therefore what is defined today as new residential stock will represent a significant portion of total building stock in future years. By simply multiplying out latest year's annual new construction data gathered from report participants to both 2030 and 2050, table 1 below illustrates the size of the total building stock that new residential construction can represent. Lastly, BIPV can be more easily applied in new residential construction and be done more optimally if fore-thought to its incorporation occurs in the design and planning stage of either individual buildings or entire developments.

Table 1: Number of dwellings constructed after 2003 and percentage of total housing stock

	2030	*%*	*2050*	*%*
Austria	1 131 678	26%	1 969 958	38%
Canada	4 063 527	24%	7 073 547	36%
Denmark	510 636	18%	888 885	27%
France	9 825 300	24%	17 103 300	36%
Germany	7 406 000	16%	12 696 000	25%
Japan	31 322 241	40%	54 523 901	54%
Netherlands	1 815 075	21%	3 267 135	32%
Norway	501 264	19%	918 984	30%
Portugal	1 776 138	25%	3 142 398	37%
Sweden	702 000	14%	1 222 000	22%
Switzerland	647 610	35%	1 079 350	48%
USA	39 298 500	26%	68 408 500	38%

Note: Data for Japan 2002, Netherlands 2005, Norway 2006, Portugal 2004, Switzerland 2000

Source: Task 10, Subtask 3.1 surveys

The intended audience for this report are those in the PV industry, the construction industry and policy makers. Some of the content of this report will be common knowledge to some members of this audience but has been included to provide a complete picture of the important considerations that must be included in encouraging BIPV in the new residential construction industry. This report will be divided into 4 sections:

1. Innovation and the residential construction industry context
2. BIPV considerations for residential building typologies
3. Proposed PV Industry and policy based solutions to encourage BIPV
4. New residential BIPV potential by data analysis

The emphasis of this report is to provide a new residential construction industry context to the deployment of BIPV. It will describe the building industry's response to new technology and solutions to encourage deployment in the context of the new residential construction industry. This emphasis will be supported by including specific considerations for the most prevalent typologies of residential dwellings including building dimensions, typical building and dwelling ownership structure and typology specific construction industry characteristics. Suggested PV industry and Policy based solutions to encourage the uptake of BIPV by the new residential building industry will then be discussed. Lastly, the presentation and discussion of both dwelling stock and annual construction of residential dwelling stock data by country and related BIPV potential will provide the quantification of this market at an initial penetration level of 1% of all new residential construction.

It is hoped that this report will provide value to the intended audience and encourage increased deployment of BIPV in the new residential construction industry.

1 Innovation and the Residential Construction Industry Context

In an effort to examine best approaches to encourage increased deployment of BIPV in the new residential construction industry, a literature search was undertaken to understand the adoption and diffusion of innovative technology both in general and specific to the building industry, but not including BIPV. This research helps to develop an understanding from the experience that has been gained by other industries and products that have been adopted in various situations.

There is significant literature devoted to the adoption and diffusion of innovation over many industries. From this literature it can be determined that the factors and relationships that lead to adoption and diffusion of innovation are very complex. Determinants can include industry characteristics, human resource availability, economic stimuli and others. The following chart from Koebel et al (2004) summarizes these factors.

Adopter's Human Resources	Adopter's Organizational Structure	Adopter's Organizational Culture and Decision Process
• Skills • Motivation • Commitment • Specialization and Professionalism • Technical knowledge and resources • Managerial attitudes and support	• Size and resources • Centralization • Flexibility • Communication/ administrative intensity • Complexity • Formalization	• Innovation proneness • Organizational support for innovation • Technology champions • Cooperation and openness • Orientation (outward vs. inward) • Organizational position and role of decision maker
Adopter's Market Context	**Industry Characteristics**	**Communication Channels and Social Networks**
• Location • Competitive Strategy • Market scope • Growth strategy • Knowledge of competitors' behaviour • Unionization	• Regionalization • Concentration • Heterogeneity • Inter-firm competitiveness • Growth rate • Wage rates • Government regulation	• Mass media • Word-of-mouth • Opinion leaders • Profession and trade associations • Boundary spanners • Informal and indirect links
Technical Attributes of the Innovation	**Economic Attributes of the Innovation**	**Supplier/Vendor Characteristics**
• Divisibility • Learning by doing • Complexity-crudeness • Type of innovation (process or products) • Complementarities required • Relative improvements in old technologies • Compatibility (values and practice) • Communicability • Relation to innovator product class schemas • High, medium, and low tech • Radical vs. incremental	• Profitability • Uncertainty / risk • Expectations about future prices • Expectation about future tech trajectory of innovation • Labor saving vs. materials saving • Scale neutral vs. lumpy • Initial cost • Continuing cost • Rate of recovery of cost • Time savings • Start-up investment	• Technial capabilities and support • Communications skills • Expertise in monitoring deployment • Public relations

Figure 1.1: Determinants of Adoption and Diffusion (Koebel et al., 2004)

This chart encompasses a wide range of determinants that can influence adoption and diffusion of innovative products or processes. The key aspect is to find which of these determinants are most relevant to the building industry and to BIPV and to focus on these items in developing the BIPV support policies, products and marketing approaches.

One source, Taylor and Levitt, 2004, states that 'Residential building, along with the construction industry in general, is often described [by others] as a laggard in adopting new products and processes'. Taylor and Levitt, 2004 as well as Koebel et al., 2004 have found that this conclusion has not been justified or clearly established. Koebel et al., 2004 go on to state 'Studies specifically focused on technology innovation in construction have found more innovation than suggested by a "laggard" industry'.

Levitt and Taylor, 2004 proceed to differentiate between localized and systematic innovations within the building industry. 'However, upon close examination, research describing "localized" product or process innovations (i.e., those that simply change in practice for a single specialist type project) typically find the industry to be on par with manufacturing industries [in terms of adopting and diffusing innovations], whereas research on product and process innovations that require multiple firms to change their processes ("systemic" innovations) find the industry to be a laggard adopter.' In this context BIPV can typically be considered a localized product or process innovation since it can be adopted by simply a change in practice by a single project specialist, such as an architect or solar installer, and this will influence the context in which solutions are developed to encourage further adoption and deployment of BIPV by the building industry. Although not focussed on in this report, certain approaches to energy efficiency would be considered systematic innovation since they require multiple construction players to appropriately interact in the process of building a home and therefore this can explain why there is laggard behaviour by the building industry in the adoption of such innovations.

By qualifying the construction industry as potentially innovative with respect to the deployment of BIPV technology, one can conclude that the organizations that participate in the residential building industry will be spread across the Rogers Adoptions /Innovation Curve as shown in Figure 1.2. Based on this conclusion it makes sense to separate which builders are part of the Innovators, Early Adopters and Early Majority from the Late Majority and Laggards in the building industry.

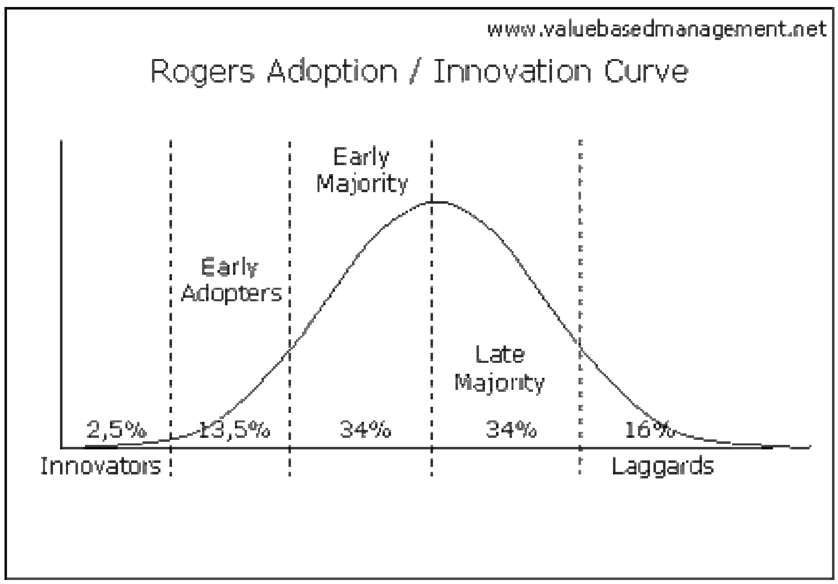


Figure 1.2: Rogers Adoption/Innovation Curve

Koebel et al., 2004 qualify the types of home building firms in the United States that are most likely to be early adopters as:

- Modular builders and multi-family builders
- Single-family custom home builders
- National and regional builders.

Secondly, Koebel et al., 2004 state that these more innovative firms were also more likely to:

- Have a technology advocate within the building firm
- Stress the importance of being creative and the first to use new products
- Use technology transfer programs like the Partnership for Advancing Technology in Housing (PATH) and Universities

- Use union labour at least sometimes.

Conversely, Koebel et al., 2004 state that the types of home building firms that wait until new products, materials, and practices have been around much longer were more likely to be local firms and single-family production builders that also:

- Emphasize marketability and profit
- Associate the firm's success with land development
- Emphasize the 'tried and true' of conventional material and avoid the risks of new materials and products

It is important to note that the quoted items have been source from the USA and therefore will have an American perspective. Other countries will have cultural differences influencing residential construction industry structure and policies. It is important to determine what characteristics can be used to identify a potentially innovative builder or industry sub sector such as government buildings or co-operatives respective to individual countries.

Some other interesting items were found in Koebel et al.2004:

- "Although small, less established manufactures often are the first to introduce new products, residential building construction relies heavily on established manufacturers who stand behind their products.
- In surveys about innovation among home builders, the home purchaser is often identified as an impediment to innovation in residential construction. Homebuyers are supposedly risk-adverse and want the "tried and true." Consequently, the reasoning goes, builders have no choice other than to avoid innovation.
- Higher-income home purchasers, who prefer custom built homes, might perceive traditional building practices as superior to innovative practices. Additionally, upper-income communities might impose more exclusionary regulatory requirements.
- Innovation is inherently risky and disruptive. Rationales for both first-mover and second-mover advantage can be found, with advantage tipped to the second-mover under conditions of uncertain profitability."

These findings in the literature on adoption and diffusion in a range of industries, including the building industry indicate that the construction industry itself should follow typical characteristics of adoption and diffusion innovation. Consideration will now be given to the residential building typology and associated construction industry aspects to encourage the use of BIPV.

2 BIPV Considerations for Building Typologies

Based on the survey information that has been gathered from Task 10 members, three main residential typologies have been identified:

- Single detached
- Attached
- Multi-unit

In order to provide a context under which to describe the application of BIPV to each building type, the description, building dimension and geometry, construction business and typical ownership structure will be discussed. Issues specific to the building type will be discussed in more detail. The basic descriptors are shown in Figure 2.1 below.

Table 2.1: Typical Building Type Descriptors

	Single Family Detached	Attached Housing	Multi-Unit Attached
Description	• Single dwelling unit per building • No other attached dwelling	• Multiple dwelling unit per building • Portion of dwelling, such as wall or foundation attached to other dwelling	• Many dwelling unit per building • Portion of dwelling, such as wall, ceiling or floor attached to other dwelling
Dimension and Geometry	• Near infinite possibilities • Low density per capita • Ratio of roof area/dwelling area dependant on design	• Typically linear geometry • Medium density per capita • Medium ratio of roof area/number of dwelling unit and dwelling area	• Multi- story geometry • Linear geometry • High density per capita • Low ratio of roof area/number of dwelling units and dwelling area
Construction Business	• Small to large companies • Single home to many home developments	• Typically medium to large companies or consortia	• Large companies and consortia
Typical Ownership Structure	• Owner occupied • Some owner investor • Owner maintained property	• Owner occupied or rented • Property maintenance performed by owner or outside contractor per cooperative monthly fee	• Owner occupied or rented • Property maintenance performed by outside contractor per cooperative monthly fee

2.1 General Aspects of Solar Application

A significant number of papers and publications have been created to outline details associated with proper design and implementation of BIPV systems. One such publication provides a definition of BIPV. In his report, Cole et al, 2004 gives a definition of BIPV as ‘Where the PV elements actually become an integral part of the building’. This publication, among others, provides a more thorough description of these aspects.

Although the building type will significantly impact many aspects regarding the integration of BIPV, there are several aspects that are similar in all applications. In the northern hemisphere the optimum orientation of the BIPV panels is due south and in the southern hemisphere the optimum orientation is due north. The optimum slope of the BIPV panels is dictated by the latitude of the location of the building and can be roughly approximated at a slope that is the same number of degrees as the latitude of the location. There is little impact on solar energy harvest within +/- 15 degrees of optimum orientation or slope and the impact of such variations can be simulated through appropriate software by a solar energy designer. Along with considering the orientation and slope of the BIPV panels it is essential to consider if the PV panels will be shaded from the sun by any trees or other buildings over the course of the day and over the course of the year. If there is shading one must determine the significance of this shading and then evaluate if the decreased energy harvest is acceptable, if any of the shading objects can be removed or if the PV module wiring should be adjusted.

2.2 Single Family Detached

2.2.1 Description

Single detached houses are qualified under various names, as demonstrated through the surveys that were returned from Task 10 members. Terms used are as follows: single family dwelling, one unit detached, farmhouse, single family residence and detached house. These can be described as a single building that is designed to provide dwelling space for one family. No other residential dwellings are attached to this building.

2.2.2 Building Dimensions and Geometry

The single detached dwelling has almost infinite flexibility for its general dimensions and geometry within the constraints of the given lot or plot of land that the building is constructed upon. Based on this aspect, effort in design can be undertaken to better accommodate PV and BIPV products. The importance of this aspect is that the design aspects to accommodate BIPV are most easily included up front in the design process. Changes to the design, especially once construction has started can add significant cost to the over all home.

Typically, the PV array is installed on the roof of the single family detached dwelling that faces south in the northern hemisphere and north in the southern hemisphere.

The simplest roof geometry to consider is a square or rectangular plane of the roof. This is demonstrated by the picture shown on the right.

Arial view of rectangular roof plane – ARISE Technologies, Canada

Non-rectangular roof surface - ETI Solar, Canada

Close up of PV panels ETI Solar, Canada

Non-rectangular roof surface -Sharp Solar

The rectangular geometry is not always acceptable from an architectural point of view and therefore some module makers have addressed this by creating modules of various shapes and sizes to accommodate various roof shapes, although non-standard modules adds to the cost. Consideration must still be given to ensure that roof surfaces and geometries themselves do not shade the PV array significantly over the course of the day. Secondly, items like chimneys and plumbing stacks should also be located on the non solar side of the roof whenever practical. In the case where these items need to be located on the solar side of the roof, evaluation of the impact on solar energy harvest needs to be undertaken and the array design can be adjusted to minimize the impact of any reduction on solar energy harvest.

2.2.3 Construction Business

Single detached dwellings are built and marketed in a number of different ways. A home purchaser can hire a company to build a home in a specific location. A second approach is for the builder to purchase and develop land with the construction of homes, offering a number of models and options to the home purchaser.

In the first case where the home purchaser hires a builder or company to build the home, often referred to as custom home building, the home purchaser dictates what he or she desires for the home within certain financial constraints. Therefore with the help of a skilled architect or designer the home purchaser can create a home well suited for BIPV. In this case two main non-financial barriers can exist that may either add cost or prevent the home purchaser from installing the BIPV. The barriers are typically a lack of familiarity of the designer or architect to determine a design to accommodate the BIPV or the inability to find experienced contractors to install the system on the building. In the case where the architect, designer or home builder is not familiar with the technology, they can often influence the home purchaser away from purchasing a BIPV system by communicating some of their own valid or invalid concerns with the technology. These are not technical limitations, as the application of this technology has been seen many times over throughout the world. As the industry grows these non-technical barriers will continue to decrease. As demand increases by home builders there is an increased need for photovoltaic manufacturers and others in the BIPV value chain to provide reliable and readily available solutions to satisfy this market.

In the second case, where the builder is developing a section of land, often the builder will provide several full scale model homes for potential customers to view before they decide whether to purchase. In this scenario it is at the discretion of the builder whether a BIPV option is provided. As discussed in the previous paragraph, a number of issues can prevent the builder from offering BIPV, such as a belief that the homeowner is too risk adverse; the builder is not an early adopter; or the financial return on investment in the given market is not adequate. Product offerings and home designs as well as prices for such offerings and designs are set up front. New technologies and the respective customer response is a risk to the builder. A builder must compete on an open market where prices for homes are compared by price and value in a specific region. In these markets a perceived new technology may or may not have value for the general home purchaser and therefore the builder will appear to be selling homes at a higher price and lower value.

As an example, it has been seen in some markets that when the 'BIPV Option' is offered there is not significant uptake of the option by home purchasers. Alternatively, it has been demonstrated that when a given portion of lots or homes are offered with BIPV as a standard option there is uptake which can be attributed at least in part to the desirability of the location and setting of a given home and not necessarily to the BIPV offering.

