Reducing Energy by a Factor of 10

Promoting Energy Efficient Sustainable Housing in the Western World

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Management

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PREFACE

Sustainability can be seen as the most fundamental notion and challenge of the 21st century. The challenge consists in the fact that we have reached and already transgressed the natural limits of our globe, whereby the global population growth towards 10 billion people and world-wide inequalities build up additional pressure. This holds especially for our consumption of energy and the resulting green house gas emissions. Changes in the “percent range” will not be sufficient. In the Western world we are currently missing sustainability by an order of magnitude implying a corresponding “factor of ten” reduction task. Regenerative energies will help, but not solve the problem. Rather, we have to exploit the large potential of energy efficiency especially in those high consumption sectors, where efficiency gains can relatively easy be harvested with multiple side-benefits. The housing sector appears as the most relevant one.

This study addresses the “factor of 10” and energy efficient sustainable housing challenge. As orders of magnitude are at stake, the study tries to catch the key trends and forces, looking for the number of digits rather than for the digits themselves. In this sense, the factor of “10” stands for an order of magnitude, which in fact may become a factor of “20” in North America and a factor below ten under favourable conditions in Europe. The emission target we have to strive for is about 1 ton of energy related CO_2-emissions per annum and capita world-wide.

For sustainability to succeed, economic viability and the mix of driving forces in the public, political and market sphere have to be taken into account. Thereby a long term perspective is essential. The study analyses promising developments. Here, the passive house emerges as a core solution template, which can be easily extended to yield zero-energy as well as plus-energy performance. The technology opens up promising possibilities for energy-efficient sustainable new housing. Even more important is its wide-spread application to the building stock as a key sustainability factor of this century. Obstacles and opportunities in Germany as well as in Europe and North America are discussed.

The author himself has been active in the area of energy efficient housing for about three decades. A prerunning scientific experience in relativistic astrophysics taught him the relevance of logarithmic large scale thinking, while a more than ten year outing into the world of microelectronics and IT management opened the eyes for the micro-cosmos and the breathtaking speed of global innovation in a branch where cylces are counted in quarters - rather than the decades met in the building sector. Consequently, to accelerate sustainable innovation in the sluggish building sector became a key motif, which also drives the current study.

The author embarked on sustainability management as a member of the IWU[1] executive board in 1997 and with his own undertaking “Dr. Bernd Steinmüller Sustainability Management Consulting” in 2001. Studies at the Centre of Sustainability Management CSM of the

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[1] Institut Wohnen und Umwelt GmbH – Institute Housing and Environment, Darmstadt

Leuphana University Lüneburg[2] led to new insights with respect to driving forces in socio-economic systems addressed in this investigation.

The present study has been stimulated by the vivid resonance with respect to two key note "promotion speeches" on energy efficient sustainable housing given by the author in the US in 2006 and 2007. While the main thread and central theme of this study are already touched in these talks - and in various previous investigations - this study systematically unfolds the background, current developments and key forces relevant for factor of 10 improvements and a sustainability breakthrough.

The findings build on a multitude of insights of other people as well as on thirty years of experience accumulated by the author himself. The author explicitly acknowledges the input of a large scientific and non-scientific community. Given the breadth of the subject and the limitations of this work, it was not possible to track down all the roots of the big scientific tree. Thus, the author had to be selective and focus on the core aspects. Hence, he wants to express his gratitude for the rich input he could use and at the same time ask for excuses concerning omissions of relevant parts not explicitly woven into this study.

The first version of the study was finished in November 2007. The current edition includes minor updates and adds a brief critical review of the German Energy Performance Certificates introduced by the Energy Ordinance Act.

Paderborn, March 2008 Bernd Steinmüller

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[2] CSM initiated the first MBA course on "Sustainability Management" worldwide in 2003

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ABBREVIATIONS

a	annum
ACEEE	American Council for an Energy Efficient Economy
ACI	Affordable Comfort Incorporated
AIA	American Institute of Architects
AKKP	Arbeitskreis Kostengünstige Passivehäuser (Germany)
ARGE	Arbeitsgemeinschaft - consortium
BAKA	Bundesarbeitskreis Altbausanierung (Germany)
BBR	Bundesamt für Bauwesen und Raumordnung (Germany)
BDI	Bundesverband der Deutschen Industrie (Germany)
BGW	Bielefelder Gemeinnützige Wohnungsgesellschaft (Germany)
BMBF	Bundesministerium für Bildung und Forschung (Germany)
BMF	Bundesministerium der Finanzen (Germany)
BMU	Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (Germany)
BMVBS	Bundesministerium für Verkehr, Bau und Stadtentwicklung (Germany)
BMWi	Bundesministerium für Wirtschaft und Technologie (Germany)
bn	billion = 1 US billion = 1 [modern] Britisch billion = 1000 million
BRH	Bundesrechnungshof (Germany)
BSMC	Dr. Bernd Steinmüller Sustainability Management Consulting (Germany)
BT	Building Technology Programme (US)
Btu	British Thermal Unit (energy unit)
BUND	Bund für Naturschutz und Umwelt Deutschland (Germany)
CEC	Commission of the European Community (see also EC)
CEO	chief executive officer
CEPHEUS	Cost Effective Passive Houses as European Standard
CEU	Council of the European Union
CSM	Centre for Sustainability Management, Lüneburg University (Germany)
CTI	Conservation Technology International (US)
DENA	Deutsche Energieagentur (Germany)
DIN	Deutsches Institut für Normung (Germany)
DIN-EN	DIN Europanorm (Germany)
DIW	Deutsches Institut für Wirtschaft (Germany)
DM	Deutsche Mark (Germany)
DOE	Department of Energy (US)
DUH	Deutsche Umwelthilfe (Germany)
E, EH	Experimental Standards House, Experimental Standards House Heavy
EC	European Commission (short for: Commission of the European Community)
eco-	ecological-
ed.	editor
EEG	Energieeeinspeisegesetz (Germany)
EnEG	Energieeinspargesetz (Germany)
EnEV	Energieeinsparverordnung (Germany)
EP	European Parliament
EPA	Environmental Protection Agency (US)
EU	European Union
EU-27	European Union with 27 members
EWI	Energiewirtschaftliches Institut an der Universität Köln
ft	foot (British unit)
FY	financial year
FZ	Forschungszentrum
G8	Group of Eight
HMWVL	Hessisches Ministerium für Wirtschaft, Verkehr und Landesentwicklung (Ger.)
HUD	Department of Housing and Urban Development (US)

ibid.	ibidum (ebenda)
IBP	Institut für Bauphysik (Germany)
IFEU	Institut für Entsorgung und Umwelttechnik (Germany)
IG	Informationsgemeinschaft, Interessengemeinschaft, interest group
IPCC	Intergovernmental Panel on Climate Change
IÖW	Institut für Ökologische Wirtschaftsforschung gGmbH (Germany)
ISES	International Solar Energy Society
IWU	Institut Wohnen und Umwelt (Germany)
kBtu	1000 Btu
KfW	Kreditanstalt für Wiederaufbau (Germany)
KWh	kilo-watt-hour (energy unit)
m^2	square meter (area unit)
M^2	square meter (extrapolated from thermal volume according to EnEV)
mill.	million
LBL	Lawrence Berkeley Laboratory
LEED	Leadership in Energy and Environmental Design
N, NH	Normal House, Normal House Heavy
n. d.	no date
NABU	Naturschutzbund Deutschland
NAIMA	North American Insulation Manufacturers Association
NGO	non-governmental organization
NPO	non-profit organization
NPV	net present value
NREL	National Renewable Energy Laboratory
p. a.	per annum
p. c.	per capita
PE	primary energy
PEP	Promotion of European Passive Houses
PHI	Passivhaus Institut (Germany)
Q	parameter denoting energy
q_{ek}	parameter normalizing energy inflation to capital interest
R&D	research and development
S, SH	Swedish Standards House, Swedish Standards House Heavy
TREN	Directorate-General Energy and Transport (EU)
TV	television
UBA	Umweltbundesamt (Germany)
UN	United Nations
US	United States of America
VAT	value added tax
W	Watt, power unit
WBCSD	Word Business Council for Sustainable Development
WCED	World Commission on Environment and Development
WSchV	or WSVO Wärmeschutzverordnung (Germany)
ZDF	Zweites Deutsches Fernsehen (Germany)

1 THE SUSTAINABLE ENERGY AND HOUSING CHALLENGE

Starting point of this study is the observation that sustainability limits have been transgressed in the Western world particularly in the area of energy consumption and its associated emissions. Thereby the housing sector belongs to the most prominent energy consumers and emitters. This leads to the core question driving this study: "**How can we induce drastic changes towards sustainable energy strategies especially in the housing sector of the Western world?"** This study does not give simple answers, but analyses relevant concepts, developments and driving forces in order to highlight promising solution approaches. While the geographical focus is on Germany, general structures and important trends in Europe and North-America will be considered.

This chapter outlines the overall challenge and puts the study into perspective. Basic methods, concepts and tools are summarized in chapter 2. In the subsequent chapters we shall first look at basic housing approaches in order to learn from past experience and understand the main innovation lines in energy efficient sustainable housing. Then we shall analyse the relevant markets, market mechanisms and the influence of the public and political sphere. Thereby we shall begin with a general, structural market analysis. After that, we shall look at Germany, Europe and North America in order to discuss specific developments and possibilities to promote highly energy efficient sustainable housing approaches.

1.1 The Sustainability Challenge

Driven by growing global problems, leading personalities from 178 countries pointed to the joint responsibility of all nations for our "one world" at the Rio Earth Summit in 1992 UN 1992, BMU n. d.). "Sustainable development" appeared as key concept for a joint solution approach. This concept basically describes a development "that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987:8, Hauff 1987). It integrates ecological, social and economic aspects on a global, as well as local scale. Thereby the ecological dimension is of special importance, as nature provides the essential fundament and precondition for economic, as well as social life and the survival of mankind (cf. UBA 2002a).

Sustainable development - with the ideal target of "sustainability" - can be seen as the most fundamental notion and central global challenge of the 21st century. Having transgressed the natural limits of our globe at the end of the last century, the global population growth towards 10 billion people by the middle of this century and world-wide inequalities build up additional pressure. The situation is characterized by the fact that just 20% of the world population spend about 80% of the resources[3] (see e.g. World Bank 2005 and 2007).