2.2.4 Typical Ownership Structure

Single detached homes are typically owned by the occupants of the home. These home owners are therefore able to invest in a BIPV system for other values than simply financial payback. Such values include environmental, future energy price mitigation, prestige and others. As mentioned by Haas, 2002, the determination of a customers' willingness to pay (WTP) will be influenced by both the customers' specific economic situation and value as well as regional aspects such as BIPV support mechanisms and electricity prices. When the builder is providing BIPV in his/her product offering it is not often clear what the customer is willing to pay for these benefits and therefore it is difficult to determine what product offering and price is appropriate.

It has been shown that, although there are a range of possible aspects that a home purchaser will value in the installation of BIPV, the threshold for additional payment is 10 - 15% more for the majority of people (Haas, 2002) and most people in the USA are turned off by a simple payback beyond 15 years (Perez et al.,2004). Some would argue that the installation of BIPV will offer returns by increasing the value of the home, but there has been little data to support such a claim. The customer and the builder will have to evaluate the costs of the system in the context of the regional policy structure that exists and develop approaches that align customer expectations.

Creative cash-flow approaches may offer an economic picture that is more palatable to home owners, such as where capital costs are incorporated into the mortgage. In this case the builder must ensure that the home purchaser has available credit to increase the overall amount spent for the home. Some policy structures may increase the borrowing amount for specific items such as BIPV and energy efficiency measures. Maintenance of the BIPV system will be of significant interest to the home owner and contracts for such maintenance may be of interest from service providers and financiers to provide peace of mind for any maintenance requirements.

2.3 Attached Housing

2.3.1 Description

Attached housing is defined as single family dwelling units which have a common building element such as a foundation or wall. The adjoining dwelling is typically found beside the original dwelling and not above or below. Typical descriptors include row house, linked house, double house, town house, terrace house, tenement house and semi-detached house. All of these types of houses are described in the following section.

2.3.2 Building Dimensions and Geometry

The geometry of this housing type has a significant amount of flexibility, but less than that of single family detached housing. The most common geometry is such that the units are aligned in a linear fashion as shown in figure 2.2 below.

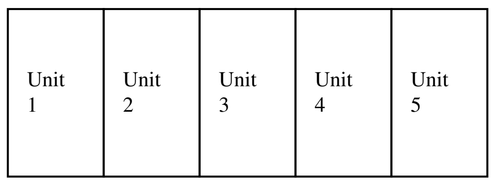


Figure 2.1: Common layout for attached housing

As with single family detached housing, the BIPV panels typically mount on the common roof of the units. Based on the common roof structure, it is extremely important during the design and planning phase to orient the overall set of attached units in a direction such that, when combined with the chosen roof surface geometry, the surface in which the BIPV panels will be mounted is oriented appropriately for maximum solar energy harvest. It is important to consider such items early on where appropriate choices can be made at little or no cost. Alternatively, such changes at a later stage can add significant cost and project delay.

PV Installed on Attached Housing Units, Netherlands.

2.3.3 Construction Business

The construction process for this type of housing will emulate that of detached housing builders who build multiple units, rather than that of custom homebuilders. Again, this dictates that the business model for such units must be competitive in the market in which they are being sold. Local and regional policy will have a significant impact on this building type in order to enable the installation of PV systems. Secondly, in this construction model the builder will be able to consider the benefits of BIPV solutions such as displacement of materials, since the overall design and construction will be typically managed by one entity.

In larger developments, economies of scale are taken advantage of by building repetitive blocks of units. This increases the importance of the planning process for both the installation of PV and design aspects where the purpose is to improve energy efficiency. In larger projects design changes can add significant costs to contractual arrangements, non-usable pre-purchased material and actual cost for changed items. This often perpetuates the belief that both energy efficiency and renewable energy products are not cost effective, even in areas with appropriate policy.

2.3.4 Typical Dwelling Unit Ownership Structure

This building type can be rented or owned. The structure of the ownership of the home will impact the economic structure for which the occupant of the home may best benefit from the installation of the PV system. Attached houses have three basic types of ownership structure:

- Occupant owned with full responsibility of maintenance
- Occupant owned with monthly fee paid to cover maintenance of specific items and overall building and facilities management – such as exterior of home
- Investor owned and rented to occupant

In the occupant owned scenario, the ownership structure will be very similar to that of occupant owned single detached housing. The cost and value of the BIPV system will be carried by the home owner. As mentioned in the section on single detached homes, the value associated with the BIPV system can go beyond simple economics and can be placed on items such as environmental benefits, future electricity price mitigation and prestige. At this point the acceptance by this segment of the market will be dictated by the customers' willingness to pay (WTP) and this will have to be estimated and then tested by the builder. In attached housing consideration would have to be given to the regulations or covenants associated with the entire group of attached dwelling units as these often restrict any exterior change or addition.

In occupant owned attached housing with a monthly maintenance fee, additional approaches to deploying the BIPV system can be employed beyond the approaches mentioned above. The capital cost of the BIPV system per dwelling unit could be reduced by spreading the ownership of a given system through out all owners in a given complex. The value to each owner would then also be reduced, but this could increase the level of affordability to the respective occupants. The financial benefit from the PV system could then be used to offset monthly maintenance and general operational costs. Another approach would be to install the BIPV system only on specific units, providing an option for the home purchaser to choose or not choose the BIPV system for their unit. The maintenance of the system for either option could also then be taken care of by the governing body (or sub-committee of system owners) of the attached housing complex, therefore mitigating the risk for the individual homeowners.

In the last scenario where the attached housing is owned by an investor and rented to the occupant it is most likely that the investor will be most motivated by the economic return from the BIPV system. Regional markets and support policies will influence this economic return. If the BIPV system is installed in such a way that the overall cost of living in such a unit can be lower than comparable units available in the respective market, the installation of BIPV could be seen as a market advantage, but would likely still require additional marketing to convince respective tenants that they may have to pay additional rental costs, but experience lower operating costs. Other values associated with BIPV such as prestige will play less of a role for the investor, but may still increase the marketability for the renter.

2.4 Multi-Unit Residential

2.4.1 Description

Multi-unit residential housing is typically described as a single building with multiple dwelling units separated by both vertical barriers (walls) and horizontal barriers (the ceiling of one unit is the floor of the above unit). Multi-unit residential buildings are often separated into low-rise and high-rise designations. Low-rise is differentiated from high-rise in the following ways:

- Four or less floors is described as a low-rise multi-unit building
- The absence of an elevator is described as low-rise and the presence of an elevator is described as high-rise.

Both low-rise and high-rise dwelling types share many of the characteristics that qualify its ability to effectively install PV on the building.

2.4.2 Building Dimensions and Geometry

The multi-unit residential housing configuration results in significantly higher area of living space per ground area (often referred to as housing density) by essentially stacking housing units on top of one another. This aspect in turn decreases the ratio of the area of roof space that would be appropriate for the installation of PV compared to the number of dwelling units, therefore impacting the amount of electricity generation from PV per dwelling area. For this reason alternative building mounting methods must be considered in addition to roof mounting.

The range of building specific surfaces that are appropriate for BIPV is only limited by the imagination of an architect or designer. The two most common PV mounting techniques on multi-unit residential buildings are roof mounting and façade mounting. Roof top mounting can use similar techniques to that of both single-family detached and attached housing, depending on the specific geometry of the roof surface. Multi-unit buildings are more likely to employ flat roofs for which a variety of flat roof mounting systems are available that are less common for residential, but very common for industrial and commercial applications. Flat roof mounting systems may employ a structure that slopes the BIPV panel toward the sun, or the panel may rest flat on the roof surface. Systems that mount the BIPV directly on the roof surface with no slope often employ additional insulation which can add to the thermal efficiency of the building.


Window shade structure BIPV mounting technique

Façade mounting techniques can be carried out in a variety of ways. The most common two types are mounting the BIPV in the plane of the façade in the curtain wall and mounting the BIPV in a fashion that provides window shading. If done properly, the window shading technique has the opportunity to provide passive solar heating and light in the winter and cooling mitigation in the summer, in addition to the production of electricity.

As for all residential building types, BIPV panel shading must be considered in the design of the system. For high-rise buildings it is less probable that the roof surface will have any shading from other buildings or vegetation, but consideration on the location and grouping of various roof mounted building infrastructure such as air handlers and air conditioners can significantly impact both the ease for mounting and the amount of BIPV located on the roof. Façade mounting of the BIPV panels will need to consider shading from buildings and vegetation, which can be significant in densely populated urban areas.

2.4.3 Construction Business

As in large developments of attached housing, in multi-unit residential development significant time and planning is undertaken for any project in order to gain the most benefit and return from all investments, both in terms of quality and financial return. For this reason the areas of energy efficiency and renewable energy must be considered and planned for early on in the design process to develop appropriate and cost effective solutions. There is significant opportunity for application of BIPV products that have multiple purposes, such as the window shade mounting technique shown above. Often units in a given building are sold prior to construction, based on a described set of features and a rendering of the proposed building. This reinforces the need for up front planning of all aspects that are going to be included in the construction to appropriately market all relevant value sets to the customers.

2.4.4 Typical Dwelling Unit Ownership Structure

In multi-unit residential building the two most common types of ownership structure are:

- Occupant owned with monthly fee paid to cover general building maintenance and common area costs such as pools, tennis courts, etc.
- Investor owned building with units rented to occupants

The first case is very similar to the occupant owned with monthly fee type structure for attached housing, with some exceptions. In multi-unit residential there can often be significantly more units per area appropriate for the installation of BIPV. Secondly, in many buildings there will be dwelling units that do not have direct exposure to the optimum solar orientation. This decreases the likelihood that the electricity that is generated from the BIPV systems could be evenly distributed to all of the dwelling units in building. These inherent aspects of multi-unit residential buildings would better facilitate the use of BIPV generated electricity to be used for common building applications shared by all occupants. Another approach would be to apply the BIPV to specific units, such as penthouse units at the top of the building or units on the optimum side for solar, with appropriate increase prices for such options. The approach taken would influence how the BIPV system would be metered and interconnected to the grid and therefore it is important to consider this in the planning and design stage.

Investor owned buildings would again be likely influenced more by the economic return of BIPV to the building. These will be highly influenced by the policy support and market conditions associated in the area where the building is constructed. As described in the section on attached housing, if the additional costs for the BIPV installation can yield appropriate operating cost savings for the renters, this could be a strong marketing advantage for the building owner. Environmental benefits could also add to the desirability of the units over and above other units in the respective rental market. Lastly, the building owner could simply use the BIPV system to generate additional revenue for the building that is separate from the revenue generated from the renters.

3 Proposed PV Industry and Policy Based Solutions to Encourage BIPV

The increase in adoption and diffusion of BIPV by the new home building industry is a complex issue. Outlined below are a number of proposed solutions, some that have been done and some that are being done, but are presented in the context and understanding of the building industry approach to adoption and diffusion of innovative products as developed in previous sections. Also presented in this section are some approaches suggested in PV and BIPV literature. All solutions will be impacted by regional market conditions in addition to building specific technical aspects of a given technology. Significant effort has been undertaken by the PV industry to address the end customer, but there must also be considerations in policy direction and market structure to encourage builders to offer BIPV products to their customers. The approaches suggested here do not negate the requirement of policy and financial support mechanisms for PV, but rather provide areas of focus in the development of financial tools to exploit this one application area for PV and BIPV technology. Without appropriate financial support measures other efforts to increase uptake in the new residential building industry will have little impact.

3.1 Proposed PV Industry Based Solutions to Encourage BIPV

3.1.1 End-Customer Focus

As stated in the previous section, one impediment to the acceptance of innovative technology such as BIPV in the new residential construction industry is the perception that the customer is risk-averse to new and innovative products. The main goal of the building industry is to generate positive returns by providing various types of dwelling units for its customers by offering products that are desired by these customers for an appropriate price. This goal can only be aligned with the implementation of BIPV if the builder can appropriately understand and access the BIPV customer in his/her market.

The definition of the PV customer has been developed in detail by Haas' 2002 report. In his report, PV customers are described as the group of people who purchase a PV system and/or purchase PV Electricity. Where a residential builder incorporates BIPV on a given structure, the customer's needs and values for the dwelling unit, the PV system and PV electricity must be met. The interest of the PV industry will be focused on the aspects which the BIPV system can meet, but the builder is required to meet all the needs of the customer. Acknowledgement of this fact can help to ensure appropriate engagement of stakeholders in the building industry, such as contractors, installers, and architects, to ensure that stakeholder needs are satisfied in an effort meet all the needs of the end customer. If the needs with respect to the dwelling unit are in any way compromised, or perceived to be compromised due to the application of BIPV this will not be acceptable to the builder and will create a barrier to deployment. Successful integration of BIPV over simply building mounted PV should help to ensure that all stakeholder needs are met due to better aesthetics and overall integration with the building structure.

The customer values tied to the BIPV system on a residential building range from economics to prestige and positive image associated with the installation of a PV system. BIPV products, although unique and attractive to many, will have to compete with many, and mostly more established products that are used in residential construction. Regardless of what set of values are used to rationalize the customer motivation, the BIPV system cost must be lower than the customer's willingness-to-pay (WTP) amount and still provide a financial return to the builder for delivering such a product for continued BIPV deployment in the new residential building industry. This focus and understanding of the PV customer described by Haas is essential for the builder to understand in the delivery of BIPV as part of their product in a given market, but it is the responsibility of the PV industry to provide this information in a concise and articulate manner to the builder.

3.1.2 Identification of Early Adopter Builders

As mentioned in a previous section, it has been shown that builders will range in their respective location on the Adoption/Diffusion Curve. BIPV manufacturers, distributors and installers should target early adopter building companies as they will be more likely to accept and adopt innovative technologies such as BIPV. The work by Koebel et al., 2005 is specific to the United States and therefore such studies to determine characteristics associated with early adopter builders would be relevant to respective countries.

3.1.3 Product Solutions by Manufacturers

The manufacturers of BIPV products must strongly consider construction industry practices in the development of their products. Products that are rugged, can be installed quickly, are aesthetically pleasing and can be proven to be long lasting with little chance of any after-installation support are paramount to builders. In his report, Schoen et al, 2001 states: 'PV manufactures must learn to produce PV systems which meet regular building standards and can be applied by contractors in a straightforward way'. The characteristics mentioned by Schoen can take priority for the building industry over typical 'BIPV only' perspectives that tend to maximize aspects such as solar aperture, cost and efficiency. Of course product design will attempt to maximize as many aspects as possible, but if common building practices are not taken into consideration, the mainstream building industry will be more resistant to accepting the products.

The scope of effort by the manufacturers and their affiliated distributors and installers should also be expanded to areas including education and training of designers/architects and trades as part of the overall promotion of products. To maximize the effectiveness of this effort, the development of such training and education programs would have to be specific to the needs of stakeholders in the building industry. This would expand expertise to the overall BIPV industry, but primarily with their product initially. Such stakeholder participation could also be used to generate new BIPV product ideas and could be formally accomplished through design charrettes or workshops. Efforts of engagement which emphasise that appropriate product support from the manufacturers can be obtained by the builder after the installation are also essential for the building industry stakeholders to begin offering and gaining confidence in such products.

3.1.4 BIPV Market Structure

Partnership between the BIPV manufacturers and the building industry suppliers or directly with new residential builders is a key component to overcoming both the risk associated with an innovative product and the ability to maximize the builder's and manufacturer's profitability. These partnerships should focus on the innovators and early adopters in their respective markets. Some market models for both PV and BIPV have too many participants in the value chain, often placing smaller companies at various stages in the value chain. In an emerging market this is often initially required but as the market matures it can limit certain niches from further market expansion. The sale of BIPV products into the mainstream building industry in the traditional models that include the manufacturer, distributor, installer, and finally the customer increases the net price to the customer far above market values, does not give the participants in the value chain appropriate margins and separates the manufacturer from the builder in terms of customer support.

A direct approach or more direct approach will add cost to the manufacturer, but is required to enter new residential construction markets successfully. This model is already being demonstrated by some leaders in the BIPV market place. An example can be found with Powerlight who is marketing its new SunTile Residential product to homebuilders. It specifically states at www.powerlight.com/product/suntile.php 'SunTile is not available for custom homes or residential retrofit projects'. The SunTile is a BIPV product only available through a list of builders that offer the product, but not to individual dealers and homeowners. This focused effort will result in both cost savings in the overall value chain allowing for increased profitability and to solving specific relationship and product support needs of the building industry. As the market matures, it is expected that this model will again change and introduce building product suppliers to sell to the builders as BIPV production prices decrease for the manufacturer and there is increased margin available in the overall sales structure.

3.1.5 Engagement of construction industry in the design and planning stage

Although this topic may be common knowledge for some in the PV industry, it is of even more importance for the implementation of BIPV. In order for BIPV approaches to be fully integrated into a building and to operate optimally for its given context many building and site aspects must be considered such as the following:

- Roof slope
- Building orientation
- Shading of building and roof from trees, other buildings, other parts of the roof and building
- Development layout including road directions and building placements
- Dimensions of the mounting surface in relations to dimensions of the BIPV system
- Other.

Such characteristics are often chosen arbitrarily in the planning and design phase, but once this phase is complete, there is often very little opportunity for change. It is for this reason that all stakeholders be engaged early in the design and planning stages of a given building or development.

3.2 Proposed Policy-Based Solutions to Encourage BIPV

3.2.1 Building Industry Specific Policy and Market Stimulation

Initial growth of the PV industry has been driven by policy, as demonstrated by the strength of regional markets with appropriate policies in place such as Japan, Germany and California. This is also confirmed by the lack of the PV market growth in countries without appropriate PV support policy such as Canada and Portugal at the present time. The support mechanisms that do exist in the broader photovoltaic markets are positive and need to remain in place as the market matures to the point where they are no longer required. These support policies have typically been aimed at lowering the price of the PV system and/or increasing the value of solar electricity for the end customer. This type of funding continues to be essential, but further efforts are required to address the building industry specifically.

In the report 'Supporting Photovoltaics in Market-Rate Residential New Construction: A Summary of Programmatic Experience to Date and Lessons Learned', Barbos, Wiser and Bolinger, 2006, provide case studies of the PV support programs in nine States of the USA.

This study focuses on the single family dwelling market and finds programs that both encourage and discourage the use of PV in the mainstream building market. In summary, the authors provide 8 recommendations to consider in the development of a support policy to encourage increased deployment of PV by the mainstream building industry, summarized below:

1. Do not create programs that inadvertently disadvantage the new home construction market
2. Track key information about PV installations on new homes
3. Ensure sufficient funding and duration of programs to accommodate long planning processes for the building industry
4. Consider a higher incentive level for new home builders
5. Coordinate PV and energy efficiency programs for residential new construction to minimize transaction costs to builders
6. Cultivate the installer infrastructure
7. Educate and train key professionals in the residential building industry
8. Engage the building community in the development of programs.

Some other key findings mentioned in the paper as specific policy examples are as follows:

1. Prescriptive builder mandates requiring the deployment of PV on homes
2. Financing strategies that provide either increased borrowing amounts for new home purchasers or lower interest rates for new home purchasers that employ BIPV systems
3. Entitlements to home builders that use BIPV such as reduced permitting and inspection fees, higher density allowances, or shorter wait times
4. Bulk purchases by groups of builders
5. Tax rebates directly to the builder rather than the home purchaser.

Regional consideration and other cultural and market specific aspects will have to be given in the development of any policy. The suggestions given toward the development of the policy and the examples of such approaches may or may not maximize the deployment of BIPV within the residential building industry, but the lack of any consideration will limit it. The targeting of early adopter builders and engaging them in the development of such policies will help to maximize the benefits of any support mechanisms.

3.2.2 Demonstration Projects

Demonstration projects provide an opportunity to significantly influence the opinions of the building industry. Schoen et al, 2001 discusses the approach taken by The Netherlands by Novem pv-GO. The approach was 0-1-10-100 where 0 referred to R&D, 1 stands for one off trial, 10 stands for demonstration on a row or street of houses and 100 stands for a neighbourhood demonstration. This type of scale approach will offer builders the opportunity to carry the technology in a lower risk forum where credibility can be added by support from various organisations. As the scale of the demonstrations increase, more builders can be employed in the program and the technology begins to normalize in the building industry.

3.2.3 BIPV Specific Policy

The majority of roof top applications, whether supported by policy or not have been non-BIPV applications. There are a number of reasons for this including:

- Higher availability of conventional framed, non-BIPV modules
- BIPV systems may not meet code requirements
- BIPV systems may have higher costs due to lower volume production
- Application of BIPV systems may require specific building dimensional characteristics
- Weather sealing requirements of BIPV systems may not be proven

The barriers above are neither a complete nor an insurmountable list. Each of the barriers can be adequately addressed by manufacturers of BIPV solutions. The added benefits of BIPV, such as improved aesthetics and reductions of building material, can create both product sales opportunities and positive environmental returns.

Specific policies that provide additional support levels above non-BIPV mounting applications could provide the opportunity to further expand the use of BIPV products to the point where there are no longer cost or other barriers and BIPV applications become normative. This could also provide industrial opportunities to those countries whose market development is less mature and currently face significant imports of PV and related technologies.

3.3 Further Work

There is more work to be done to better understand the needs of the construction industry with respect to BIPV. Japan has established significant in-roads in developing BIPV solutions with builders. The United States is also demonstrating the beginnings of success in this area. Some suggested work that would further this discussion and add to this body of knowledge follows:

1. Detailed analysis of the Japanese home building industry and its context in the development of BIPV system offerings in the housing market. Japanese PV support policy placed focus in the residential markets and has subsequently been successful in developing leading BIPV products that are now being exported around the world. Detailed characterisation of the approaches carried out by the Japanese would allow for other countries and markets to contextualize the Japanese experience and to apply aspects of its success to their own respective market.
2. More country specific analysis of how early adopter builders are characterised and identified to allow these specific builders to be targeted in the development of policies and market structures. This country specific analysis should include cultural as well as building industry characteristics that will vary from country to country.
3. Study and development of additional case studies of large scale deployments of BIPV in the new residential building market, identifying policy context and building industry attributes such as level of innovativeness by the participating builders.

4 New Residential BIPV Potential by Data Analysis

The purpose of this section is to provide analysis to quantify the potential for deployment of BIPV in the new residential construction market. This analysis will compare the number of dwelling units being constructed annually to the existing distributed PV market and therefore provide a quantitative potential for this deployment area.

4.1 Methodology

Data has been gathered from Task 10 and PV-Upscale member countries to determine the potential of BIPV in the new residential application area. Data was requested for both the existing residential building stock and the annual new residential construction for single family detached, attached and multi-unit attached housing based on the number of dwelling units. A target year of 2003 was chosen because it was determined that this year provided the most recent and most complete data sets. It is specifically noted where alternate year data was used.

To determine the technical potential for the application of BIPV in the new residential construction market, values of installed BIPV per dwelling unit were chosen and multiplied by the annual new residential construction values. The following values were used for the respective new residential construction typologies:

- 3 kWp per single family detached dwelling unit
- 1,5 kWp per attached dwelling unit
- 0,5 kWp per multi-unit attached dwelling unit

These numbers have been developed based on a cursory view of case studies of existing PV and BIPV projects. It is expected that these values are conservative in nature and therefore a range of values have been shown in the full data sets found in the annex.

The resultant product based on this calculation yielded a maximum technical potential in this market and was then compared to the annual representative PV installed in each respective country. Values for two categories of grid-connected PV installations are currently being captured by the IEA PVPS: centralized and distributed applications. Below are the definitions as provided in the glossary at http://www.iea-pvps.org/:

- Grid-connected distributed photovoltaic power system: System installed on consumers' premises usually on the demand side of the electricity meter. This includes grid-connected domestic photovoltaic power systems and other grid-connected photovoltaic power systems on commercial buildings, motorway sound barriers, etc. These may be used for support of the utility distribution grid.

- Grid-connected centralized photovoltaic power system: power production system performing the function of a centralized power station (also said centralized photovoltaic power plant).

New residential BIPV fits under the distributed category and therefore the BIPV potential measured in kWp developed from the annual new residential construction and the respective kWp per dwelling unit were compared to the annual distributed grid-tied PV installations of the same year. A 1% penetration into this deployment area was then chosen as an initial target. This target was chosen because it appeared that only a nominal amount of BIPV was deployed in new residential construction and therefore this would be an appropriate starting penetration level. Secondly, it was deemed relevant to determine if this level of penetration could provide significant market opportunity for respective countries. This 1% penetration is shown in units of both kWp and as a percentage of the existing distributed grid-connected PV market, referred to as New Residential BIPV potential and New Residential BIPV percentage potential respectively

4.2 Results

The building stock data collected from the respective countries is shown below in Figure 4.1 and Table 4.1. The figure and table show the number of dwelling units in total from the three typologies collected from the respective countries. This data provides an indication from a building stock perspective of what types of housing are currently most common in each country and the relative market size when compared to other housing stocks from other countries. Detailed data sets for each country can be found in the section 7 annex.

Figure 4.1: Building Stock by number of dwellings by residential building type, by country, 2003

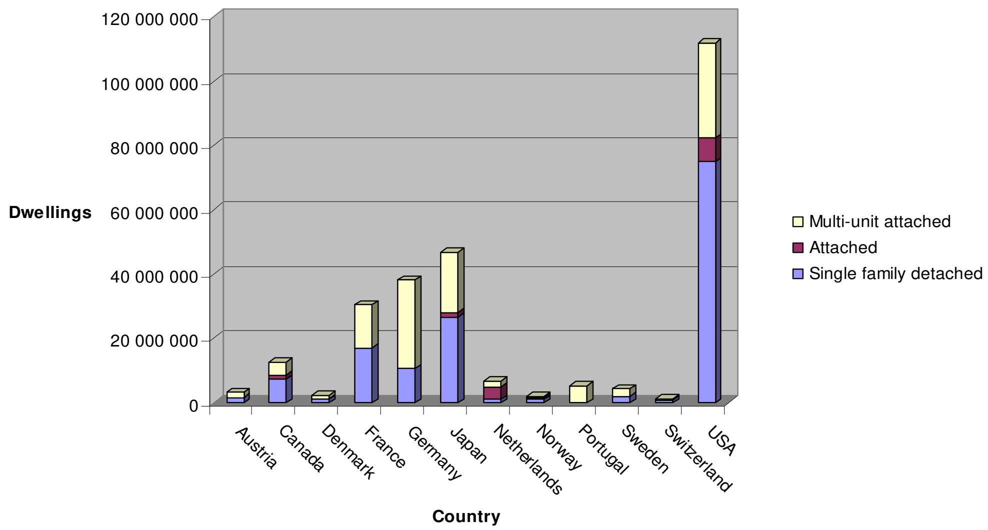


Table 4.1 Building Stock by number of dwellings by residential building type, by country, 2003				
	Single family detached	Attached	Multi-unit attached	Total
Austria	1 587 000	0	1 672 000	3 259 000
Canada	7 349 362	1 340 580	3 852 737	12 542 679
Denmark	1 039 539	333 312	984 827	2 357 678
France	17 133 000	0	13 341 000	30 474 000
Germany	10 658 000	0	27 500 000	38 158 000
Japan	26 491 200	1 482 600	18 732 800	46 706 600
Netherlands	1 062 150	3 819 290	1 992 785	6 874 225
Norway	1 119 844	415 068	360 770	1 895 682
Portugal	0	0	5 319 878	5 319 878
Sweden	1 986 000	0	2 366 000	4 352 000
Switzerland	821 719	129 760	227 799	1 179 278
USA	74 916 000	7 227 000	29 663 000	111 806 000

Note: Data for Germany are for 2002, Data for Netherlands is 2005, Data for Norway is 2001, Data for Switzerland is 2000
Note: Dwelling stock data from Portugal did not separate building typology. It is assumed that single family detached represents this smallest portion of the dwelling type.
Note: Where Attached housing is not shown, it is included in the multi-unit attached category, except for Sweden where it is included in the Single family detached category

Figure 4.2 and Table 4.2 below show the annual construction and building typology for each of the countries involved in the study. This data was used to calculate the BIPV potential that was possible in the new residential construction area.

Figure 4.2 : Number of dwellings constructed annually by residential building type, by country in 2003

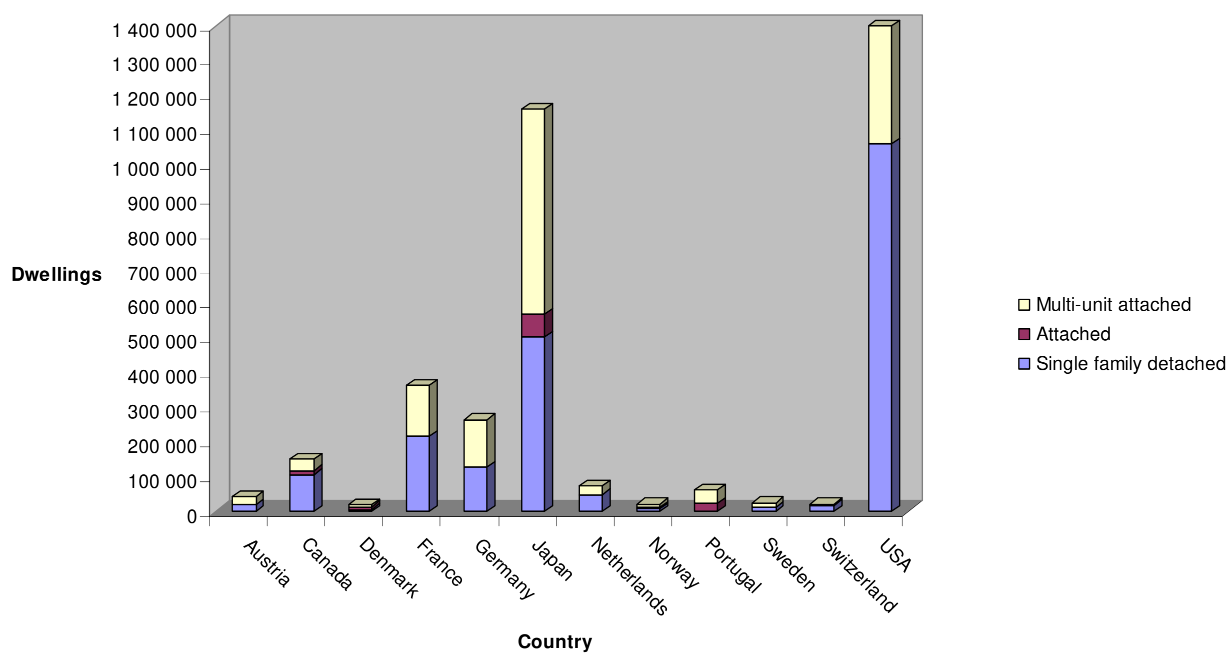


Table 4.2:Number of dwellings constructed annually by residential building type, by country in 2003

	Single family detached	Attached	Multi-unit attached	Total
Austria	20 410		21 504	41 914
Canada	106 467	12 424	31 610	150 501
Denmark	6 631	6 275	6 006	18 912
France	216 000		147 900	363 900
Germany	128 000		136 500	264 500
Japan	501 785	66 147	592 151	1 160 083
Netherlands	49 123		23 480	72 603
Norway	7 141	4 959	8 786	20 886
Portugal	571	23 594	37 459	61 624
Sweden	12 000	0	14 000	26 000
Switzerland	16 825	1 131	3 631	21 587
USA	1 060 000		395 500	1 455 500

Note: Data for Germany are for 2002, Data for Netherlands is 2005, Data for Norway is 2001, Data for Switzerland is 2000
Note: Dwelling stock data from Portugal did not separate building typology. It is assumed that single family detached represents this smallest portion of the dwelling type.
Note: Where Attached housing is not shown, it is included in the multi-unit attached category, except for Sweden where it is included in the Single family detached category

Figure 4.3 and Table 4.3 below now compare the above mentioned annually constructed residential dwelling stock data to the annual installed grid connected distributed PV installed for each respective country. This figure indicates the technical installed capacity potential of BIPV on new residential construction based on a 1% penetration in the new residential construction deployment area.