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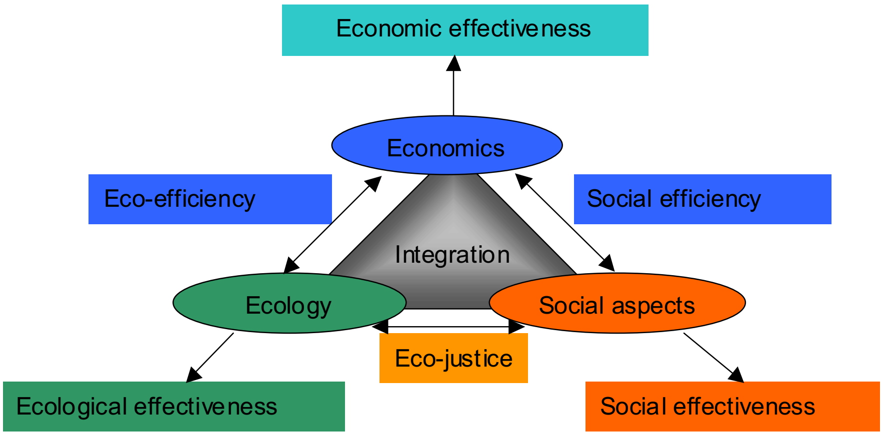
[3] … e.g. when measured in terms of GDP. This ratio reflects the well known Pareto rule.

Thereby the 500 mill. people in the European Union belong to the “high-end” consumers together with the 300 mill. US inhabitants even topping the European demand. At the same time, much bigger countries like China and India (2500 mill. people) with a lower consumption ask their share. This implies an enormous challenge for society as a whole and management in particular.



based on Schaltegger et al. 2002 and 2003

Figure 1: Main Dimensions of the Sustainability Challenge

The basic **management challenges** involved are summarized in Fig. 1 (cf. Schaltegger et al. 2002:6, 2003:23, 2007b:14). Accordingly, balanced approaches are needed, which are “effective” along all three sustainability dimensions and “efficient” especially in economic terms. Thereby “**effectiveness**” measures the degree to which “absolute” ecological and social goals are achieved, while (economic) **“efficiency”** measures the ratio of economic value to ecological or social impact added. The integration challenge also involves the balancing of ecological and social impacts as expressed by the concept of “**eco-justice**” (Schaltegger et al. 2003:21), which is closely linked to the questions of intra- and inter-generational equity (Schaltegger et al. 2003:23). Though “efficiency” strategies appear particularly attractive, they cannot guarantee “effectiveness” on their own. Thus, they have to be supplemented by strategies of “**sufficiency**[4]” and “**consistency**” (Schaltegger et al. 2003:25).

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[4] Thereby “sufficiency” does not imply asceticism or denial of needs. Rather, it asks for the recognition of “true” needs and the distinction from “apparent” ones (see e.g. philosophical reflection on “Begehrungen” and “Bedürfnisse” in Kamlah 1973 and “Gut leben statt viel haben” in BUND & Misereor 1996:206 ff). This distinction is usually blinded out in economic theories, though it opens up important choices for sustainable life styles.

1.2 The Energy and Global Warming Challenge

1.2.1 CO_2-Emissions and Implications for the Western World

While energy has almost been synonymous with progress and wealth in the last century, it is clear that is has become one of the most critical natural resources ecologically, politically and economically with corresponding implications for all three management dimensions described above. Fossil deposits are limited with insecure access in unstable countries, but the sinks – in particular our atmosphere – have already reached their limits as indicated by the increasing global warming problem. In fact, it has been almost universally agreed that the global limit for energy-related CO_2-emissions is about 10 bn tons per year, a limit which has already been missed by a factor of 2 in 1990 with a much lower population. **Thus, it is necessary to drastically reduce energy consumption in order to decrease the dependency on limited, insecure sources, as well as the impact upon vulnerable sinks[5].**

Taking into account that the global population is going to reach about 10 bn people by the middle of this century, this implies that we have to strive for a **maximum emission rate of 1 ton per person and year** (cf. Fig. 2). This number defines a key "sustainability limit" in a straight forward transparent way and defines a target for "ecological effectiveness" - to be achieved in an economically, as well as socially efficient and effective way.

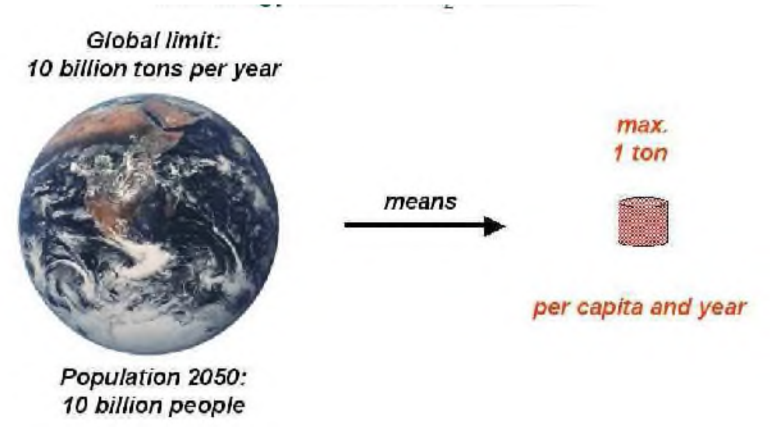

Figure 2: Sustainability Limit for Energy Related CO_2-Emissions

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[5] Triggered by the report of the Club of Rome (Meadows & Meadows 1972) and the oil crisis in 1973, the "source" problem appeared to be the most critical one in the beginning. In the seventies, however, and in particular with the systematic evaluations started by the IPCC in the nineties (cf. IPCC 1990 and 1995), it became apparent that the "sink" problem and the associated global warming problem poses an even more urgent challenge (see also Rahmstorf & Schellnhuber 2006, IPCC 2001 and 2007). Here we focus on energy related emissions, which roughly make up half of the anthropogenic green house gases.

Looking at the distribution of CO_2-emissions across the world (Fig. 3, Wikipedia 2006, 2007 and US EIA 2007), it can be seen that we are surpassing this limit by about a factor of 20 (and more) in North America, Arabia and Australia and by a factor of 10 in Europe. Thus, in order to become sustainable, **it will be necessary to reduce energy-related CO_2-emissions and corresponding energy consumption by a factor of 10 in Europe and at least a factor of 10 in the Western world.** This holds for all relevant sectors.

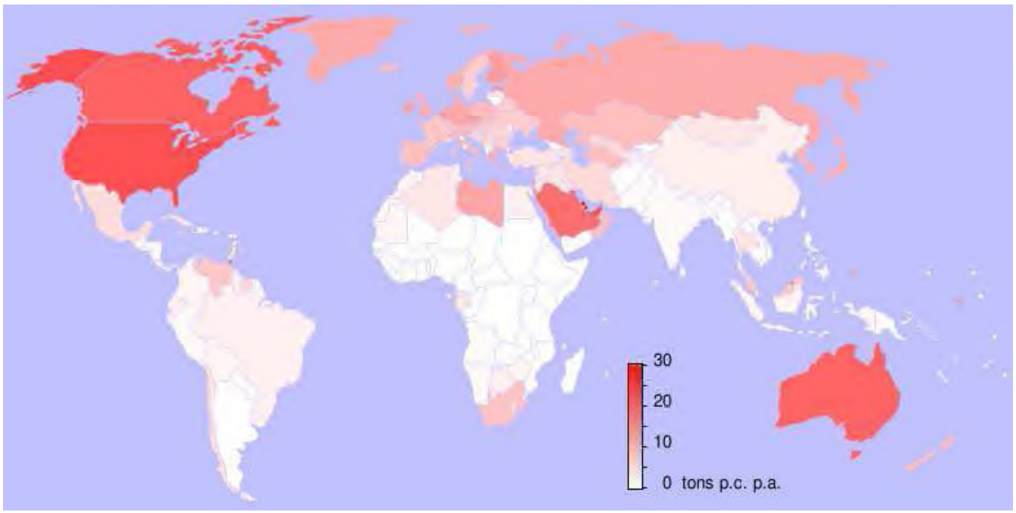

Figure 3: Global CO_2-Emissions 2004 (Wikipedia 2006, GNU- Licence)

While the overall reduction target is largely implied by natural limits and risk prevention[6], the transformation into equal per capita targets is based on the principle of "eco-justice", which implies that all men have equal rights with respect to the usage of public goods. Context-specific arguments may lead to differentiations. Big deviations from equal budgets per capita, however, will be difficult to argue[7]. Concerning the distribution over sectors, by mathematics it is clear that an overall reduction of a factor of ten can only be achieved, if order of magnitude reductions are realized in all main sectors as well. Though some differentiation is possible and reasonable, it is safe to start with the same minimum reduction factors especially in sectors where reductions are relatively easy to achieve.

Note that the global factor of 2 and the derived factor of 10 are fully **consistent with other factors quoted in the literature** as well as the last IPCC reports (IPCC 2007). They rather present a lower than an upper limit of what needs to be achieved in the future[8]. Schmidt-Bleek 1994:26 calls for a factor of 2 reduction on the global scale arriving at a factor of 10 for

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[6] Concerning the discussion as to whether later environmental repair might be cheaper than immediate action, recent studies (e.g. Stern 2006) confirmed the necessity and cost-effectiveness of preventive measures

[7] This again became apparent in the recent climate debates at the G-8 summit 2007. Urged to join in, the big developing countries China, India, Brazil and Mexico explicitly pointed to the responsibility of the industrialized nations and the wide gap in per capita emissions (Marschall 2007).

[8] The inclusion of "source" arguments as well as uncertainties about the carbon-feed-back cycle (IPCC 2007) may lead to additional requirements.

the Western economies: "Wir müssen unsere westlichen Wirtschaften im Durchschnitt um einen Faktor 10 oder mehr dematerialisieren – und eben auch "de-energisieren" – wenn sie zukunftsfähig werden sollen" (ibid., p.24). An apparent discrepancy with the book by Weizsäcker et al. 1995 entitled "Faktor 4" already dissolves, when considering the subtitle "Doppelter Wohlstand – halbierter Naturverbrauch." Thus, a global load reduction factor of 2 is demanded with respect to our environment, which transforms into a required efficiency gain factor of 4, if global welfare is to be doubled at the same time[9]. The factor of 4 proposed by Lovins & Hennicke 1999 has a similar composition. In BUND 1996:58, Loske et al. only suggest an 80% reduction target for CO_2-emissions in Germany, pointing out, however, that a 90% target (i.e. a factor 10 reduction) has to be met, if equal rights are assumed. Consistently, the German Enquête Commission (Enquête Kommission 1991) called for a 80% reduction target "at least", whereby the "at least" tacitly was dropped in later political proposals implicitly converting the minimum requirement into a maximum target value.

1.2.2 Can Renewables Solve the Problem?

The energy and global warming challenge can be tackled from the demand and the supply side, whereby demand side approaches are closely associated with energy conservation and the efficient use of energy, while supply side strategies focus on the replacement of fossil energy by alternative sources. Traditionally, politics has strongly focussed on the supply side, where renewable energies have been loaded with much hope to solve the energy problem, while demand side measures until recently have received considerably less attention.

As Fig. 4 shows, global primary energy consumption has almost doubled since 1971 in spite of several supply crisis in between. The growing consumption reflects the growing world population, but also its addiction to the "energy drug" and its neglect of effective energy conservation measures. Thereby, the share of renewables remained almost constant. Even as recent as 2004, about 80% of the primary energy consumption was covered by fossil resources and only 13 – 14 % by renewables respectively, with the rest attributed to nuclear. Here, "renewables" predominantly mean rather "traditional" renewables like biomass and water, the use of which has crossed the sustainability limits in many of the developing countries, while exploitation limits are in sight in many developed countries, as well (cf. also BMU 2007b:43, 46). The "new" renewables like geothermal, wind and solar energy only contribute a negligible 0,5% share. Though this indicates considerable growth potential, it is clear that the role of renewables will remain a limited one, unless the growth of overall energy consumption is radically stopped and reversed.

As far as the European Union is concerned, renewable energies only have a 6% share with a near term target (2010) of 12%. Thereby CO_2-Emissions shall be reduced by 8% in line with the Kyoto protocol. These goals, however, will be difficult to achieve, and it has been recognized that efficiency and demand side measures need much more attention in the future (EC 2006a and 2007a). Concerning the composition of renewables, traditional sources

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[9] If mapped to Western economies, this implies efficiency improvements beyond a factor of 10 – namely a factor of 20 – an implication, which is often overlooked.

as water and biomass are dominant, as well (see Fig. 5). Only in Germany, Spain, Italy and Denmark the "new renewables" have gained a sizable share Fig. 5).

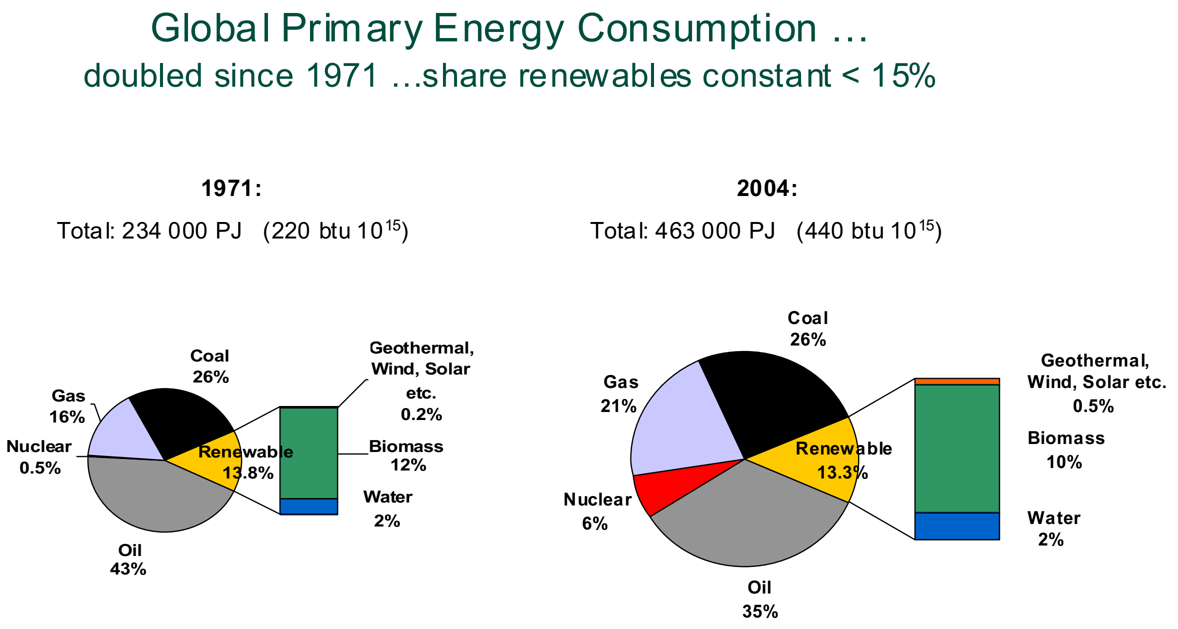

Figure 4: Global Primary Energy Consumption (cf. BMU 2007b, IEA 2006a, b)

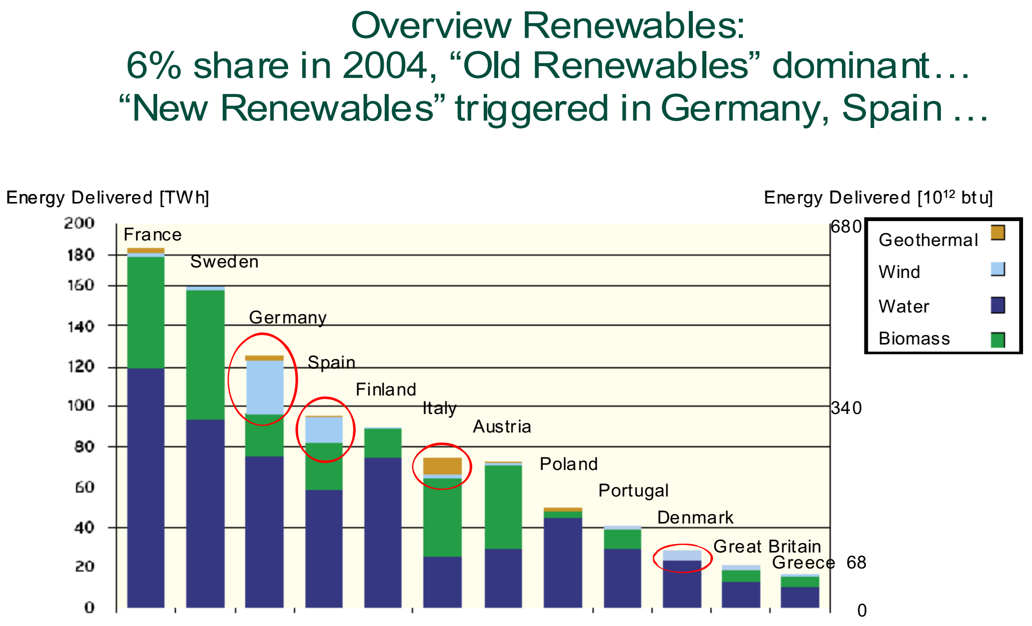

Figure 5: Renewables in European Countries (cf. BMU 2007a)

In **Germany** wind has experienced exponential growth during the last decade, which has put Germany into a world-wide leading position only recently being taken over by the US. Nevertheless, the contribution of renewables to primary energy consumption just reached 5,8% in 2006 (BMU 2007b). There are different scenarios how this can be extrapolated into the future - an example of which is shown in Fig. 6. The scenario assumes a halving of the overall primary energy consumption with respect to the baseline year 1990 and a 75% reduction of fossil and nuclear supply so that the contribution of renewables to the remaining rest can reach 50% by 2050. This way overall CO_2-emissions can be reduced by about 80% down to 2 ton p.c. and annum – which, however, still is a factor of two above the 1 ton target given above.

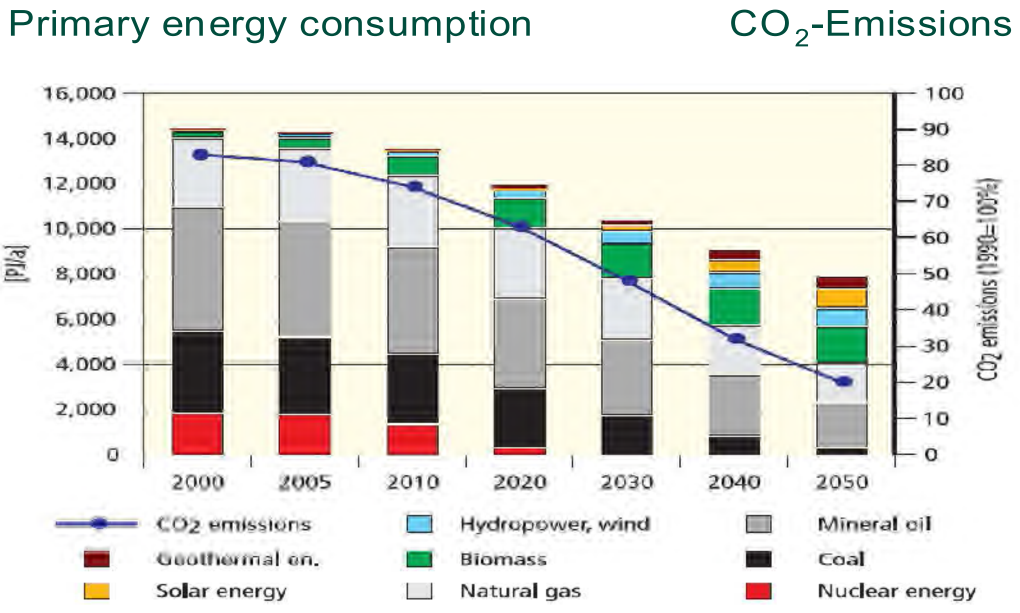

Figure 6: German Scenario for Energy and CO_2 Emissions (BMU 2007b:36)

In summary, it appears that order of magnitude reductions in CO_2-emissions can only be achieved, if energy demand is reduced in the first place so that renewable energies can cover a significant share of the remaining rest. This holds especially for Mid-Europe - where the access to cheap regenerative energy sources is limited.

1.3 The Challenge of Energy Efficient Sustainable Housing

According to estimates the **building sector accounts for about 30 to 40% of the global energy use**[10] (IEA 2006c, UNEP 2007a, b). Thus, it exceeds the industrial as well as the

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[10] Official CO_2 emission statistics for buildings usually only quote the direct emissions at the building site, which leads to a strong distortion of the overall picture giving rise to misinterpretation and systematic underestimation of the environmental impact of buildings. Hence, final energy statistics, which account for the amount of energy used

transport sector, whose shares range between 25 and 30% each (IEA 2007). In Germany, Europe and the US the contributions of buildings even amount to 40% (DENA 2007, EC 2005, US EPA 2004). Thereby residential buildings or “housing” make up the main part, reaching about 30% in Europe (UNEP 2007b). Thus, if factor of 10 energy reductions are to be obtained, **housing is of utmost importance** and has to contribute a corresponding reduction share at least.

At the same time, there is almost no other sector comprising such a complex network of ecological, economic and social aspects (Enquête Kommission1998). Besides energy and emissions, ecological aspects include material flows, immissions, area consumption, surface sealing and land fragmentation. The social dimension a.o. embraces health, comfort, adaptability to user-needs, creation and securing of personal property, affordability, creation and securing of jobs. Most issues are interlinked with the economic dimension, whereby buildings represent a considerable long-term investment with energy and other operational costs often surpassing initial investment cost. Hence, the building sector has a considerable impact upon sustainability as a whole.

In this study, we shall **focus on energy**, as one of the most prominent challenges, and consider those sustainability aspects, which are associated with energy and energy-efficiency in particular.