Figure 4.3: Installed PV in Distributed Applications and New Residential BIPV Potential, 2003

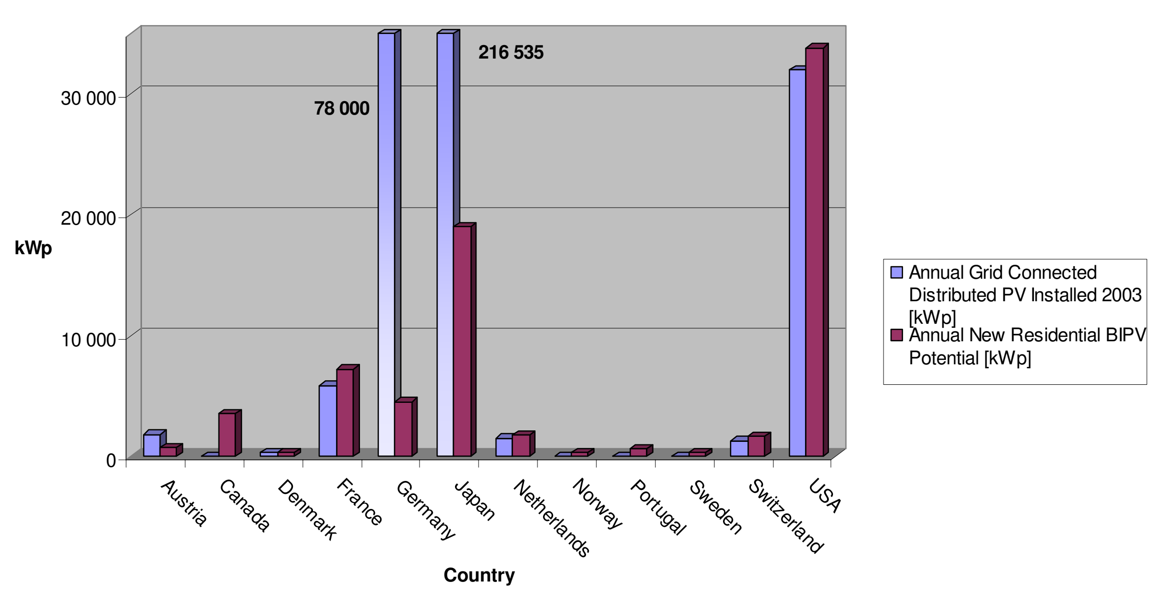


Table 4.3: Installed PV in Distributed Applications and New Residential BIPV Potential, 2003

	Annual Grid Connected Distributed PV Installed 2003 (kWp)	Annual New Residential BIPV Potential (kWp)	Market Potential Percentage compared to existing market
Austria	1 833	720	39%
Canada	37	3 538	9 563%
Denmark	300	323	108%
France	5 900	7 220	122%
Germany	78 000	4 523	6%
Japan	216 535	19 007	9%
Netherlands	1 547	1 786	115%
Norway	7	333	4 751%
Portugal	33	631	1 912%
Sweden	15	300	2 000%
Switzerland	1 300	540	42%
USA	32 000	33 778	106%

Note: Annual Grid Connected Distributed PV Installed 2003 Data for Austria is 2004, for France is 2005, for Germany is 2002, for Netherlands is 2005, for Portugal is the average of 2002, 2003 and 2004, for Sweden is the average of 2002, 3003 and 2004
Note: Housing Data for calculations for Annual New residential BIPV Potential for Austria is from 2002, France is from 2005, Germany is from 2002, for Norway is from 2001, for Netherlands is from 2005, for Portugal is from 2004, for Switzerland is from 2000
Note: Annual New Residential BIPV Potential is based on 1% market penetration with 3kWp installation per single family unit, 1.5 kWp installed per attached unit and 0.5 kWp installed per multi-unit attached unit built per year.
Note: The Netherlands had significant support programs for PV prior to 2004. Beginning in 2004, these programs were abruptly ended and this has resulted in significant market decline, reportedly to year 2000 levels. More recent IEA data indicates that further market decline from 2000 levels has been experienced and therefore annual grid-connected PV installed 2005 data is used for this graphical illustration.
Source for Annual Grid Connected Distributed PV Installed 2003: http://www.iea-pvps.org/isr/index.htm

4.3 Technical New Residential BIPV Market Discussion

Figure 4.3 and Table 4.3 above indicates a range of potential for new residential BIPV when compared to existing distributed grid connect PV markets. Based on the parameters outlined in the methodology, the potential for BIPV in this new residential construction application area ranges from 6% to 9563%. This is a very wide range and therefore requires further evaluation.

4.3.1 Influencing Factors

Two main factors influence the potential percentage of the distributed grid-connected PV market that the new residential construction deployment could represent. The first factor is the size of the existing distributed PV market. The size of the market is typically directly influenced by whether favourable or unfavourable support mechanisms exist for PV or BIPV. If this market is very small, as in the case of Canada, Norway, Portugal and Sweden, which are all under 40 kWp per year, a modest implementation of BIPV in the new residential construction area can represent a significant percentage of the distributed grid-connected PV market. If the distributed grid-connected PV market is large, as in the case of Germany, Japan and USA, a larger implementation of BIPV in the new residential construction area will be required to result in significant percentage potentials being shown.

The second factor is the size of the annual construction market and respectively, the typology of residential units that are most prevalently being constructed. The five largest markets shown by the data are USA, Japan, Germany, France and Canada. These respectively have the largest potential in new residential construction deployment when measured by kWp. With respect to the typology of new home construction, since the methodology indicates that a higher level of kWp BIPV can be installed per dwelling unit on single family detached units, compared to both attached and mulit-unit attached, a higher construction rate of single family detached units will result in a higher potential for new construction BIPV deployment. Secondly, where the dwelling unit data did not separate attached and multi-unit attached, the blending of these two dwelling unit types into the multi-unit attached typology will result in a lower average kWp deployed per total dwelling units constructed. Since this data was not readily available, based on the surveys returned from some of the member countries, further investigation on this aspect may be warranted for specific countries.

4.3.2 Very High New Residential BIPV Percentage Potential Countries

For Canada, Norway, Portugal and Sweden, deployment of BIPV in 1% of new residential construction could represent 9563%, 4751%, 1912% and 2000% respectively of the 2003 distributed grid-connected PV market. The reason for such a high percentage is a combination of the influencing factors as discussed above. All 4 markets have very modest annual distributed grid-connected PV markets (the 4 smallest markets and all under 40 kW per year). The Norwegian, Portuguese and Swedish new residential construction markets are the 7th, 9th and 11th largest of the 12 countries polled, but in relation to its small annual distributed grid-connected PV market, a net potential is significant. The Canadian new residential construction market is the 5th largest of the 12 countries polled and therefore results in the largest potential for new residential BIPV to grow the distributed grid-connected market through the BIPV application area.

The chart indicating the typology of housing constructed annually in the four countries shows some differences. Portugal is significantly weighted in favour of multi-unit attached and attached housing, while Canada is weighted in favour of single family detached. Norway and Sweden are evenly distributed through the varying housing typologies. These differences could significantly influence the development of both product solutions and policy structures to best develop the potential in this area. Portugal may focus on both product solutions and policy directions that focus on attached and mult-unit construction, where Canada may focus on single family detached dwellings. Norway and Sweden may choose which ever typology appears the simplest to access and then later focus on alternate typologies. The merits of such a focused approach should be examined further.

4.3.3 High New Residential BIPV Percentage Potential Countries

The countries that fall into this category are countries that have a new residential BIPV percentage potential that is greater than 25% and include Austria, Denmark, France, Netherlands, Switzerland and USA. This level is chosen rather arbitrarily, but since only a 1% market penetration into the new residential construction industry has been chosen for this analysis, a modest penetration of 5% into this application area could easily result in a doubling of the existing total distributed grid-connected PV market, since all survey respondents indicated that less than 1% of new residential construction dwelling units implement BIPV today.

The countries that fall into this category represent a range of both distributed grid-connected PV market size and annual new residential construction size. Based on the combination of these two factors the new residential BIPV percentage potential ranges from 39% to 122% percent, and by far the USA represents the largest market size in terms of kWp potential per year due to its number of annual new residential construction dwellings built. In the range of countries some countries have support programs that specifically address the new residential construction market while some do not. Regardless of which is the case, specific market or policy structures, as described in previous sections, could be used to significantly exploit this particular market, considering again the relative weighting of respective residential typologies.

4.3.4 Low New Residential BIPV Percentage Potential Countries

The largest and two most mature PV markets in the world are Germany and Japan. These two markets also yield the lowest percentage potential for new residential applications. In these markets it can be assumed that the new residential construction market is already providing a portion of the overall distributed grid-connected PV market, but received surveys indicate that new residential construction is contributing less than 1% to the overall distributed PV market.

The latest IEA data for the German grid-tied PV market no longer breaks out the distributed versus centralized installations and therefore a comparison between the distributed versus centralized installations can not be made. It is known that under the current feed-in tariff support structure significant centralized installations are being undertaken. The influence of the size of the existing grid-connected market in Germany significantly reduces the direct influence that new residential construction could have on the overall grid-connected PV market. Secondly, the amount of new residential dwellings constructed annually in Germany is significantly less than in Japan.

Japan is the most mature grid-connected PV market in the world and has had various financial support mechanisms in place, some specifically for residential application of grid-connected PV. Although this residential specific funding has ended in FY 2005, leadership from Japan can be seen in the area of residential PV and BIPV applications. As shown in Figure 4.4 the residential market for PV is the largest market in Japan. As shown in Figure 4.5, the new residential construction market only represents a small portion of this residential market, and BIPV represents an even smaller portion of that.

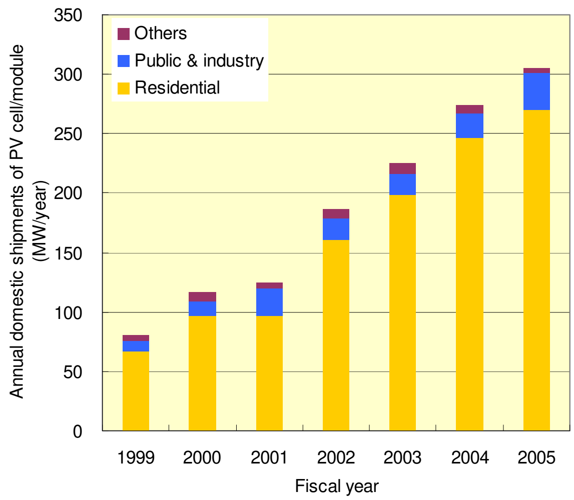


Figure 4.4: Annual Domestic Shipment of PV in Japan

Source: Presentation by K. Komoto, Stakeholders Workshop, IEA-PVPS Task 10, Malmo Sweden, September 2006, Reference: Japan Photovoltaic Energy Association

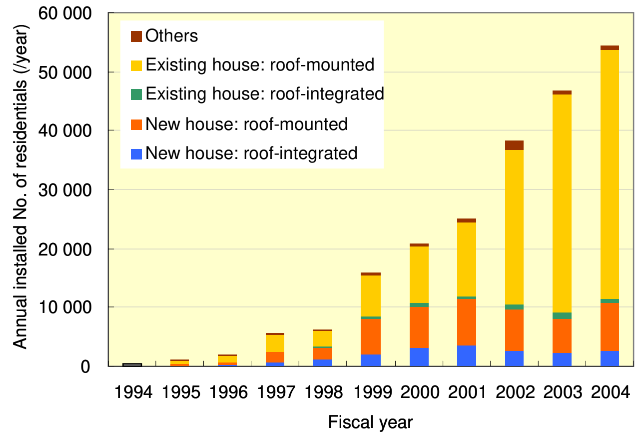


Figure 4.5 Japanese Annual installed Number of systems by typology

Source: Presentation by K. Komoto, Stakeholders Workshop, IEA-PVPS Task 10, Malmo Sweden, September 2006, Reference: New Energy Foundation

Even though this is small in proportion to the overall Japanese market, when compared to other countries, the Japanese experience is significant. The high percentage of residential applications in the overall market in Japan indicates the value of a targeted approach for both policy support and resultant technological solutions. Further study of the Japanese applications in the new residential construction market is merited to determine more specific lessons that can be learned and used by other countries.

5 Conclusions

The building industry has the opportunity to significantly further the use of BIPV in buildings throughout the world. Although this is the case, there has at times been very slow uptake of this innovative technology by the residential construction industry. This report has focused on the new residential construction industry and by understanding this industry and its approach to the adoption and diffusion of innovative technology one can take measured steps to encouraging its use of BIPV.

The building industry, often thought to be a laggard to all innovation, has been shown to be on par with adoption and diffusion of innovations with many industries. This realization allows for the initial targeting of those companies and firms in the new residential construction industry that are early adopters to develop production solutions and policy and promote market programs to encourage acceptance of BIPV. This is the responsibility of both the BIPV manufacturers and those developing government support policy. This approach can be further leveraged by engaging these early adopters and innovators in the building industry that they are trying to target in the development of such product solutions and policy support approaches.

The varying common types of residential building structures, along with the typical ownership structure and construction business, impact on how BIPV can be deployed. The attributes of each building type can strongly influence what technologies are considered as well as how both marketing and support policies can be implemented at all levels of the BIPV value chain. Regardless of the building typology, there are no technical barriers that cannot be overcome by appropriate design and planning. The PV industry and those developing policy must include typology specific considerations when developing approaches intended to encourage the use of BIPV in the new residential construction industry such as typology dimensional, ownership, and construction industry characteristics.

Many of the application areas and related policy support mechanisms that have been exploited in the PV industry do not adequately address the new residential construction industry. Approaches have been outlined for both the PV industry and policy developers to better encourage BIPV use in the new residential construction industry. These approaches and the rational supporting them must be considered and used to have maximum impact in this application area for BIPV.

Using what is believed to be a conservative methodology, the data shown and discussed indicates that the new residential construction market can play a significant role in the overall distributed grid-connected PV market. The most significant opportunity can be found in areas where the grid-connected PV market is smaller and less mature, combined with a comparatively active new residential construction market. Canada, Norway, Portugal and Sweden exhibit very high BIPV potential percentage in the new residential construction industry at 1912% to 9563% when compared to existing distributed grid-connected PV markets. Austria, Denmark, France, Netherlands, Switzerland and USA exhibited significant BIPV potential percentage varying from 39% to 122%. Germany and Japan exhibited a low BIPV potential percentage of 6% and 9% respectively. This low BIPV potential percentage was largely influenced by the significant size of the respective distributed grid-connected markets, being the two largest markets in the world. The USA has the highest BIPV potential in this application area when measured in kWp. This is due to the significant level of new residential construction in the USA.

Further work is recommended in the specific countries that were not able to provide housing data that fully separates the housing typologies, as this can influence the BIPV potential.

Secondly, further refining of the size of systems per housing typology could provide a more accurate measure of the potential for this application area. Lastly, it is recommended that the Japanese experience be studied more closely since they have shown significant leadership in the application of PV in the new residential construction area.

6 References

Barbose, G., Wiser, R., Bolinger, M., Supporting Photovoltaics in Market-Rate Residential New Construction: A Summary of Programmatic Experience to Date and Lessons Learned, Berkleley Lab and the Clean Energy States Alliance, 2006

Cole, R.J., Crowley, P., Davidson, B., McDonald, I., Mainstreaming Building –Integrated Photovoltaics in Canada, UBC School of Architecture, Royal Architectural Institute of Canada, Natural Resources Canada, 2004

Haas, Reinhard, Market Deployment Strategies for PV Systems in the Built Environment, Report IEA PVPS T7-06:2002

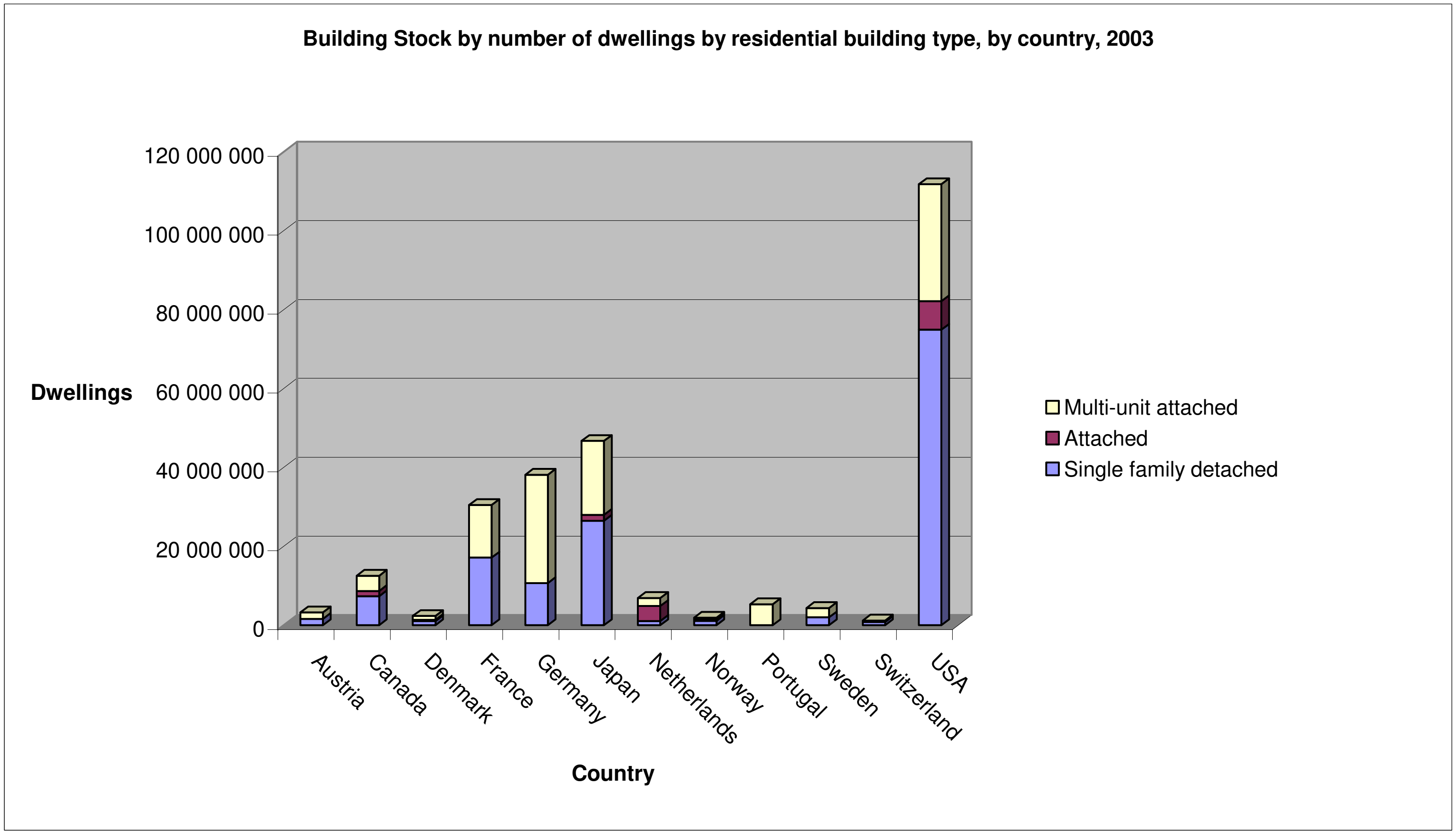
Koebel, C.T., Papadakis, M., Hudson, E., Cavell, M., The Diffusion of Innovation in the Residential Building Industry, Prepared for the U.S. Department of Housing and Urban Development Office of Policy Development and Research, 2004