Considering the energy characteristics of houses (see Fig. 7 and section 2.1), it turns out that **heating is the dominant component** making up almost 80% of the energy demand and 2/3 of the primary energy consumption of an average German house. The remaining part is attributed to hot water, household appliances and possibly cooling. As the demand forms the root of the causal chain it’s reduction must receive top priority. Thus, though all components have to be considered in the end, it can be said that the main **challenge of energy efficient sustainable housing** consists in **the reduction of the heating demand** by an order of magnitude in a sustainable efficient way.

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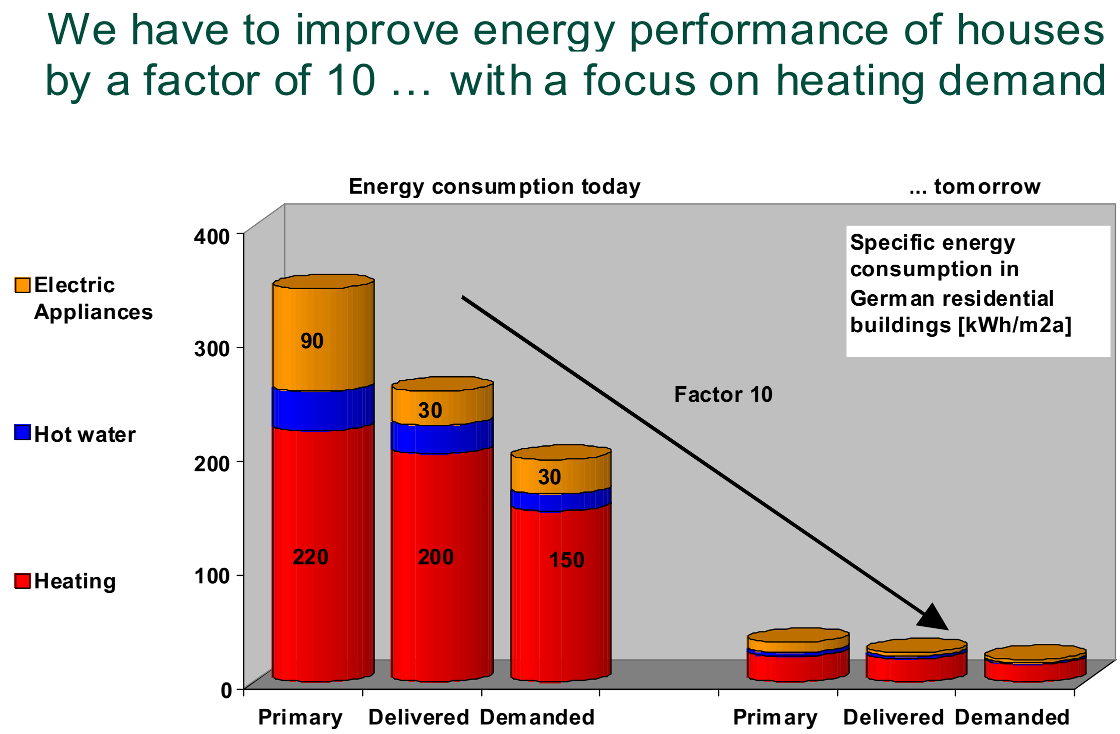
at the destination, give a more adequate cause-related picture.



We have to improve energy performance of houses by a factor of 10 … with a focus on heating demand

Figure 7: The Key Challenge of Energy Efficient Sustainable Housing[11]

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[11] Cf. Steinmüller 1999b

2 BASIC METHODS, TOOLS AND CONCEPTS

The promotion of energy efficient sustainable housing touches a broad range of sustainability management concepts and thus has links to most modules of the CSM course. In this chapter methods, tools and concepts which are basic for the following investigations are briefly introduced and discussed.

2.1 The Building Lifecycle - Value and Supply Chain

To start off with, it is necessary to look at the **building life cycle** and the relevant business stages making up the "**value chain**"[12]. Fig. 8 shows a simplified picture of the life cycle and the chain including the main feed-back loops (cf. also Koller 1995:143; Enquête Kommission 1998:140; Kaiser et al. 2007:4):

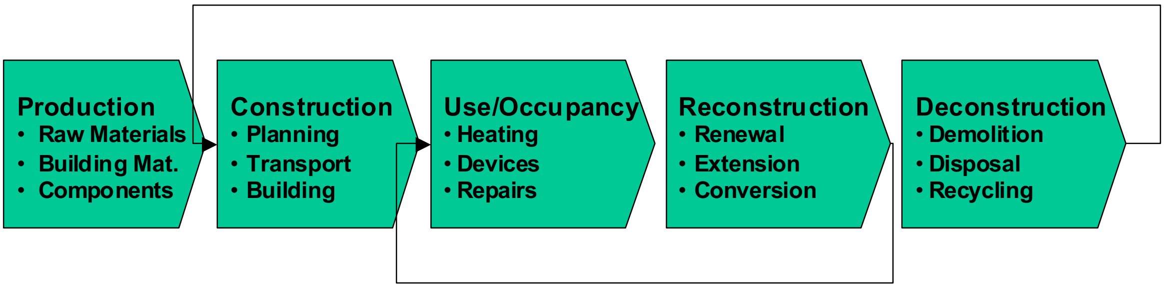

Figure 8: Simplified Life Cycle and Value Chain "Building and Housing"

An overall picture of sustainability along the life cycle can be obtained by evaluating the relevant aspects at each business stage. This leads to a two-dimensional matrix, which in the case of ecological impact analysis is called "ecological impact matrix" (cf. Koller 1995:124). This study focuses on the energy problem, which among all ecological impacts appears as the most urgent one (cf. Koller 1995:110, Steinmüller et al. 1999c, Steinmüller & Werner 2000). Thereby the impact of energy consumption in the "use"or "occupancy" stage dominates all other stages by an order of magnitude (e.g. Koller 1995:114, Moosmann et al. 2005, UNEP 2007b:7)[13]. Thus, for reducing energy by a factor of 10, this stage is decisive.

On the other hand, the impact of the use stage is strongly defined by the characteristics of

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[12] The concept of a "value chain" or "value creation chain" originally was introduced by Porter (1985) for describing value-adding activities within individual organizations. Here it is used to analyse chains extending beyond individual organisations so as to include the relevant actors of the overall product/service supply process.

[13] Note that the corresponding ecology matrix in Koller 1995: 124 (taken over by Dyllick et al. 1997: 15) has to be interpreted with care, as it hides the factor 10 difference between the use and production phase. This is due to the use of simple qualitative impact values "high", "mean", "low." These blur the large potential differences between the different ecological dimensions, as well as between the stages.

the building, which in turn is determined by the preceding stages and the reconstruction stage. Hence, for promoting energy efficient sustainable housing approaches, it is necessary to analyse these stages and the associated business processes, which supply the relevant process owner of the use stage with the relevant products and services. This leads to the concept of the "**supply chain**", which is detailed in section 4.3 .

2.2 Eco-Efficiency and Economic Assessment Approaches

In order to judge energy efficiency from a technical and economic point of view, it is necessary to introduce efficiency indicators and to define appropriate economic assessment approaches.

2.2.1 Energy Efficiency and Intensity Indicators

As indicated in section 1, the following basic forms of energy have to be distinguished:

1) Building energy use or net energy use or energy demand ("Nutzenergie")
2) Energy delivered or end/final energy or on-site energy ("Endenergie")
3) Primary energy ("Primärenergie")

As indicated by the alternatives, in literature, as well as in practical use, a broad spectrum/combination of terms is used for these basic concepts. Thus, some caution is necessary, though the meaning can usually be inferred from the context. Here, the respective first English and last bracketed German terms are the ones suggested in DIN V 18599-1:17. As far as heating is concerned, the building energy use (1) is defined as the amount of useful energy supplied by the heating system to the rooms, whereas the energy delivered (2) is the amount of energy supplied to the housing site, whereas the primary energy (3) is the energy taken from nature.

As the **energy demand** "drives" the energy supply chain, it is a **key parameter for cause-oriented reduction measures**. Energy "delivered" determines the energy bill and economic considerations on a house or business level. Finally, "primary" energy represents energy taken from nature, whereby national primary energy balances usually fully include renewables, while building level balances only include them in an environmentally weighted manner (DIN 18599 V-1:59) so that **on the building level primary energy can be taken as a direct measure for the ecological impact** of energy consumption.

In the housing business energy consumption is usually normalized to floor area and main measuring periods (e.g. in units of kWh/m^2a):

(Equ. 1) **Energy indicator** = annual energy consumption/floor area

These energy indicators directly measure energy intensity or energy efficiency on an inverted scale (i.e. a low value indicates high energy efficiency and vice versa). **As these intensity indicators are widely adopted we shall refrain from explicitly introducing new inverse**

versions, but use intensity indicators for measuring efficiency, as well[14]. This way indicators can be defined for energy demanded, energy used and primary energy. Note that Schaltegger et al. 2003:63 define:

(Equ. 2) **Environmental energy efficiency** = desired output/environmental impact added

Equating

(Equ. 3) Desired output = floor area

Environmental impact added = annual primary energy consumption

The **primary energy indicator** (in its inverted form) can also be interpreted as a measure for environmental efficiency in the sense of (Equ 2). As CO_2-emission and primary energy consumption are closely correlated, it is usually sufficient to consider the latter[15]. Alternatively, CO_2-emissions can be calculated from delivered energy with standardized energy type dependent conversion factors in a straight-forward way (see Öko-Institut 2007).

2.2.2 Eco-Efficiency

For economic assessment, it is necessary to extend the concept of environmental efficiency by associating monetary value with the numerator of the efficiency formula (Equ 2), whereby in a more general sense the denominator of the formula – i.e. energy consumption – has to be included into the monetary valuation, as well (cf. section 2.1.5) . According to Schaltegger et al. 2003:65 (quoting Schaltegger and Sturm (1994: 283)) economic ecological efficiency or “eco-efficiency” is defined by:

(Equ. 4) **Eco-efficiency** = economic value created/environmental impact added.

For buildings, depending on purpose, we can assess “economic value created” by associating appropriate monetary values with floor space (such as the annual rent, mortgage or construction cost), which leads to a spectrum of alternative eco-efficiency indicators.

The World Business Council for Sustainable Development WBCSD suggest the more general definition (see e.g. WBCSD 2000):

(Equ. 5) **Eco-efficiency =** product or service value/ environmental influence,

where the numerator can be measured by a broad range of indicators including **value-related indicators** as “space” or “floor area” themselves (WBCSD 2000: 31). Thus, in the general sense of WBCSD, the primary energy indicator defined above (in its inverted form) represents an indicator for **eco-efficiency** as well.

While these eco-efficiency indicators allow a ranking of houses - e.g. by floor space normalized to primary energy consumed - this ranking is of limited value.

When promoting energy efficient sustainable housing and energy conservation measures, we are **more interested in differential values**, such as the ratio **cost added in relation to**

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[14] Cf. also EnEV 2007:68: “Der Primärenergiebedarf bildet die Gesamtenergieeffizienz eines Gebäudes ab.”

[15] However, note that the weighting factors involved can be argued (see e.g. IWU 2007a)

the amount of **energy saved**. This leads an indicator, which is often used in the field of energy conservation (see e.g. German Energy Agency DENA at www.zukunft-haus.info , and Enseling 2003), namely the "**cost of an energy unit saved**", which is also called **"price of the energy unit saved".** It enables comparison among saving measures, as well as with actual energy prices and is quite popular, as it

a) transforms investment and possible maintenance costs into an energy price tag, which on the first sight looks familiar and easy to comprehend,

b) suggests an easy way to judge economic attractiveness of a measure without knowing actual (and future) energy prices.

However, there are pitfalls, which limit the value of this indicator:

a) The price expressed by the eco-efficiency indicator customarily is derived by calculating the annuities of the costs added. Thus, it involves assumptions about the rate of interest and lengths of the calculation period. A common fault with respect to the latter is that the time period used for the calculation of annuities is taken as the pay back period of the mortgage - which may significantly differ from the life-time of the measure. Thus, rest values are neglected, which may result in significant errors. A comparison to the actual price of energy is not straight forward either, as the latter has to be transformed into a consistent annualized form involving assumptions about energy inflation, capital costs and life-times again.

b) The indicator can be misleading, as it suggests that measures with a lower price tag are economically more attractive than measures with a higher one. This, however, can be wrong: Economy is defined by opportunity cost, which here is given by the equivalent cost of an energy unit supplied (taking into account its future development and opportunity capital cost). Thus, measure extensions are as long economical as their incremental energy price tag stays below the price of an energy unit supplied. Otherwise, economic saving potentials are wasted.

c) Finally, it has to be taken into account that the investor – e.g. in the case of landlords - may only indirectly benefit from energy savings and that other contextual factors have to be considered as well.

A very good description of the method – which explains the benefits and most of the pitfalls – is given by Feist (1997b). Yet, when converting to annuities, fixed time spans of 30 years are assumed without evaluating the effect of possible rest values. As a measure for economy, a "mean future energy price" of 10 Pfg/kWh is suggested, but its derivation and appreciation are left to the reader.

Hence, though the cost of an energy unit saved is popular and may give a first indication of economic attractiveness, it is insufficient, as it hides important assumptions in an apparently straight-forward price tag. **Consequently, extended methods have to be considered**. Some are suggested in (Enseling 2003, Feist 2005). In the following, we shall briefly summarize considerations needed for a detailed economic assessment and then introduce simplified dynamic models, which take the valuation of the energy supply price as a starting point.

2.2.3 Detailed Economic Assessment Approaches

As already indicated, economic decisions in the area of housing involve a long time horizon and a large number of parameters. In fact, housing companies have to balance decisions on whole building **portfolios** (cf. Wellner 2002). Thereby, classic assessment dimensions (see e.g. InWIS 2003) have to be combined with ecological ones (cf. Schaltegger & Sturm 1998:46, Schaltegger et al. 2003:326), which results in correspondingly extended two- or multi-dimensional portfolio matrices (see Fig. 9).

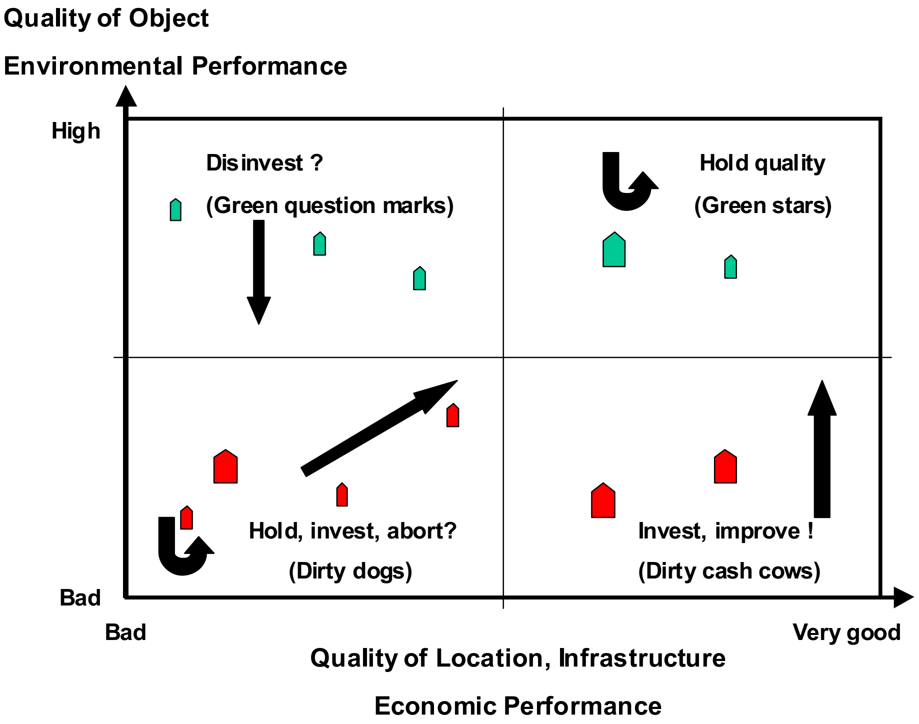

Figure 9: Two-Dimensional Portfolio Matrix

In parallel dynamic **socio-economic developments** (see Fig. 10) including market, location, object and cash-flow aspects (cf. Wullkopf 2005, InWIS 2003, Lützkendorf et al. 2007) have to be evaluated.

Assuming that all model parameters are known, detailed economic calculations can be performed on an object by object basis (cf. Enseling & Behle 2006), whereby **complete financial plans** ("Vollständige Finanzpläne VOFI") allow the most advanced assessment and integration of all relevant cash-flows during the economic life-time of an investment (cf. Eichener 2006). Though very detailed evaluations are possible this way, a serious limitation is given by the complexity of the instruments and the large number of input parameters required. Moreover - as these tools are tailored to whole house analysis - assumptions relevant for specific energy conservation measures may easily be overseen and undervalued, e.g. if rest value considerations do not adequately take into account corresponding “rest saving potentials”[16].

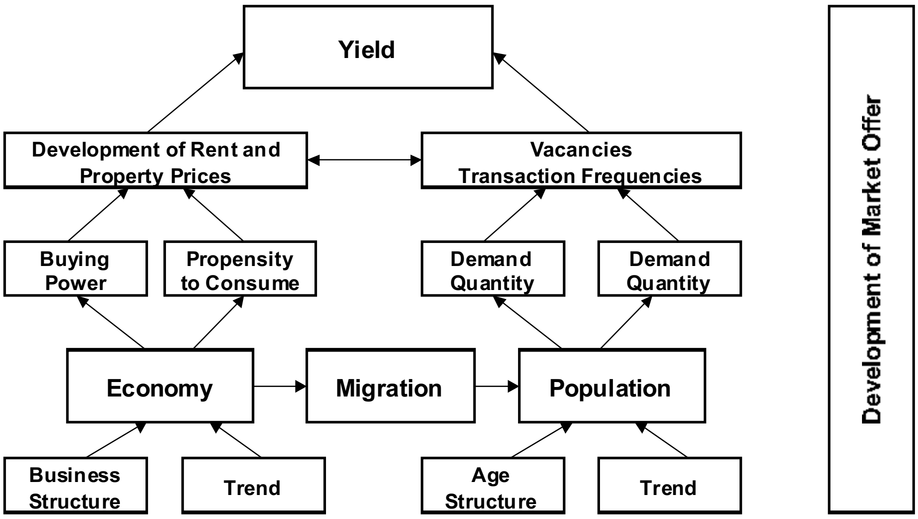

Figure 10: Socio-Econo-mic Development and Risk analysis (cf. InWIS 2003)

Thus, it is necessary to supplement these complex models with simpler dynamic models targeted at strategic decision making.

2.2.4 *Simplified Net Present Value Approaches*

A simplified approach for economic assessment and optimization of energy efficiency measures has been described by Steinmüller (2004a) and applied to the promotion of energy efficient renewal of buildings (see Steinmüller 2005, and section 3.3). Thus, it is sufficient here to outline the essential ideas.

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[16] Standard literature even suggests (Petersen 2003a:23): “Differenzen im Ansatz langer Restnutzungsdauern haben kaum Einfluss auf das Ertragswertergebnis.“ As shown in the following, this cannot hold for yield components, whose rate of inflation is sufficiently close to capital interest.

The **net present value** NPV of 1 unit **of annual energy delivered** over n years is given by

(1) $\mathbf{NPV} = E_0 * N_{eff} = E_0 \sum q_{ek}^{t}$

where the summation extends from t = 0 to t = n-1 and

where E0 := initial energy price, q_{ek} := (1+energy inflation)/(1+ capital interest)

(2) If q_{ek} constant then $N_{eff} = (q_{ek}^{n}-1)/(q_{ek}-1)$

The resulting net present value NPV, when multiplied with the units of annual energy savings ΔQ, defines an **upper limit for economically viable investment ΔI:**

(3) $\Delta I < NPV * \Delta Q = E_0 * N_{eff} * \Delta Q$ **i.e.** $\boldsymbol{\Delta I/\Delta Q < NPV = E_0 * N_{eff}}$

Note that **ΔI/ΔQ can be interpreted as eco-efficiency indicator** for the non-annualized cost of an energy unit delivered. **N_{eff} as an “effective time factor”.**

Box 1: Deriving Net Present Value of Energy Delivered

While the eco-efficiency approaches described in 2.1.2 focus on annualized costs trying to disregard energy value as long as possible, the **approach here reverses the order and starts with net present energy value which in a first step yields an upper limit for economically viable investment costs** (see Box 1) and in a second step can be used to derive economically optimum solutions (see Box 2). According to Box 1(1) **all the dynamics and all the “unknowns” of future developments are put into a single factor Neff,** which to a first order approximation is equal to the length of the delivery period n. Hence, N_{eff} assumes the role of an “effective time factor”, which, when multiplied with initial energy price E_0, delivers the net present value of a periodically spent unit of energy[17]. Thereby, energy inflation and capital interest are merged into a single time dependent “scenario parameter” q_{ek}, which decisively reduces the complexity of parameter space[18]. In the case of constant q_{ek} (see Box 1, equation 2), N_{eff} only depends on the two parameters n and q_{ek} so that it can be easily displayed in a diagrammatic fashion (see Fig. 11).

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[17] N_{eff} can also be interpreted as NPV (E_0 = 1). See appendix, Fig.47 for examples of historical data.

[18] While one parameter dimension is eliminated this way, the fact that the two parameters energy inflation and capital interest are not fully independent is automatically accounted for. Energy inflation cannot arbitrarily exceed capital interest over a long time, as this would trigger substitution and saving measures. For this reason, it can be assumed that (a) $q_{ek} < 1 +$ epsilon and that (b) the probability distribution of scenarios is asymmetric with respect to qek = 1 showing a higher density below 1.