Perez,R., Burtis, L.A., Hoff, T., Swanson S., Herig, C., Quantifying Residential PV Economics In the US 2004

Schoen, Tony J.N., Building Integrated PV Installations in The Netherlands – examples and operational experiences, 2001

Taylor, T., Levitt, R., Bridging the Innovation Gap in Project-based Industries: 2003-2004 CIFE Seed Project Report, Stanford University Center for Integrated Facility Engineering, 2004

7 Annexes –International Housing Data and Definitions



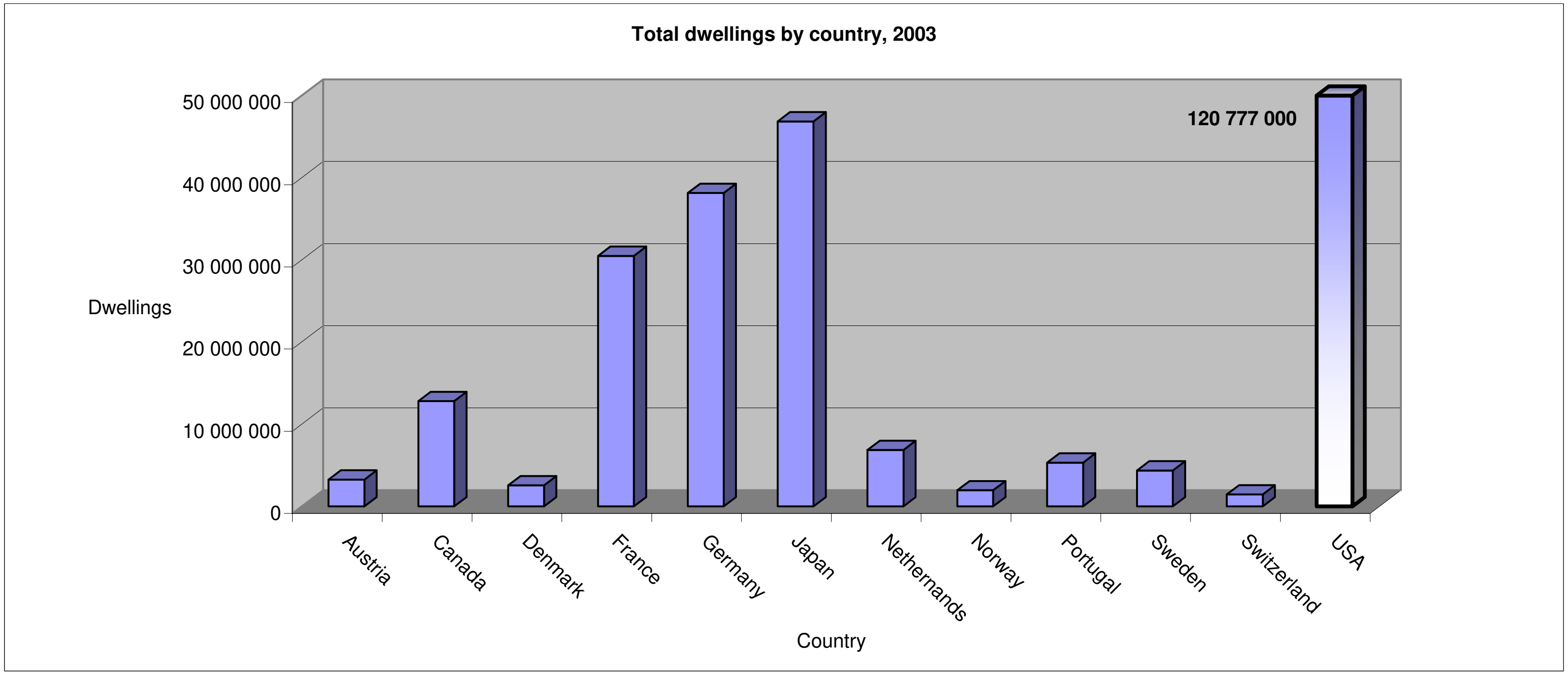
Building Stock by number of dwellings by residential building type, by country, 2003

	Austria	*Canada*	*Denmark*	*France*	*Germany*	*Japan*	*Netherlands*	*Norway*	*Portugal*	*Sweden*	*Switzerland*	*USA*
Single family detached	1 587 000	7 349 362	1 039 539	17 133 000	10 658 000	26 491 200	1 062 150	1 119 844		1 986 000	821 719	74 916 000
Attached		1 340 580	333 312			1 482 600	3 819 290	415 068			129 760	7 227 000
Multi-unit attached	1 672 000	3 852 737	984 827	13 341 000	27 500 000	18 732 800	1 992 785	360 770	5 319 878	2 366 000	227 799	29 663 000

Note: Data for Germany are for 2002, Data for Netherlands is 2005, Data for Norway is 2001, Data for Switzerland is 2000

Note: Dwelling stock data from Portugal did not separate building typology. It is assumed that single family detached represents this smallest portion of the dwelling type.

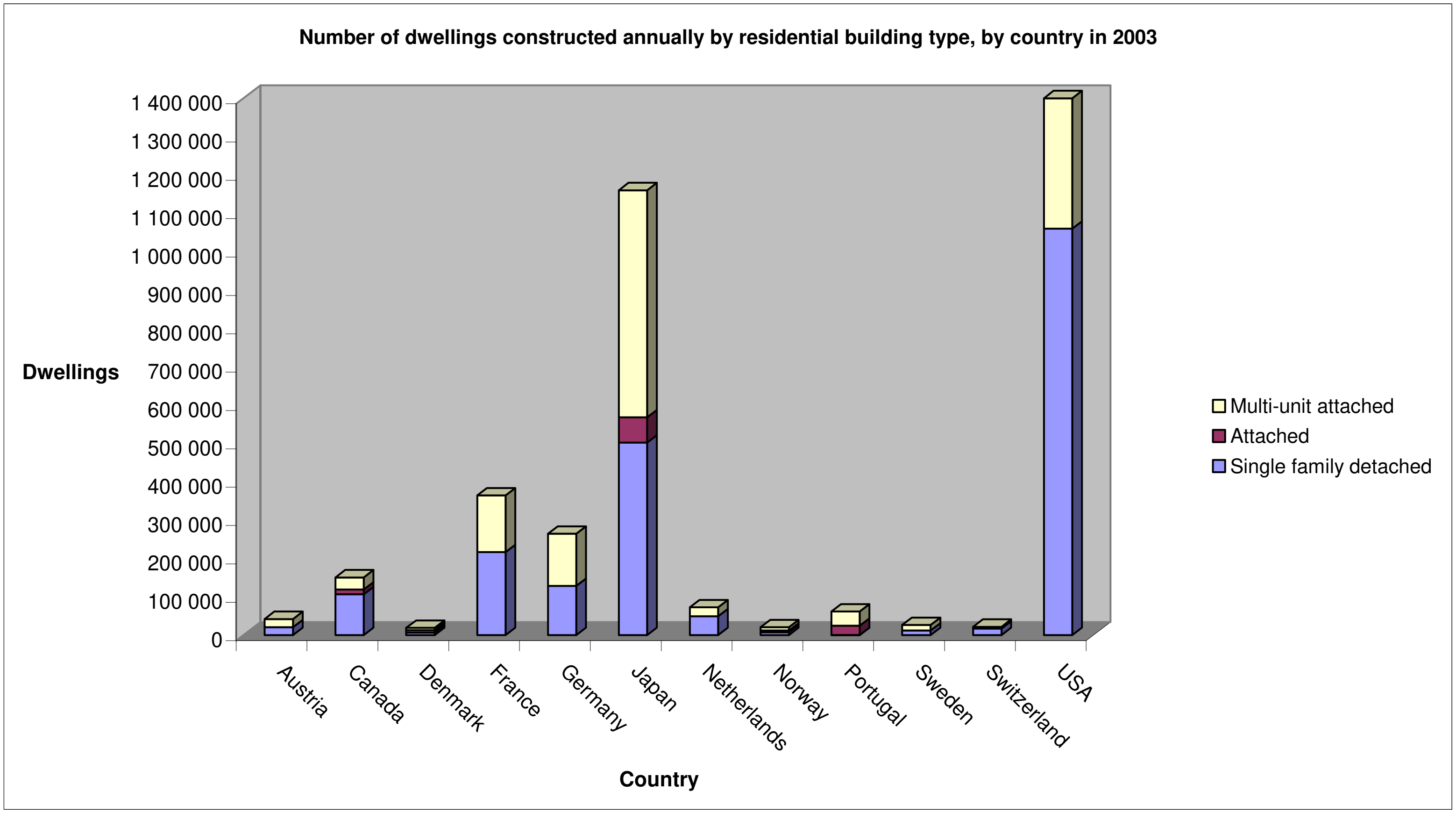
Note: Where Attached housing is not shown, it is included in the multi-unit attached category, except for Sweden where it is included in the Single family detached category



Total number of dwellings by country, 2003

	Austria	*Canada*	*Denmark*	*France*	*Germany*	*Japan*	*Nethernands*	*Norway*	*Portugal*	*Sweden*	*Switzerland*	*USA*
Total dwellings	3 259 000	12 810 000	2 561 000	30 475 000	38 158 000	46 862 900	6 874 225	1 961 548	5 319 878	4 351 000	1 462 167	120 777 000

Note: Data for Germany are for 2002, Data for Netherlands is 2005, Data for Norway is 2001, Data for Switzerland is 2000



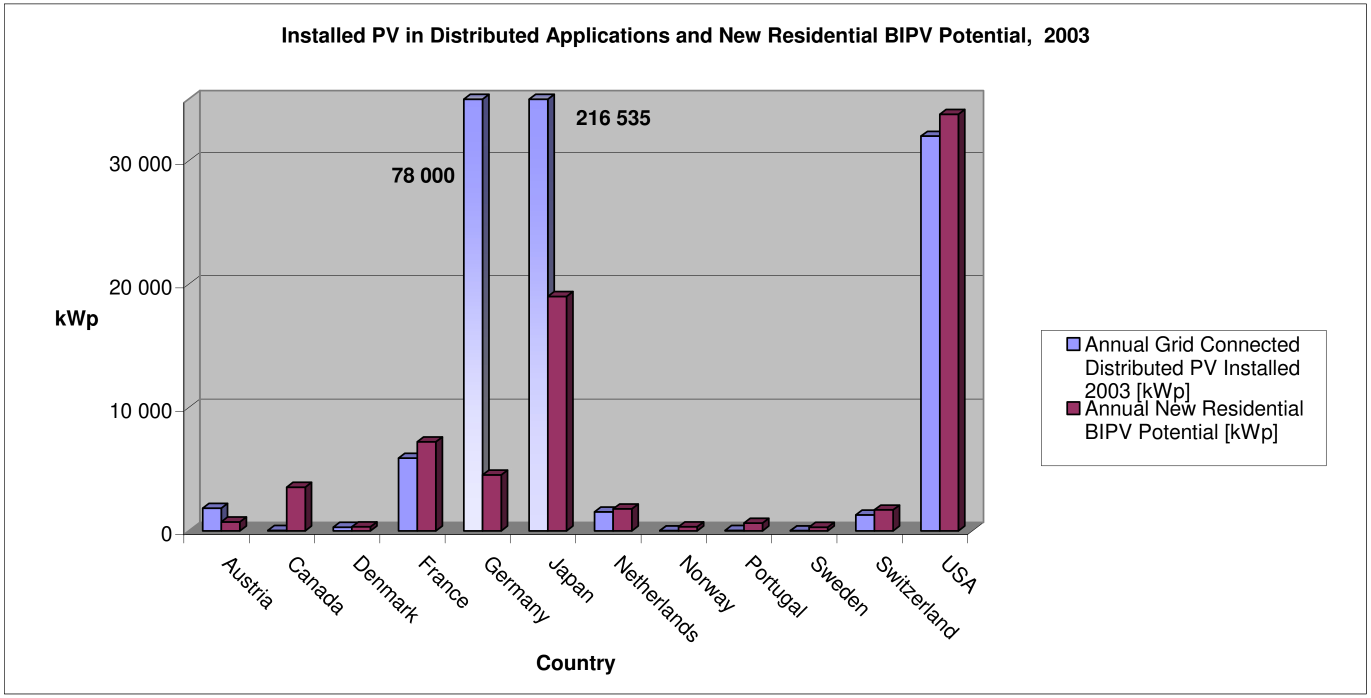
Number of dwellings constructed annually by residential building type, by country in 2003

	Austria	*Canada*	*Denmark*	*France*	*Germany*	*Japan*	*Netherlands*	*Norway*	*Portugal*	*Sweden*	*Switzerland*	*USA*
Single family detached	20 410	106 467	6 631	216 000	128 000	501 785	49 123	7 141	571	12 000	16 825	1 060 000
Attached		12 424	6 275			66 147	0	4 959	23 594	0	1 131	
Multi-unit attached	21 504	31 610	6 006	147 900	136 500	592 151	23 480	8 786	37 459	14 000	3 631	395 500
Total	41 914	150 501	18 912	363 900	264 500	1 160 083	72 603	20 886	61 624	26 000	21 587	1 455 500

Note: Data for Germany are for 2002, Data for Netherlands is 2005, Data for Norway is 2001, Data for Switzerland is 2000

Note: Dwelling stock data from Portugal did not separate building typology. It is assumed that single family detached represents this smallest portion of the dwelling type.

Note: Where Attached housing is not shown, it is included in the multi-unit attached category, except for Sweden where it is included in the Single family detached category



Installed PV in Distributed Applications and New Residential BIPV Potential, 2003

	Austria	Canada	Denmark	France	Germany	Japan	Netherlands	Norway	Portugal	Sweden	Switzerland	USA
Annual Grid Connected PV Installed 2005 [kWp]	1 980	612	320	5 900	632 000	287 105	1 547	0	20	0	3 800	70 000
Annual Grid Connected Distributed PV Installed 2003 [kWp]	1 833	37	300	5 900	78 000	216 535	1 547	7	33	15	1 300	32 000
Annual New Residential BIPV Potential [kWp]	720	3 538	323	7 220	4 523	19 007	1 786	333	631	300	1 697	33 778
Market Potential Percentage compared to existing market	39%	9 563%	108%	122%	6%	9%	115%	4 751%	1 912%	2 000%	42%	106%

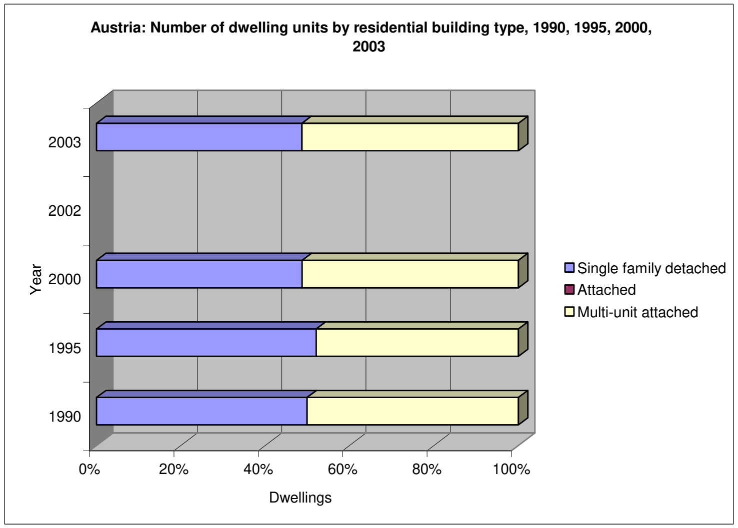
Note 1: Annual Grid Connected Distributed PV Installed 2003 Data for Austria is 2004, for France is 2005, for Germany is 2002, for Netherlands is 2005, for Portugal is the average of 2002, 2003 and 2004, for Sweden is the average of 2002, 3003 and 2004

Note 2: Housing Data for caluclations for Annual New residential BIPV Potential for Austria is from 2002, France is from 2004, Germany is from 2002, for Norway is from 2001, for Netherlands is from 2005, for Portugal is from 2004, for Switzerland is from 2000

Note 3: Annual New Residential BIPV Potenial is based on 1% market penetration with 3kWp installation per single family unit, 1.5 kWp installed per attached unit and 0.5 kWp installed per multi-unit attached unit built per year.