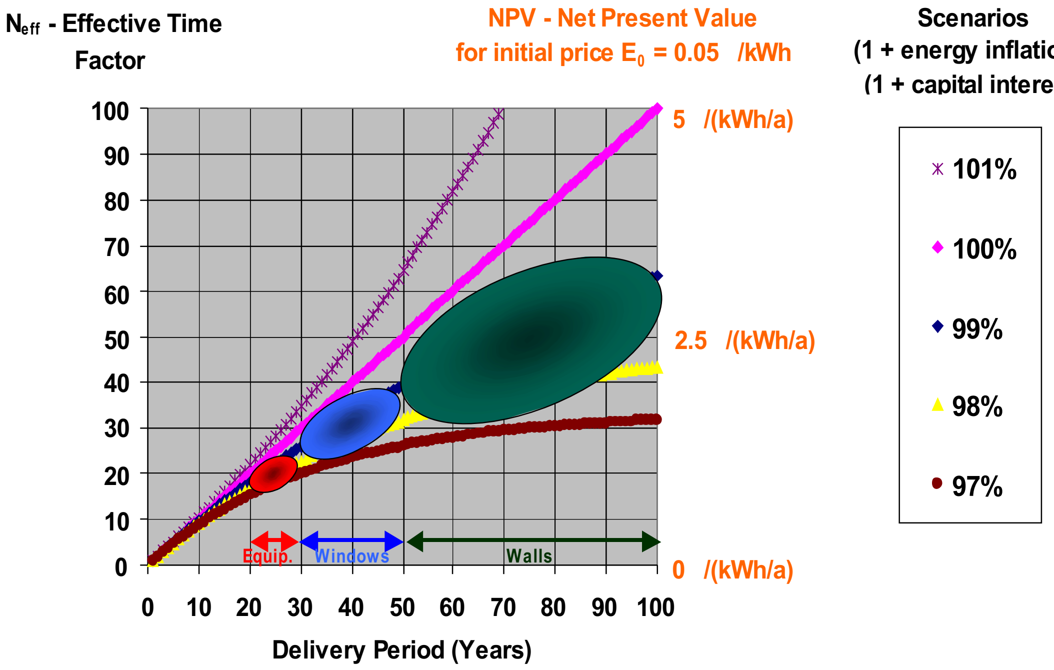

Figure 11: Coordinate System for Estimating Net Present Energy Value

The corresponding diagram can be used as a “compass” and “coordinate system” for estimating net present values, whereby scenarios with variable qek may also be included, in order to study the effect of possible alternatives and weight them in order to isolate most probable areas and ranges for Neff (see Steinmüller 2005). Taking into account typical lifetimes for equipment, windows and walls with their projections to typical scenario curves coloured areas can be derived highlighting most probable, typical parameter combinations. Fig. 11 shows that resulting effective time factors for walls are in the range of 30 to 70 years, with 50 as a typical average. “Conventional” mortgage based calculations implicitly assume factors between 20 and 30 indicating a potential underestimation of corresponding net present values by a factor between 1,5 and 3,5.[19]

For economically optimizing energy saving measures, it is necessary to minimize the net present value of capital and energy expenditure (see Box 2). Thereby, the investment cost for energy saving measures typically increases with the extent X of the measure, while the amount of energy saved decreases. **Assuming a linear scaling for the former and an inverse scaling for the latter - which is the simplest characteristic for measures with diminishing marginal utility** - the first order derivative of the capital value renders a quadratic equation, which can easily be solved for X.

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[19] Note that life-times of important building components like wall insulation systems are grossly undervalued in official guidelines (e.g. factor 2 for insulation, cf. Künzel et al. 2006) leading to economic misconclusions.

Economic optimization calls for minimization of total capital cost C(X):

(1) $C(X) = I(X) + NPV * Q(X) + \text{other costs} = \min !$ ➔ **(1')** $dC/dX = 0$

where X = extent of measure, I(X)= investment, Q(X) = annual energy delivered

For relevant functions I(X) and Q(X) equation (1') can be solved analytically:

If (2) $I(X) \sim a*X + \text{constant}$ **And** **(3)** $Q(X) \sim b/X + \text{constant}$

where a = incremental cost and b = thermal system parameters

Then (4) $\mathbf{X_{opt} = \sqrt{(NPV)} * \sqrt{b/a} = \sqrt{(N_{eff})} * \sqrt{E_o * b/ a}}$

Box 2: Economic Optimization Principles

This way, **it is possible to derive economic optima and assess their principal dependence and sensitivity on key scenario, cost and thermal parameters in a transparent way** (cf. Steinmüller 2005). Note that due to the symmetry of (1), (2) and (3) in X and q, similar solutions can be obtained for C(q), which extends the applicability of the formulas. On the other hand - though decreasing marginal utilities are typical for most measures – certain combination of measures may create synergies, which render sudden utility gains so that "cost barriers" can be "tunneled" to reach "new optima". These combinations are of special interest for increasing efficiency beyond traditional limitations (cf. section 3.2.1 and 7.5).

2.3 Market Interaction and Transformation Models

While technical and economical feasibility is a precondition for the successful promotion of energy efficient sustainable housing, market mechanisms ultimately determine whether niches of energy efficient sustainable housing can be transformed into mass-markets. Specific models for the transformation of ecological niches are discussed and proposed by Wüstenhagen (2006). His delineations are taken as a starting point for the derivation of framework elements useful for this study. Thereby, we shall look at top level system concepts first of all and then briefly survey lower level ones, which will be used and detailed upon in later sections.

2.3.1 Top Level Concepts

On the top level of abstraction, Wüstenhagen (based on Dyllick 1990, Belz 1995 and Dyllick et al. 1997) distinguishes **three "control systems"** ("Lenkungssysteme"): public, political and market control.

These systems purportedly transform ecological problems into fields of market competition along **three consecutive steps** (cf. Wüstenhagen 2006:3 and Fig. 12):

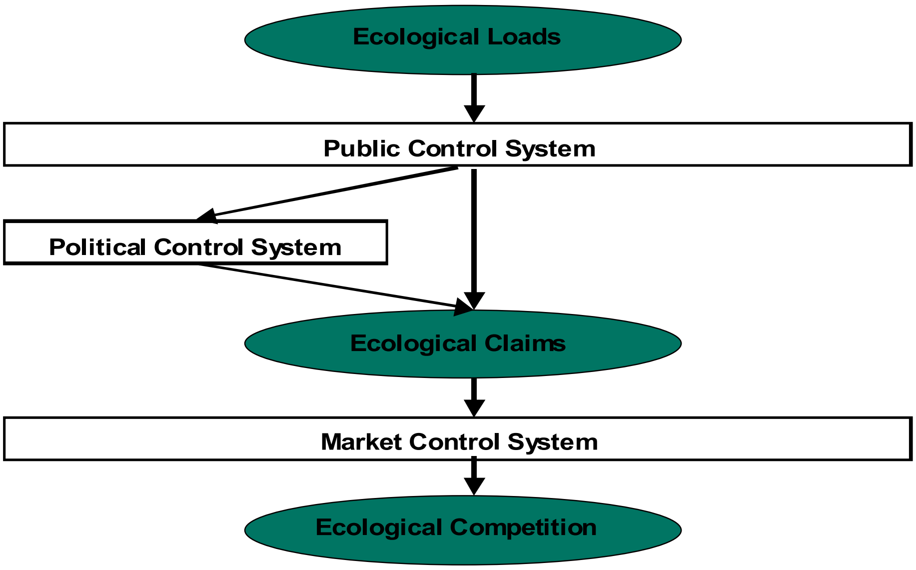

Figure 12: Control Systems and Ecological Transformation Processes

1) Stakeholder groups of the **public control system** - including scientists, environmental organisations and media - take up environmental problems and create public pressure.
2) The **political control system** reacts and attempts to find ways of solution, e.g. by regulations.
3) Public pressure and regulations result in ecological claims which are transformed into fields of ecological competition by means of the **market control system.**

Though plausible at first sight, **this model appears problematic** both with respect to

a) the notion of “control systems” and

b) the sequence of processes and direction of control flow.

a) The term “control system” suggests a1) well-defined entities, which a2) exert control in a systematic manner. However, neither a1) nor a2) are evident. While system boundaries and membership remain diffuse, experience shows that the behaviour of public, political and market actors can be rather chaotic, full of conflicts and void of clear direction. The climate debate demonstrated (cf. also section 5.2.2 and Rosenkranz 2007) how strong convictions and “claims” shared by the overwhelming majority of scientists can be diluted and filled with doubts by part of the media. Thus, instead of transforming ecological problems into claims effectively, the “public control system” often works as an assembly of conflicting forces without a clear overall direction.

b) Hence, the sequence of processes and direction of control flow is less clear than suggested. Moreover, the core concepts of mega-marketing and eco-marketing (cf. Kotler 1986 and below) even build explicitly upon reverse control flows from market to public and politics.

Studying the background literature (Dyllick 1990, Dyllick et al. 1997) for clarification, Dyllick et al. (1997: 27) point out that the sub-systems should present a “functional” rather than an “institutional” view[20]. An association with specific stakeholder groups is considered problematic (ibid. p. 28). Nevertheless, in the construction of ecological claim matrices for the building industry (ibid. p. 32), **functional and institutional aspects are finally mixed**: Here, “politics” explicitly includes “political”, “informational”, as well as “market-oriented” instruments. This shows that the **institutional view even dominates** – which is not too amazing, as from a strategic point of view, the knowledge of the actors behind a function is as important as the functions performed.

Looking for a solution of these inconsistencies, it has to be acknowledged that a model, which explicitly separates the institutional and functional views, would lead to a 3 x 3 representation. This could become unwieldy in strategic discussions. Hence, the following **pragmatic generalizations are suggested:**

a) For “control systems”

institutional as well as functional aspects should be included so that the terms “public”, “politics”, “market” acquire a context-sensitive meaning,

1. **indeterminism, heterogeneity and concurrent conflicting actors** have to be taken into account, whereby “**key drivers**” (cf. Dyllick et al. 1997:45) have to be spotted, as they may exert decisive **influence within and among the “control systems**.“

b) Regarding “control flow”

1. **multiple bidirectional interconnections** have to be allowed explicitly,
2. **feed-back loops** have to be added (ibid: 140 ff).

When **comparing the concept of “control systems” with the concept of “influence spheres”** described by Schaltegger et al. 2003:37, at least **two more observations can be made:**

c) the public control system resembles the socio-cultural sphere, the market system the economic sphere, the political control system primarily maps to the “legal sphere”,

the “sphere of politics” (“Interessenpolitik”) as defined by Schaltegger et al. 2003 has no direct counter part in the approaches of Wüstenhagen and Dyllick et al

Observation c) confirms that **the distinction between the terms “sphere” and “control system” is less significant than it appears on the first sight**. With some care, both terms

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[20] This functional or “force-field-type of” view is extreme in Dyllick 1990, where the “moral system” replaces “public system” as a key driving force.

can almost be used in a synonymous way.

Observation d), however, shows that care is needed, when using the term “politics”. Checking Schaltegger et al. 2003, the political sphere of “Interessenpolitik” in essence embraces intricate power-play as opposed to controlled system behaviour. Thereby, the associated behaviour and structural elements are loosely modelled by the concept of an “arena” (see e.g. Schaltegger et al. 2003:150 quoting Renn and Webler 1994, as well as Lowi 1967). Thus, **the concept of a “chaotic arena” supplements the concept of orderly “control systems”** [21]. In fact, it can be seen as the chaotic action element within and between the systems.

In conclusion, the top-level concepts suggested in Wüstenhagen 2007 shall be adopted with pragmatic modifications a) and b), whereby the terms “control system” and “sphere” will be used synonymously in the sense of c). Thereby the **institutional** view is taken as a main clustering criterion. The possibly ambiguous concept of a “political sphere” is defined by the institutional view approximating Wüstenhagen’s political control system, whereas the original “sphere “of “Interessenpolitik” d) is reinterpreted as a supplementary **behavioural view** cutting across the public, political and market sphere. Fig. 13 illustrates the conclusions in an informal way.

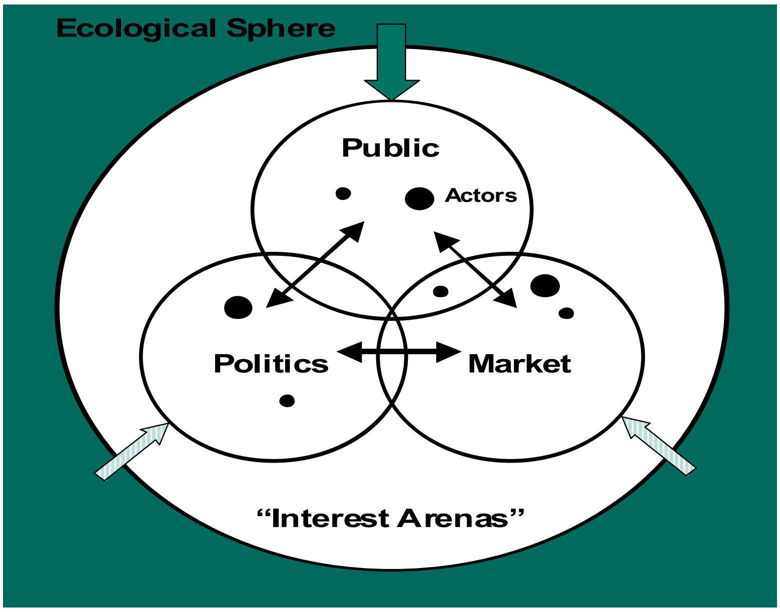

Figure 13: Action Spheres and Interactions

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[21] Applying the arena concept to the international struggle about climate protection, it appears as a key metaphor, which however needs further differentiations and some modifications. Here, we also find political actors in the arena, whereby binding “legal rules” are almost absent. Moreover, individual actors are moving between the actor groups, while on the other hand there is a continuous flow of interest groups moving between the ranks of the arena and the arena floor, thereby passing the “information filter” of the media. Though an extension of the arena metaphor appears an intriguing idea, it is beyond the scope of this study.

2.3.2 Lower Level Concepts

In order to explain the transformation of ecological niches into mass-markets in more detail, Wüstenhagen refers to the following lower level concepts:

- The concept of ecological dominos chains
- Porter's five forces concept
- Greening Goliaths and multiplying Davids
- The ecological business life-cycle
- The concepts of eco-marketing
- The map of the ecological mass market

The concept of **ecological domino chains** is described in more detail by Dyllick et al. 1997:46 (see also section 4.3). In essence, it is a metaphor illustrating how ecological claims can ripple through the stages of a business field sequentially "greening" a whole value chain and potential side-chains as well. Yet, it does not make any specific statements about the forces involved and the "stickiness" and "inertia" of individual dominos. Nevertheless, it provokes this sort of considerations, which – in the author's view - are not limited to the market, but could be applied to the public and political sphere as well.

Porter's well known **five forces model** (Porter 1985) proposes the rivalry among existing competitors, negotiation power of suppliers and customers and the threats from substitutes and new competitors as generic forces acting upon a business. The model offers a generic framework into which ecological considerations can be embedded - without, however, having a specific ecological component.

The model of greening Goliaths and multiplying Davids has a specific background in the food industry (cf. Wüstenhagen 1998) and suggests a template for the development of green mass markets via the mutual stimulation and co-evolution of creative "Davids" and powerful "Goliaths". In the housing industry, however, Goliaths are rare. They are mainly restricted to the early stages of the value chain[22] and its context (see e.g. section 5.1.2).

The heuristic **model of the ecological business lifecycle** (Wüstenhagen 2006:21ff) integrates a spectrum of earlier concepts and develops a holistic view over the life cycle of ecological products trying to identify relevant success and influence factors for the diffusion of niche-products into a broad market. In particular, it points to the mutual dependence of development processes on the demand and supply side. The concept of diffusion along innovators, early adapters and imitators is used for modelling the former, while the concept of Davids and Goliaths is integrated into the latter. The model creates awareness for the different user types relevant in different expansion stages of the market, and thus calls for marketing strategies, which consciously address new relevant groups. In particular, the latter, as well as the necessity of addressing demand and supply side behaviour in parallel, appear relevant for the subject of this study (see e.g. section 4.4ff).

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[22] See also Koller 1995:62 ff and sections 4.3, 5.1, 7.3.

Demand and supply side behaviour are explicitly treated in **eco-marketing** (Wüstenhagen 2006:29ff, see also section 4.4 and 4.5) . According to Schaltegger et al. 2003:208 "eco-marketing attempts to defrost … educate … refreeze their [customer's][23] expectations so that they take environmental considerations into account." Besides changing customer types, information asymmetries, emotional and cognitive involvement and the intricacies of the decision process have to be considered. When expanding eco-niches into mass markets (cf. Petersen 2006:36ff), offensive ecological competition strategies are needed to progressively gain more "difficult" customer groups (Dyllick et al. 1997:76, Wüstenhagen 2006:33). This requires a careful analysis of success factors (Petersen 2006: 59ff) and a flexible adaptation of the overall marketing strategy and marketing-mix. While "promotion" (here in the sense of "communication") is the core of the classical "4 P" ecological marketing mix, "politics" and "public opinion" become important marketing issues, when moving from niche to mass-markets.

The map of the ecological mass-market (Wüstenhagen 2006:12f , Wüstenhagen et al. 1999:27 and section 5.4) appears useful for visualizing base strategies in simple structured markets, where the market share of products can be mapped to a single ecological indicator measuring the "relative ecological quality" of a product. Market segments with different market share and ecological quality are represented by rectangles covering the map. While uncovered area indicates the ecological market potential, the different options of expanding the rectangles indicate different strategies for moving towards an ecological mass market. While this map seems attractive for discussing energy-efficient sustainable housing as well, two caveats need to be put forward: a) area sizes and thus overall appearance and expressive power of the map strongly depend on the indicator chosen to represent "relative ecological quality" b) the relevant housing market consists of a large number of sub-markets, energy-saving products, services and goods, easily blasting the capacity of a map.

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[23] though Schaltegger et al. explicitly refer to customers, the defrosting and refreezing paradigm applies to the supply side as well (see section 4.5)

3 ENERGY EFFICIENT SUSTAINABLE HOUSING – BASIC APPROACHES

In order to establish a basis for discussing market processes and promotion strategies for energy efficient sustainable housing, this chapter outlines the relevant technical concepts and innovation approaches.

3.1 Early Lessons: The Philips Experimental House

Fundamental housing research in Germany was triggered by the first oil crisis in 1973 and inspired by Scandinavian work on low energy, as well as by American efforts on passive solar buildings and renewables[24]. 1974 a total outsider in the buildings sector, **Philips research**, **built the first ultra low energy[25] house in Germany** in order to systematically evaluate the potential of renewable energies and innovative supply devices, such as solar collectors, heat pumps, heat recovery units (see Hörster et al. 1980, Fig. 14).

Philips Experimental House - Aachen 1974 ff

- Super insulation: U-Value 0.14 W/m^2K (R~40)
- Efficient Window Systems: (coated double) + shutters
- Controlled ventilation, 90% air-to-air-heat recovery plus soil heat exchanger
- Heating demand 20 - 30 kWh/(m^2a) i.e. 2 – 3 kWh/(ft^2a) or 7 – 10 kbtu/(ft^2a)
- Renewable Energies
- Theory-Experiment Comparisons
- Parameter Studies US & Europe …

Figure 14: The Philips Experimental House Demonstrates Basic Principles

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[24] cf. e.g. Korsgaard 1976, Balcomb et al. 1977, Lovins 1977. Interestingly enough, efficiency strategies for electrically operated homes served as another initial input (cf. Stoy 1973 and Hörster 2007)

[25] For definitions, see Feist 1997 and Steinmüller 2001a. Under Mid-European climate "low energy" implies an annual heating demand below 55 kWh/m^2a or 70 kWh/m^2a for houses in a row and detached single family houses respectively. The heating demand of the instrumented ground floor of the Philips Experimental House under simulated living conditions amounted to 20 – 30 kWh/m^2a depending on type of experiment and year.

3.1.1 Factor of 10 Reductions Possible and Economically Attractive

The building was an **upgraded off-the shelf prefabricated wooden frame house** equipped with super insulation, the best obtainable windows, controlled ventilation with 90% heat recovery and a soil heat exchanger. The measured heating demand of 20 – 30 kWh/m^{2}a was more than a factor of 15 below the demand of normal houses at that time and already close to what a German passive house (section 3.1.2) would need today. In fact – apart from the windows, which were not available, but researched at that time – it showed all of the properties a modern passive house is known for. The small remaining energy demand could largely be covered by renewable energies, such as solar thermal energy supplied by own experimental vacuum collectors and heat pumps in the cellar.

The overall goal was to use the Philips Experimental House as a test bed in order to **evaluate the parameters of the overall system** and derive models for analysing the relevance of the different parameters under a wide set of possible boundary conditions **in the Western world**. Thus, extensive studies including the US & Europe where performed (see e.g. Bruno & Steinmüller 1977, Bruno & Hörster 1978, Steinmüller & Brund 1979, Steinmüller 1979 – 1982). As an example, Fig. 15 shows an original output of one of the studies (Steinmüller 1979) displaying the annual heating requirement of three basic house types "Experimental" (super-insulated similar to Philips Experimental House), "Swedish" (insulated according to Swedish building codes) and "Normal" (poorly insulated German building at that time) in light (E, S, N) and heavy (EH, SH, NH) versions in 4 European and 4 North American climates. Accordingly, with respect to "Normal" houses, it was **possible to reduce the heating requirement by a factor of 10 to 20 in all climates** simply by **improving the passive characteristics of the house.** In fact, it appeared that in most climates these efficiency measures are much more effective than measures on the supply side (cf. Bruno & Hörster 1978). Thus, **the paradoxical result - for a company which set out to exploit the supply side potential - was that demand side measures should receive top priorities[26].** Actually, **it became clear that houses could be run without conventional heating systems** so that corresponding internal research on small auxiliary heating devices was started.