Note 4: The Netherlands had significant support programs for PV prior to 2004. Beginning in 2004, these programs were abruptly ended and this has resulted in signficant market decline, reportly to year 2000 levels. More recent IEA data indicates that further market decline from 2000 levels has been experienced and therefore annual grid-connected PV installed 2005 data is used for this graphical illustration.

Source for Annual Grid Connected PV Installed 2005 and Annual Grid Connected Distributed PV Installed 2003: http://www.iea-pvps.org/isr/index.htm



Country	Austria				
Number of dwelling units by building type					
	1990	*1995*	*2000*	*2002*	*2003*
Single family detached	1 693 000	1 619 000	1 881 000		1 587 000
Attached					
Multi-unit attached	1 700 000	1 491 000	1 977 000		1 672 000

Source: Housing Statistics in the European Union. 2004. Table 3.1, http://www.iut.nu/EU/HousingStatistics2004.pdf

Note: Attached housing stock is included in multi-unit attached.

Country	Austria
Number of newly built dwelling units by building type	
	2002
Single family detached	20 410
Attached	
Multi-unit attached	21 504

Source: Residential Multiple New Housing Unit Building Industry Survey, Austria Statistics.xls

Note: The number found in the above table is calculated based on the ratio of single family attached to multi-unit attached dwellings in 2003 multiplied by the total number of newly constructed units in 2002 since the data indicates that the housing stock is decreasing.

Country	Austria			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		*2050*	
Single family detached	551 081	26%	959 289	38%
Attached				
Multi-unit attached	580 597	26%	1 010 669	38%
Total	1 131 678	26%	1 969 958	38%

Country	Austria	
BIPV install on newly built dwelling units by building type		
	kW BIPV per Unit	*2002*
Single family detached	1.00	20 410
	2.00	40 821
	3.00	61 231
	4.00	81 642
	5.00	102 052
Attached	0.50	0
	1.00	0
	1.50	0
	2.00	0
	2.50	0
Multi-unit attached	0.10	2 150
	0.25	5 376
	0.50	10 752
	0.75	16 128
	1.00	21 504

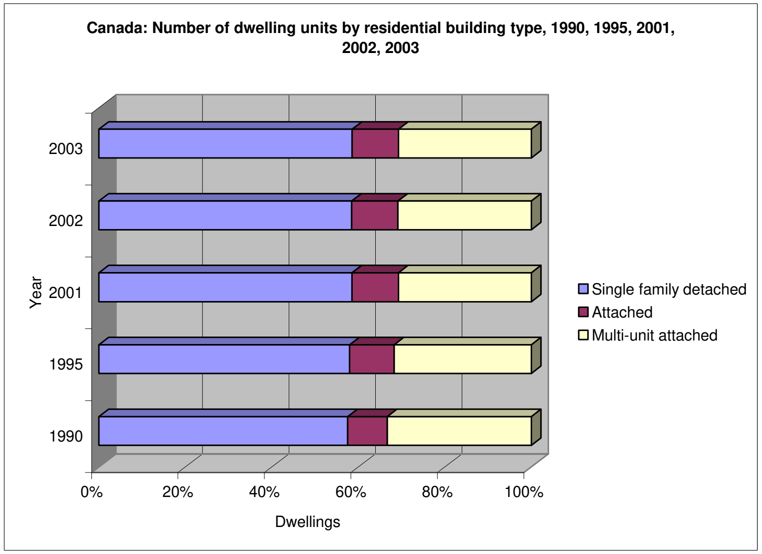
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	1 833
Potential kWp installed	61 231
1% market penetration	612
2% market penetration	1 225
5% market penetration	3 062

Attached	kWp
Installed distributed Grid Capacity in 2003	1 833
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	1 833
Potential kWp installed	10 752
1% market penetration	108
2% market penetration	215
5% market penetration	538

Total	kWp
Installed distributed Grid Capacity in 2003	1 833
Potential kWp installed	71 983
1% market penetration	720
2% market penetration	1 440
5% market penetration	3 599

% Market Potenial at 1% Market Penetration	39%
% Market Potenial at 2% Market Penetration	79%
% Market Potenial at 5% Market Penetration	196%



Country	Canada				
Number of dwelling units by building type					
	1990	*1995*	*2001*	*2002*	*2003*
Single family detached	5 865 174	6 549 372	7 166 855	7 242 895	7 349 362
Attached	928 979	1 160 206	1 314 865	1 328 156	1 340 580
Multi-unit attached	3 394 259	3 583 070	3 762 682	3 821 127	3 852 737

Source: Natural Resources Canada, Residential End-Use Model, Ottawa, February 2006.
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_3_e.xls

Country	Canada	
Number of newly built dwelling units by building type		
	2002	*2003*
Single family detached	76 040	106 467
Attached	13 291	12 424
Multi-unit attached	58 445	31 610

Source: Natural Resources Canada, Residential End-Use Model, Ottawa, February 2006.
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_3_e.xls

Country	Canada			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		*2050*	
Single family detached	2 874 609	28%	5 003 949	41%
Attached	335 448	20%	583 928	30%
Multi-unit attached	853 470	18%	1 485 670	28%
Total	4 063 527	24%	7 073 547	36%

Country	Canada		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	*2002*	*2003*
Single family detached	1.00	76 040	106 467
	2.00	152 080	212 934
	3.00	228 120	319 401
	4.00	304 160	425 868
	5.00	380 200	532 335
Attached	0.50	6 646	6 212
	1.00	13 291	12 424
	1.50	19 937	18 636
	2.00	26 582	24 848
	2.50	33 228	31 060
Multi-unit attached	0.10	5 845	3 161
	0.25	14 611	7 903
	0.50	29 223	15 805
	0.75	43 834	23 708
	1.00	58 445	31 610

Single Family Detached	**kWp**
Installed distributed Grid Capacity in 2003	37
Potential kWp installed	319 401
1% market penetration	3 194
2% market penetration	6 388
5% market penetration	15 970

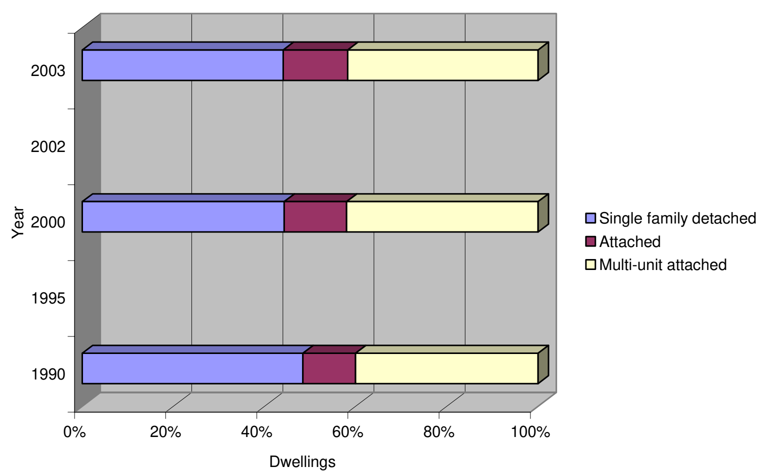
Attached	**kWp**
Installed distributed Grid Capacity in 2003	37
Potential kWp installed	18 636
1% market penetration	186
2% market penetration	373
5% market penetration	932

Multi-unit attached	**kWp**
Installed distributed Grid Capacity in 2003	37
Potential kWp installed	15 805
1% market penetration	158
2% market penetration	316
5% market penetration	790

Total	**kWp**
Installed distributed Grid Capacity in 2003	37
Potential kWp installed	353 842
1% market penetration	3 538
2% market penetration	7 077
5% market penetration	17 692

% Market Potenial at 1% Market Penetration	9 563%
% Market Potenial at 2% Market Penetration	19 127%
% Market Potenial at 5% Market Penetration	47 816%

Denmark: Number of dwelling units by residential building type, 1990, 2000, 2003



Country	Denmark				
Number of dwelling units by building type					
	1990	*1995*	*2000*	*2002*	*2003*
Single family detached	1 114 903		1 019 646		1 039 539
Attached	265 838		314 487		333 312
Multi-unit attached	922 231		966 808		984 827

Source: Residential Multiple New Housing Unit Building Industry Survey,
Denmark Residential Building Industry Experience - Aug 105.doc

Country	Denmark				
Number of newly built dwelling units by building type					
	1990	*1995*	*2001*	*2002*	*2003*
Single family detached					6 631
Attached					6 275
Multi-unit attached					6 006

Note: New construction numbers were not available and therefore 2000 numbers were subtracted from 2003 number and then divided by three .

Country	Denmark			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		*2050*	
Single family detached	179 040	15%	311 662	23%
Attached	169 425	34%	294 925	47%
Multi-unit attached	162 171	14%	282 298	22%
Total	510 636	18%	888 885	27%

Country	Denmark	
BIPV install on newly built dwelling units by building type		
	kW BIPV per Unit	*2003*
Single family detached	1.00	6 631
	2.00	13 262
	3.00	19 893
	4.00	26 524
	5.00	33 156
Attached	0.50	3 138
	1.00	6 275
	1.50	9 413
	2.00	12 550
	2.50	15 688
Multi-unit attached	0.10	601
	0.25	1 502
	0.50	3 003
	0.75	4 505
	1.00	6 006

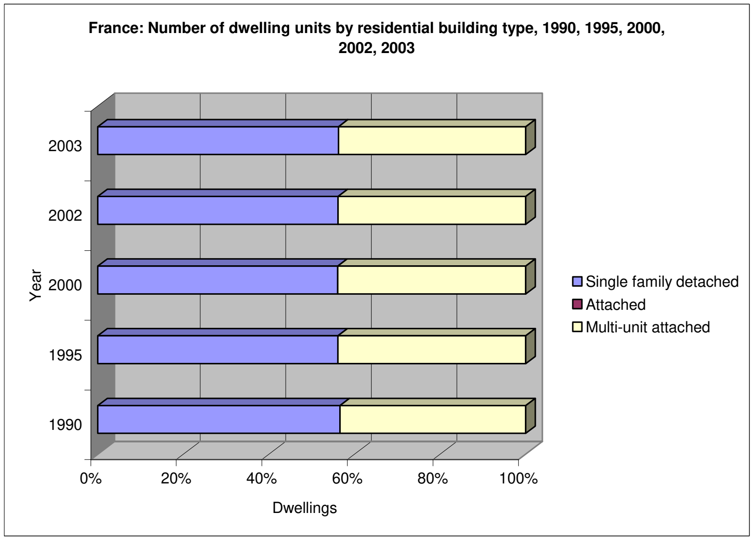
Single Family Detached	**kWp**
Installed distributed Grid Capacity in 2003	300
Potential kWp installed	19 893
1% market penetration	199
2% market penetration	398
5% market penetration	995

Attached	**kWp**
Installed distributed Grid Capacity in 2003	300
Potential kWp installed	9 413
1% market penetration	94
2% market penetration	188
5% market penetration	471

Multi-unit attached	**kWp**
Installed distributed Grid Capacity in 2003	300
Potential kWp installed	3 003
1% market penetration	30
2% market penetration	60
5% market penetration	150

Total	**kWp**
Installed distributed Grid Capacity in 2003	300
Potential kWp installed	32 309
1% market penetration	323
2% market penetration	646
5% market penetration	1 615

% Market Potenial at 1% Market Penetration	108%
% Market Potenial at 2% Market Penetration	215%
% Market Potenial at 5% Market Penetration	538%



Country	France				
Number of dwelling units by building type					
	1990	*1995*	*2000*	*2002*	*2003*
Single family detached	15 087 000	15 793 000	16 573 000	16 942 000	17 133 000
Attached					
Multi-unit attached	11 578 000	12 348 000	12 995 000	13 229 000	13 341 000

Source: Residential Multiple New Housing Unit Building Industry Survey,
Residential Building Industry Experience - Aug 1,05 FRA.doc, www.insee.fr
Note: Attached housing stock is included in multi-unit attached.

Country	France		
Number of newly built dwelling units by building type			
	1995	*2000*	*2004*
Single family detached	140 500	197 500	216 000
Attached			
Multi-unit attached	138 500	111 100	147 900

Source: Residential Multiple New Housing Unit Building Industry Survey,
Residential Building Industry Experience - Aug 1,05 FRA.doc, www.insee.fr
Note: Attached housing stock is included in multi-unit attached.

Country	France			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		*2050*	
Single family detached	5 832 000	25%	10 152 000	37%
Attached				
Multi-unit attached	3 993 300	23%	6 951 300	34%
Total	9 825 300	24%	17 103 300	36%

Country	France		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	*2000*	*2004*
Single family detached	1.00	197 500	216 000
	2.00	395 000	432 000
	3.00	592 500	648 000
	4.00	790 000	864 000
	5.00	987 500	1 080 000
Attached	0.50	0	0
	1.00	0	0
	1.50	0	0
	2.00	0	0
	2.50	0	0
Multi-unit attached	0.10	11 110	14 790
	0.25	27 775	36 975
	0.50	55 550	73 950
	0.75	83 325	110 925
	1.00	111 100	147 900

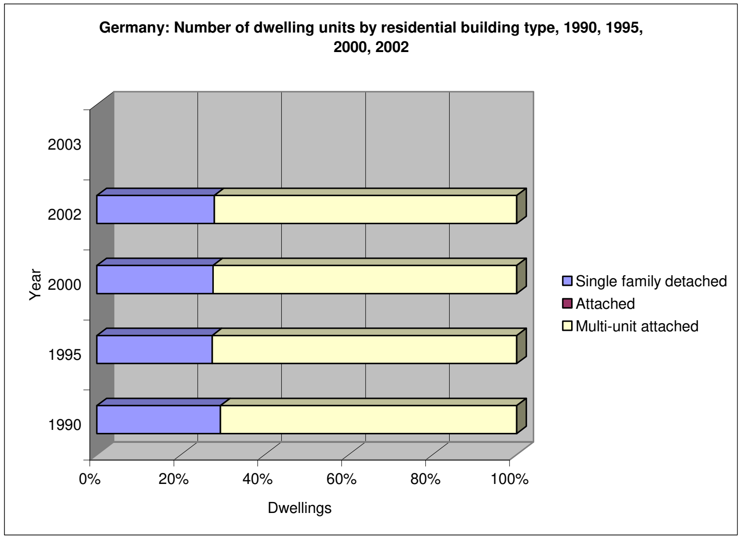
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	5 900
Potential kWp installed	648 000
1% market penetration	6 480
2% market penetration	12 960
5% market penetration	32 400

Attached	kWp
Installed distributed Grid Capacity in 2003	5 900
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	5 900
Potential kWp installed	73 950
1% market penetration	740
2% market penetration	1 479
5% market penetration	3 698

Total	kWp
Installed distributed Grid Capacity in 2003	5 900
Potential kWp installed	721 950
1% market penetration	7 220
2% market penetration	14 439
5% market penetration	36 098

% Market Potenial at 1% Market Penetration	122%
% Market Potenial at 2% Market Penetration	245%
% Market Potenial at 5% Market Penetration	612%



Country	Germany				
Number of dwelling units by building type					
	1990	*1995*	2000	*2002*	*2003*
Single family detached	7 752 000	9 688 000	10 402 000	10 658 000	
Attached					
Multi-unit attached	18 575 000	25 578 000	27 227 000	27 500 000	

Source: Housing Statistics in the European Union. 2004. Table 3.1. http://www.iut.nu/EU/HousingStatistics200

Note: Attached housing stock is included in multi-unit attached.

Country	Germany				
Number of newly built dwelling units by building type					
	1990	*1995*	*2001*	*2002*	*2003*
Single family detached				128 000	
Attached					
Multi-unit attached				136 500	

Source: Housing Statistics in the European Union. 2004. Table 3.1.
Note: Attached housing stock is included in multi-unit attached.

Note: New construction numbers were not available and therefore 2000 numbers were subtracted from 2002 number and then divided by two .

Country	Germany			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2002 construction and				
	2030		*2050*	
Single family detached	3 584 000	25%	6 144 000	37%
Attached				
Multi-unit attached	3 822 000	12%	6 552 000	19%
Total	7 406 000	16%	12 696 000	25%

Country	Germany	
BIPV install on newly built dwelling units by building type		
	kW BIPV per Unit	*2002*
Single family detached	1.00	128 000
	2.00	256 000
	3.00	384 000
	4.00	512 000
	5.00	640 000
Attached	0.50	
	1.00	
	1.50	
	2.00	
	2.50	
Multi-unit attached	0.10	13 650
	0.25	34 125
	0.50	68 250
	0.75	102 375
	1.00	136 500

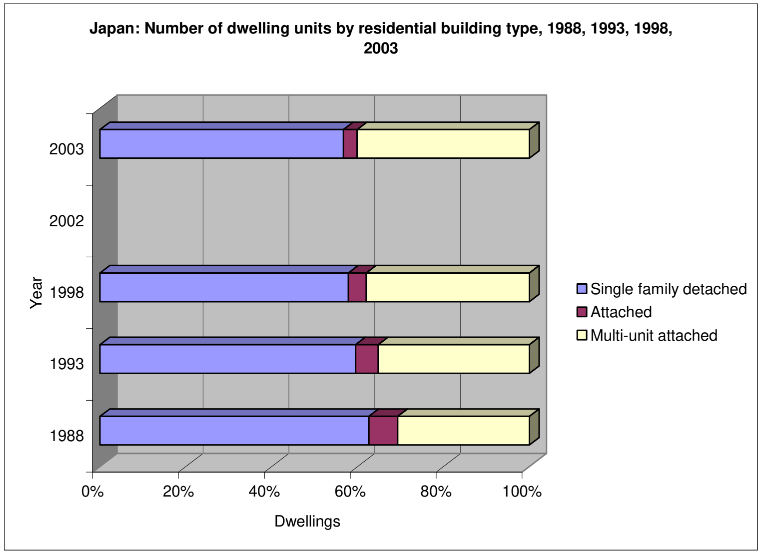
Single Family Detached	kWp
Installed distributed Grid Capacity in 2002	78 000
Potential kWp installed	384 000
1% market penetration	3 840
2% market penetration	7 680
5% market penetration	19 200

Attached	kWp
Installed distributed Grid Capacity in 2002	78 000
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2002	78 000
Potential kWp installed	68 250
1% market penetration	683
2% market penetration	1 365
5% market penetration	3 413

Total	kWp
Installed distributed Grid Capacity in 2002	78 000
Potential kWp installed	452 250
1% market penetration	4 523
2% market penetration	9 045
5% market penetration	22 613

% Market Potenial at 1% Market Penetration	6%
% Market Potenial at 2% Market Penetration	12%
% Market Potenial at 5% Market Penetration	29%



Country	Japan				
Number of dwelling units by building type					
	1988	*1993*	1998	*2002*	*2003*
Single family detached	23 311 000	24 141 000	25 269 400		26 491 200
Attached	2 490 000	2 163 000	1 827 700		1 482 600
Multi-unit attached	11 409 000	14 267 000	16 600 900		18 732 800

Source: Statistics Bureau and Statistical Research & Training Unit.
Japan in Figures, 2007. Table 67. Number of Dwellings and Housing Conditions
http://www.stat.go.jp/english/data/figures/zuhyou/1667.xls

Country	Japan				
Number of newly built dwelling units by building type					
	1988	*2000*	2001	*2002*	*2003*
Single family detached		585 494	517 853	488 296	501 785
Attached		41 665	42 809	49 952	66 147
Multi-unit attached		602 684	613 196	612 768	592 151

Source: Residential Multiple New Housing Unit Building Industry Survey,
Survey data (JPN) 060201

Country	Japan			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		*2050*	
Single family detached	13 548 195	34%	23 583 895	47%
Attached	1 785 969	55%	3 108 909	68%
Multi-unit attached	15 988 077	46%	27 831 097	60%
Total	31 322 241	40%	54 523 901	54%

Country	Japan			
BIPV install on newly built dwelling units by building type				
	kW BIPV per Unit	*2001*	*2002*	*2003*
Single family detached	1.00	517 853	488 296	501 785
	2.00	1 035 706	976 592	1 003 570
	3.00	1 553 559	1 464 888	1 505 355
	4.00	2 071 412	1 953 184	2 007 140
	5.00	2 589 265	2 441 480	2 508 925
Attached	0.50	21 405	24 976	33 074
	1.00	42 809	49 952	66 147
	1.50	64 214	74 928	99 221
	2.00	85 618	99 904	132 294
	2.50	107 023	124 880	165 368
Multi-unit attached	0.10	61 320	61 277	59 215
	0.25	153 299	153 192	148 038
	0.50	306 598	306 384	296 076
	0.75	459 897	459 576	444 113
	1.00	613 196	612 768	592 151

Single Family Detached	**kWp**
Installed Grid Connect PV in 2005	216 535
Potential kWp installed	1 505 355
1% market penetration	15 054
2% market penetration	30 107
5% market penetration	75 268

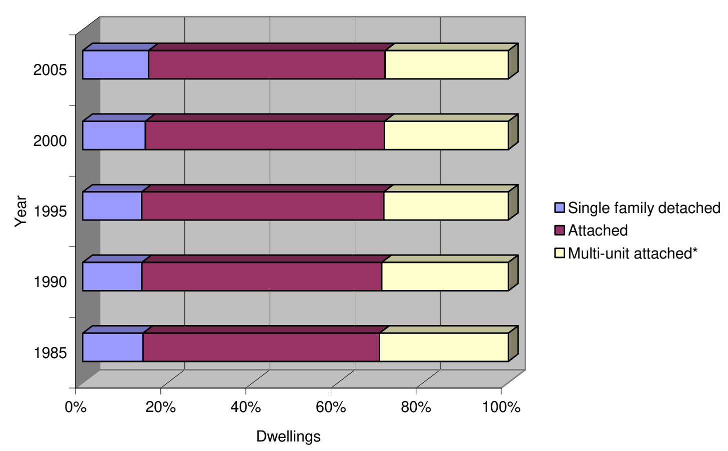
Attached	**kWp**
Installed PV in 2005	216 535
Potential kWp installed	99 221
1% market penetration	992
2% market penetration	1 984
5% market penetration	4 961

Multi-unit attached	**kWp**
Installed PV in 2005	216 535
Potential kWp installed	296 076
1% market penetration	2 961
2% market penetration	5 922
5% market penetration	14 804

Total	**kWp**
Installed PV in 2005	216 535
Potential New Construction	1 900 651
1% market penetration	19 007
2% market penetration	38 013
5% market penetration	95 033

% Market Potenial at 1% Market Penetration	9%
% Market Potenial at 2% Market Penetration	18%
% Market Potenial at 5% Market Penetration	44%

Netherlands: Number of dwelling units by residential building type, 1985, 1990, 1995, 2000, 2005



Country	Netherlands				
Number of dwelling units by building type					
	1985	*1990*	*1995*	*2000*	*2005*
Single family detached	747 748	805 498	857 954	968 584	1 062 150
Attached	2 939 106	3 269 390	3 518 536	3 700 459	3 819 290
Multi-unit attached*	1 601 467	1 727 475	1 815 430	1 920 618	1 992 785

Source: Residential Multiple New Housing Unit Building Industry Survey
Dutch National Industry Statistics 20070529
** An apartment (multi family houses) is every house which forms one object with another (working)*

Country	Netherlands				
Number of newly built dwelling units by building type					
	1995	*2000*	*2001*	*2002*	*2003*
Single family detached			60 732	55 559	49 123
Attached					
Multi-unit attached			26 315	23 799	23 480

Source: Residential Multiple New Housing Unit Building Industry Survey
Dutch National Industry Statistics 20070529
Note: Attached housing stock is included in single family detached

Country	Netherlands			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2005 construction and				
	2030		*2050*	
Single family detached	1 228 075	20%	2 210 535	31%
Attached				
Multi-unit attached	587 000	23%	1 056 600	35%
Total	1 815 075	21%	3 267 135	32%

Country	Netherlands		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	*2001*	*2002*
Single family detached	1.00	60 732	55 559
	2.00	121 464	111 118
	3.00	182 196	166 677
	4.00	242 928	222 236
	5.00	303 660	277 795
Attached	0.50	0	0
	1.00	0	0
	1.50	0	0
	2.00	0	0
	2.50	0	0
Multi-unit attached	0.10	2 632	2 380
	0.25	6 579	5 950
	0.50	13 158	11 900
	0.75	19 736	17 849
	1.00	26 315	23 799

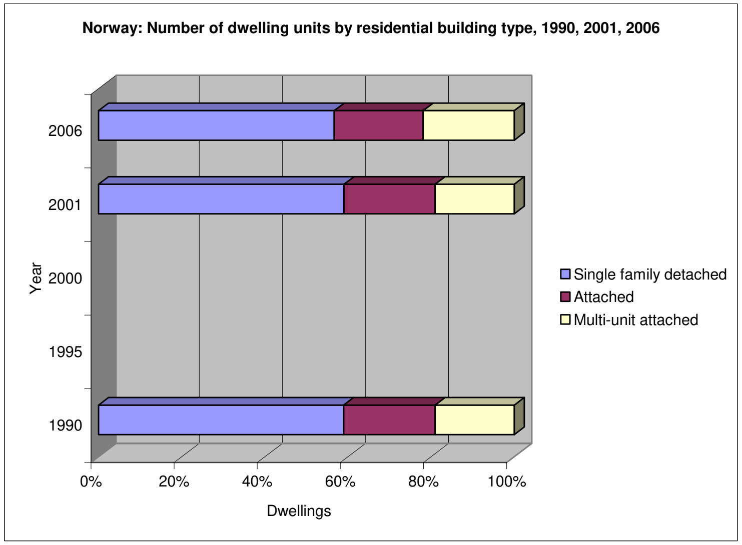
Single Family Detached	**kWp**
Installed Grid Connected PV in 2005	1 547
Potential kWp installed	166 677
1% market penetration	1 667
2% market penetration	3 334
5% market penetration	8 334

Attached	**kWp**
Installed Grid Connected PV in 2005	1 547
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	**kWp**
Installed Grid Connected PV in 2005	1 547
Potential kWp installed	11 900
1% market penetration	119
2% market penetration	238
5% market penetration	595

Total	kWp
Installed Grid Connected PV in 2005	1 547
Potential kWp installed	178 577
1% market penetration	1 786
2% market penetration	3 572
5% market penetration	8928.825

% Market Potenial at 1% Market Penetration	115%
% Market Potenial at 2% Market Penetration	231%
% Market Potenial at 5% Market Penetration	577%



Country	Norway				
Number of dwelling units by building type					
	1990	*1995*	2000	*2001*	*2006*
Single family detached	1 018 145			1 119 844	1 200 816
Attached	379 969			415 068	453 308
Multi-unit attached	328 673			360 770	463 172

Source: Statistics Norway, 2001. Dwellings, occupants and rooms, by type of building.
http://www.ssb.no/english/subjects/02/01/fobbolig_en/tab-2002-09-23-01-en.html
Source: S06265: Dwellings, by type of building (M) (2006-2007)
http://statbank.ssb.no/statistikkbanken/Default_FR.asp?Productid=10.09&PXSid=0&nvl=true&PLanguage=1&tilside=selecttable/MenuSelP.asp&SubjectCode=10

Country	Norway				
Number of newly built dwelling units by building type					
	1990	*1995*	*2001*	*2002*	*2003*
Single family detached			9 224	8 214	7 141
Attached			5 366	4 771	4 959
Multi-unit attached			7 656	7 109	8 786

Source: Building work Start. Dwelling units, by type of building. 2000 -2003
http://www.ssb.no/english/subjects/10/09/byggeareal_tab_en/arkiv/2003/t-13-en.html

Country	Norway			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2006 construction and				
	2030		*2050*	
Single family detached	171 384	12%	314 204	21%
Attached	119 016	21%	218 196	32%
Multi-unit attached	210 864	31%	386 584	45%
Total	501 264	19%	918 984	30%

Country	Norway		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	*2002*	*2003*
Single family detached	1.00	8 214	7 141
	2.00	16 428	14 282
	3.00	24 642	21 423
	4.00	32 856	28 564
	5.00	41 070	41 070
Attached	0.50	2 386	2 480
	1.00	4 771	4 959
	1.50	7 157	7 439
	2.00	9 542	9 918
	2.50	11 928	12 398
Multi-unit attached	0.10	711	879
	0.25	1 777	2 197
	0.50	3 555	4 393
	0.75	5 332	6 590
	1.00	7 109	8 786

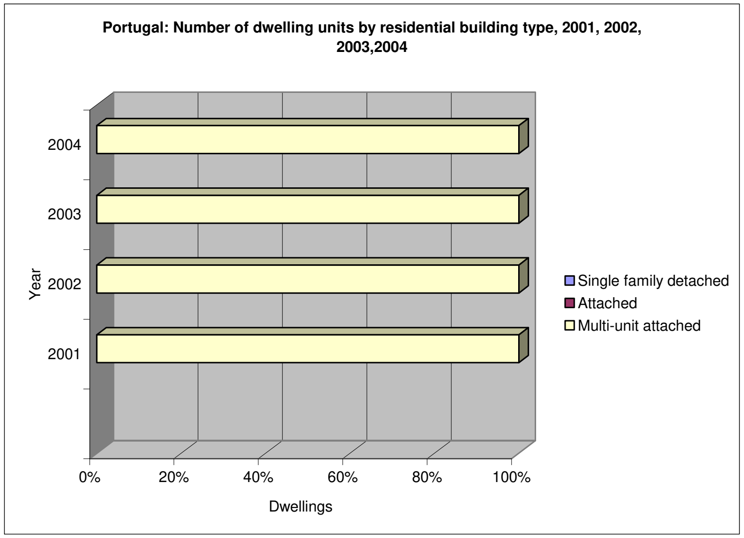
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	7
Potential kWp installed	21 423
1% market penetration	214
2% market penetration	428
5% market penetration	1 071

Attached	kWp
Installed distributed Grid Capacity in 2003	7
Potential kWp installed	7 439
1% market penetration	74
2% market penetration	149
5% market penetration	372

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	7
Potential kWp installed	4 393
1% market penetration	44
2% market penetration	88
5% market penetration	220

Total	kWp
Installed distributed Grid Capacity in 2003	7
Potential kWp installed	33 255
1% market penetration	333
2% market penetration	665
5% market penetration	1 663

% Market Potenial at 1% Market Penetration	4 751%
% Market Potenial at 2% Market Penetration	9 501%
% Market Potenial at 5% Market Penetration	23 753%



Country	Portugal			
Number of dwelling units by building type				
	2001	2002	2003	2004
Single family detached				
Attached				
Multi-unit attached	5 105 859	5 230 208	5 319 878	5 390 876

Source: Residential Multiple New Housing Unit Building Industry Survey, Residential Building Industry Experience - Portugal07

Note: Dwelling stock data from Portugal did not separate building typology. It is assumed that single family detached represents ths smallest portion of the dwelling type.

Country	Portugal	
Number of newly built dwelling units by building type		
	2004	2005
Single family detached	694	571
Attached	27 189	23 594
Multi-unit attached	40 430	37 459

Source: Residential Multiple New Housing Unit Building Industry Survey, Residential Building Industry Experience - Portugal07

Country	Portugal			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2004 construction and				
	2030		2050	
Single family detached				
Attached				
Multi-unit attached	1 776 138	25%	3 142 398	37%

Note: Multi-attached includes all unit typologies for this table

Country	Portugal		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	2004	2005
Single family detached	1.00	694	571
	2.00	1 388	1 142
	3.00	2 082	1 713
	4.00	2 776	2 284
	5.00	3 470	2 855
Attached	0.50	13 595	11 797
	1.00	27 189	23 594
	1.50	40 784	35 391
	2.00	54 378	47 188
	2.50	67 973	58 985
Multi-unit attached	0.10	4 043	3 746
	0.25	10 108	9 365
	0.50	20 215	18 730
	0.75	30 323	28 094
	1.00	40 430	37 459

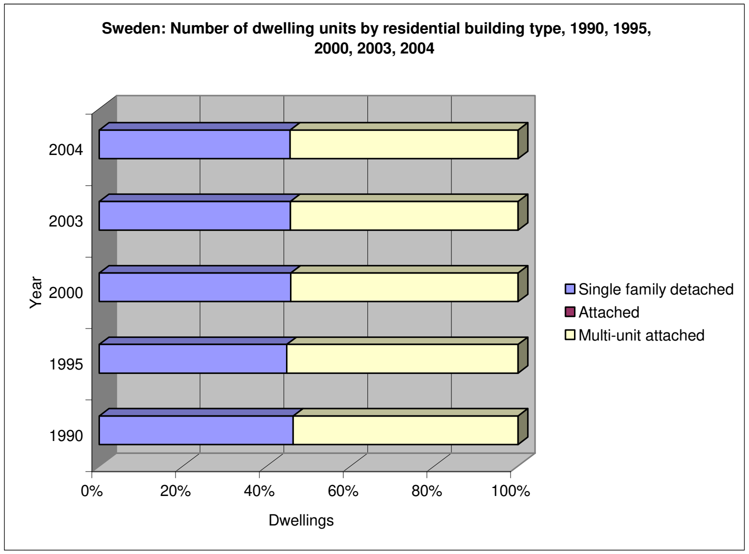
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	33
Potential kWp installed	2 082
1% market penetration	21
2% market penetration	42
5% market penetration	104

Attached	kWp
Installed distributed Grid Capacity in 2003	33
Potential kWp installed	40 784
1% market penetration	408
2% market penetration	816
5% market penetration	2 039

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	33
Potential kWp installed	20 215
1% market penetration	202
2% market penetration	404
5% market penetration	1 011

Total	kWp
Installed distributed Grid Capacity in 2003	33
Potential kWp installed	63 081
1% market penetration	631
2% market penetration	1 262
5% market penetration	3 154

% Market Potenial at 1% Market Penetration	1 912%
% Market Potenial at 2% Market Penetration	3 823%
% Market Potenial at 5% Market Penetration	9 558%



Country	Sweden				
Number of dwelling units by building type					
	1990	*1995*	2000	*2003*	*2004*
Single family detached	1 874 000	1 940 000	1 963 000	1 986 000	1 997 000
Attached					
Multi-unit attached	2 171 000	2 393 000	2 331 000	2 366 000	2 382 000

Source: Statistics Sweden, www.scb.se 2006-02-03
Note: Attached housing stock is included in single family detached

Country	Sweden				
Number of newly built dwelling units by building type					
	1990	*1995*	*2000*	*2003*	*2004*
Single family detached	25 000	4 000	6 000	8 000	12 000
Attached			0	0	
Multi-unit attached	34 000	9 000	7 000	12 000	14 000

Source: Statistics Sweden, www.scb.se 2006-02-03
Note: Attached housing stock is included in single family detached

Country	Sweden			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2004 construction and				
	2030		*2050*	
Single family detached	324 000	14%	564 000	22%
Attached				
Multi-unit attached	378 000	14%	658 000	22%
Total	702 000	14%	1 222 000	22%

Country	Sweden		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	*2002*	*2003*
Single family detached	1.00	6 000	8 000
	2.00	12 000	16 000
	3.00	18 000	24 000
	4.00	24 000	32 000
	5.00	30 000	40 000
Attached	0.50	0	0
	1.00	0	0
	1.50	0	0
	2.00	0	0
	2.50	0	0
Multi-unit attached	0.10	700	1 200
	0.25	1 750	3 000
	0.50	3 500	6 000
	0.75	5 250	9 000
	1.00	7 000	12 000

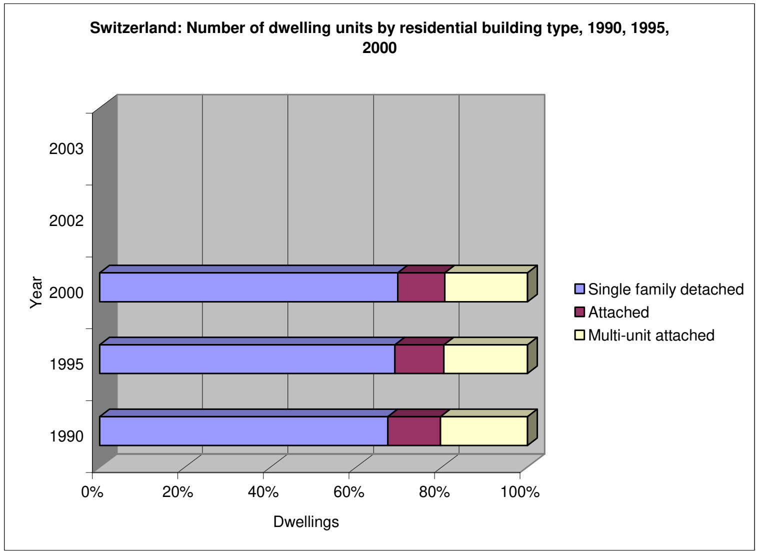
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	15
Potential kWp installed	24 000
1% market penetration	240
2% market penetration	480
5% market penetration	1 200

Attached	kWp
Installed distributed Grid Capacity in 2003	15
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	15
Potential kWp installed	6 000
1% market penetration	60
2% market penetration	120
5% market penetration	300

Total	kWp
Installed distributed Grid Capacity in 2003	15
Potential kWp installed	30 000
1% market penetration	300
2% market penetration	600
5% market penetration	1 500

% Market Potenial at 1% Market Penetration	2 000%
% Market Potenial at 2% Market Penetration	4 000%
% Market Potenial at 5% Market Penetration	10 000%



Country	Switzerland				
Number of dwelling units by building type					
	1990	*1995*	*2000*	*2002*	*2003*
Single family detached	614 926	754 419	821 719		
Attached	112 421	125 235	129 760		
Multi-unit attached	185 511	213 276	227 799		

Source: Office federal de la statistique, RFP 2000

Country	Switzerland	
Number of newly built dwelling units by building type		
	1996-2000	*2000*
Single family detached	67 300	16 825
Attached	4 525	1 131
Multi-unit attached	14 523	3 631

Source: Office federal de la statistique, RFP 2000

Note: The estimate for the number of dwellings constructed in the year 2000 is estimated by dividing 1996 -2000 value by 4

Country	Switzerland			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2000 construction and				
	2030		*2050*	
Single family detached	504 750	38%	841 250	51%
Attached	33 938	21%	56 563	30%
Multi-unit attached	108 923	32%	181 538	44%
Total	647 610	35%	1 079 350	48%

Country	Switzerland	
BIPV install on newly built dwelling units by building type		
	kW BIPV per Unit	*2000*
Single family detached	1.00	16 825
	2.00	33 650
	3.00	50 475
	4.00	67 300
	5.00	84 125
Attached	0.50	566
	1.00	1 131
	1.50	1 697
	2.00	2 263
	2.50	2 828
Multi-unit attached	0.10	363
	0.25	908
	0.50	1 815
	0.75	2 723
	1.00	3 631

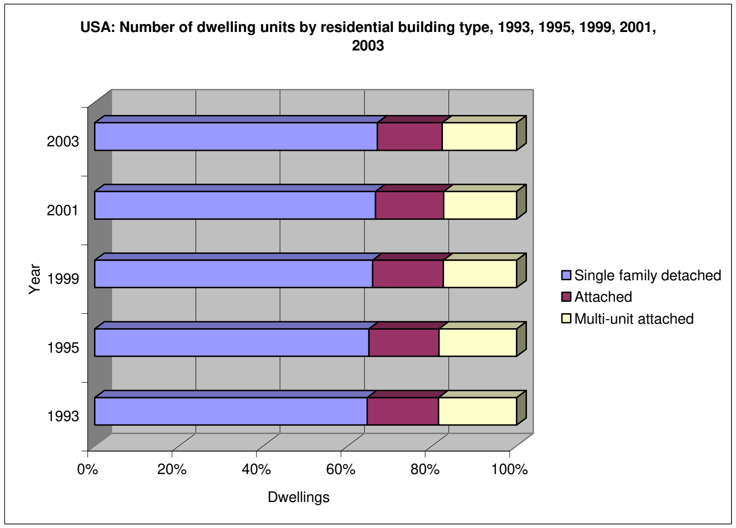
Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	1 300
Potential kWp installed	50 475
1% market penetration	505
2% market penetration	1 010
5% market penetration	2 524

Attached	kWp
Installed distributed Grid Capacity in 2003	1 300
Potential kWp installed	1 697
1% market penetration	17
2% market penetration	34
5% market penetration	85

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	1 300
Potential kWp installed	1 815
1% market penetration	18
2% market penetration	36
5% market penetration	91

Total	kWp
Installed distributed Grid Capacity in 2003	1 300
Potential kWp installed	53 987
1% market penetration	540
2% market penetration	1 080
5% market penetration	2 699

% Market Potenial at 1% Market Penetration	42%
% Market Potenial at 2% Market Penetration	83%
% Market Potenial at 5% Market Penetration	208%



Country	USA				
Number of dwelling units by building type					
	1993	1995	1999	2001	2003
Single family detached	64 283 000	66 169 000	70 355 000	72 796 000	74 916 000
Attached	16 811 000	16 913 000	17 923 000	17 662 000	17 192 000
Multi-unit attached	18 444 000	18 727 000	18 543 000	18 907 000	19 698 000

Source: American Housing Survey for the United States. (AHS) United States Census Bureau.
Table 1A-1. Introductory Characteristics--All Housing Units
http://www.census.gov/hhes/www/housing/ahs/nationaldata.html

Country	USA				
Number of newly built dwelling units by building type					
	1990	1995	2001	2002	2003
Single family detached				1 060 000	
Attached				0	
Multi-unit attached				395 500	

Note: New construction numbers were not available and therefore 2001 numbers were subtracted from 2003 number and then divided by two. Attached housing numbers fell from 2001 to 2003 and therefore it is assumed that there was very little new attached housing construction.

Country	Switzerland			
Number of Dwelling Units in 2030 and 2050 consisting of Post 2003 construction and				
	2030		2050	
Single family detached	28 620 000	28%	49 820 000	40%
Attached	0	0%	0	0%
Multi-unit attached	10 678 500	35%	18 588 500	49%
Total	39 298 500	26%	68 408 500	38%

Note: New construction numbers were not available and therefore 2001 numbers were subtracted from 2003 number and then divided by two. Attached housing numbers fell from 2001 to 2003 and therefore it is assumed that there was very little new attached housing construction.

Country	USA		
BIPV install on newly built dwelling units by building type			
	kW BIPV per Unit	2001	2002
Single family detached	1.00	0	1 060 000
	2.00	0	2 120 000
	3.00	0	3 180 000
	4.00	0	4 240 000
	5.00	0	5 300 000
Attached	0.50	0	0
	1.00	0	0
	1.50	0	0
	2.00	0	0
	2.50	0	0
Multi-unit attached	0.10	0	39 550
	0.25	0	98 875
	0.50	0	197 750
	0.75	0	296 625
	1.00	0	395 500

Single Family Detached	kWp
Installed distributed Grid Capacity in 2003	32 000
Potential kWp installed	3 180 000
1% market penetration	31 800
2% market penetration	63 600
5% market penetration	159 000

Attached	kWp
Installed distributed Grid Capacity in 2003	32 000
Potential kWp installed	0
1% market penetration	0
2% market penetration	0
5% market penetration	0

Multi-unit attached	kWp
Installed distributed Grid Capacity in 2003	32 000
Potential kWp installed	197 750
1% market penetration	1 978
2% market penetration	3 955
5% market penetration	9 888

Total	kWp
Installed distributed Grid Capacity in 2003	32 000
Potential kWp installed	3 377 750
1% market penetration	33 778
2% market penetration	67 555
5% market penetration	168 888

% Market Potenial at 1% Market Penetration	106%
% Market Potenial at 1% Market Penetration	211%
% Market Potenial at 5% Market Penetration	528%

Definition of Terms

AUSTRIA, FRANCE, GERMANY, AND SWEDEN

Source: Housing Statistics in the European Union 2004. National Board of Housing, Building and Planning, Sweden & Ministry for Regional Development of the Czech Republic. http://www.iut.nu/EU/HousingStatistics2004.pdf

"Dwelling"

According to the United Nations Economic Commission for Europe (UNECE):, a dwelling is a room or suite of rooms and its accessories in a permanent building or structurally separated part thereof which by the way it has been built, rebuilt, converted, etc., is intended for private habitation. It should have a separate access to a street (direct or via a garden or grounds) or to a common space within the building (staircase, passage, gallery, etc.). Detached rooms for habitation that are clearly built, rebuilt, converted, etc., to be used as a part of the dwelling should be counted as part of the dwelling. (A dwelling may thus be constituted of separate buildings within the same enclosure, provided they are clearly intended for habitation by the same private household, e.g. a room or rooms above a detached garage, occupied by servants or other members of the household.)

In Austria, dwellings do not include mobile dwellings, barracks or dwellings without a kitchen.

A dwelling in France is a separate and independent unit for housing. Mobile dwellings are not considered dwellings.

In Germany, a dwelling always includes a kitchen or a room with cooking facilities. It has, in principle, its own entrance that can be closed off from the outside surroundings. It has water facilities and a toilet, which may be located outside.

In Sweden, a dwelling has its own kitchen or kitchenette. It can also be a dwelling with its own entrance from a secluded hall, stairwell, etc.

For these countries, "Multi-family" building stock includes semi-detached or double dwellings, row houses, apartment blocks and dwellings in partly residential buildings.

"One-family" building stock includes single households, single family detached houses, and back yard houses.

DENMARK

Source: Residential Multiple New Housing Unit Building Industry Survey, Denmark Residential Building Industry Experience - Aug 105.doc

Single family detached includes: Single-family residences, farmhouses, and cottage houses

Attached includes: row house, linked house, double house

Apartments include: block of flats

CANADA

Source: Natural Resources Canada. Residential Housing Stock and Floor Space.
http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/tableshandbook2/res_00_3_e.xls

"Single family detached" or "One family" encompasses single-detached buildings.

Attached includes single family semi-detached, townhouse and rowhouse.

"Multi-unit" encompasses multiple household, multi-level buildings.

Tables for Canada exclude Mobile Homes, which account for approximately 2% of all residential dwellings.

JAPAN

Source: Statistics Bureau and Statistical Research & Training Unit. Japan in Figures, 2007. Table 67. Number of Dwellings and Housing Conditions
http://www.stat.go.jp/english/data/figures/zuhyou/1667.xls

A dwelling is defined as a permanent building or a structurally separated part hereof, such as a detached house or an apartment of an apartment house that, by the way it has been built or altered, is intended for habitation by one household. A structurally separated part should be completely partitioned with fixed concrete or wooden walls.

A dwelling for habitation by one household must satisfy the following four requisites with respect to facilities.
(1) At least one room;
(2) A sink for cooking for exclusive use;
(3) A toilet for exclusive used; and
(4) An entrance for exclusive use.

Dwellings are classified as follows according to how the buildings concerned are built:

7.1.1.1 ***Detached Houses:*** *Buildings which consist of a single dwelling unit.*

7.1.1.2 ***Tenement-Houses:*** *Buildings which consist of two or more dwelling units connected by walls but each having an independent entrance to the street. Terrace houses are also included in this category.*

7.1.1.3 ***Apartments:*** *Buildings which consist of two or more dwelling units of which passageways, staircases, and so on are jointly used. If two or more dwellings are built one above the other, they are also included in this category. Buildings with stores on the first floor and two or more dwellings above them also fall under this category.*

NORWAY

Source: Statistics Norway. 2001. Dwellings, occupants and rooms, by type of building.
http://www.ssb.no/english/subjects/02/01/fobbolig_en/tab-2002-09-23-01-en.html

"Single family detached" or "One-family" building stock refers to detached houses or farm houses.

"Semi-detached or Attached" houses includes linked houses, row houses, terraced houses, or vertically divided two-dwelling buildings, as well as, horizontally divided two-dwelling buildings or other houses with less than three floors.

"Multi-unit attached" refers to blocks of flats or other buildings with three or more floors, excluding commercial buildings and residential buildings for communities.

USA

Source: American Housing Survey, 2003.
http://www.census.gov/hhes/www/housing/ahs/ahs01/appendixa.pdf

A *housing unit* is a house, apartment, group of rooms, or single room occupied or intended for occupancy as *separate living quarters.* Housing units are found in the following categories of buildings:

- single-family detached houses,
- single-family attached houses

- low-rise (1-3 story) multiunit buildings, mid-rise (4-6 story) multiunit buildings, high-rise (7-or-more story) multiunit buildings

Manufactured/mobile homes and trailers are treated as a separate category. In 2003, these accounted for 8.9 million units or 7.5% of total residential dwelling stock in the US.

Other sources reviewed: Norris, Michelle and Patrick Shiels, The Housing Unit. 2004. Regular National Report on Housing Developments in European Countries. Synthesis Report. Department of the Environment, Heritage and Local Government. Ireland.
http://www.environ.ie/DOEI/doeipub.nsf/0/3f3ff45854888bbb80256f0f003db97f/$FILE/EU%20Housing%20Report-complete%20pdf.pdf