Analysis of eco-efficiency in terms of "price of the energy unit saved" (cf. section 2.2.2 and Hörster et al. 1980:153ff) showed that for Mid-European climate conditions (Hamburg)

- the step from a German "Normal" to a "Swedish Standard" house, saving a factor of 5 of heating energy, was possible for less than 0,04 DM/kWh (which at that time was less than the equivalent price for oil),
- the next step to the level of the "Experimental House Standard" rendered another factor of 4 savings. And was estimated to cost about 0,13 DM/kWh (which at that time was close the price of electric energy).

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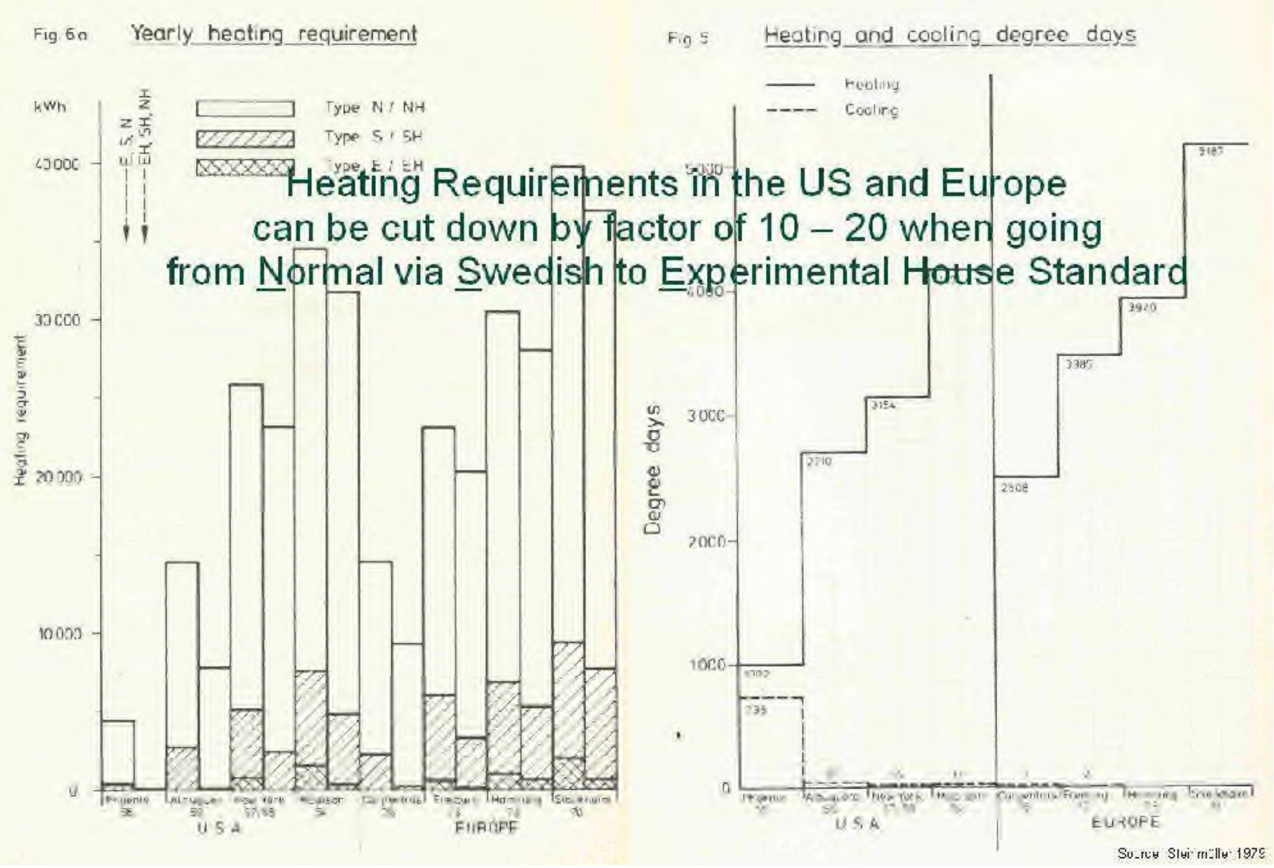
[26] Note, these conclusions included old buildings as well, where considerable saving potentials were seen and saving measures suggested (Hörster et al. 1980:188 ff)

Thus, depending on the heating system employed **factor of 5 to 20 reductions also appeared economically feasible.** The respective figures for New York were 0,05 and 0,18 DM/kWh. Note that these figures were derived for "conservative" calculation scenarios with high rates of interest, relatively short depreciation periods[27]. The building costs were grossly extrapolated from the costs of the Experimental House assuming mass production.



Heating Requirements in the US and Europe can be cut down by factor of 10 – 20 when going from Normal via Swedish to Experimental House Standard

Source: Steinmüller 1979

Figure 15: Parameter Studies US & Europe Underline Global Saving Potential

As windows appeared as the weakest component and as **passive solar heating** was under intensive discussion, **window systems** received particular attention. Highly efficient translucent walls (Bruno et al. 1979) reaching thermal parameters as current passive house windows were shown as a possible solution. Simulation experiments measured the impact of window parameters under various climates (see Fig. 16, Steinmüller 1979 and 1982). It turned out that in Mid- and North-Europe, window areas beyond 30 – 50% in the south do not lead to additional gains in well-insulated houses – which is consistent with later

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[27] These indicators were derived for an annuity factor of 10%, which corresponds to a 20 year calculation period and a capital interest of 8% (see Hörster et al. 1980:151). This is a fairly "pessimistic" assumption regarding long-term building investments (see also discussion in section 2.2.2). On the other hand, these calculations did not target at a precise assessment of building cost, but tried to find out, whether there was a chance for regenerative energies at all. Thus, the scenarios chosen, tended to underestimate the former and favour the latter ones.

recommendations for the optimum dimensioning of windows in passive houses. (Feist et al. 1994). On the other hand, in climates as in Albuquerque a broad range of passive solar options turned out feasible even with relatively simple window systems.

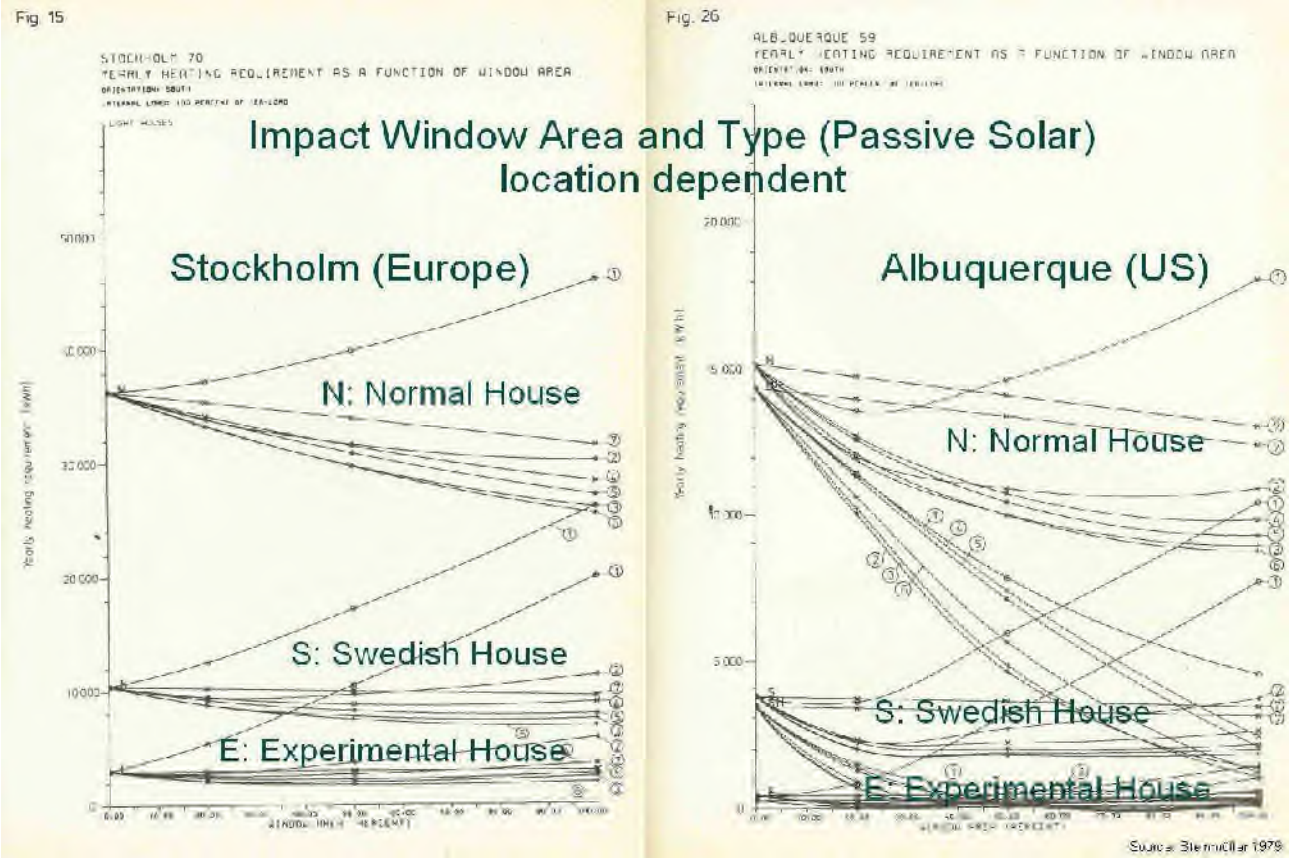

Figure 16: Passive Solar Options and the Role of Windows

In conclusion, basic lessons concerning technical and economic trade-offs between active supply side and passive demand side measures had been learnt and the feasibility for highly energy efficient sustainable housing had been clearly established for various climates in the Western world. Still, it took more than another decade until the ideas were effectively put into action (cf. section 3.2). Hence, it is worthwhile, to examine possible reasons for this delay and attempt a first mapping to the basic top-level concepts of section 2.3.1.

3.1.2 Market and Market Environment not Ripe for Adoption

The following preliminary analysis primarily relies on the personal insight and judgement of the author, who himself contributed to the Philips project from 1977 to 1983[28]:

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[28] A historic scientific evaluation is beyond the scope of this study. Main points, however, were checked for consistency a.o. in personal conversations with the former VP and chief project leader at Philips Research Aachen (Hörster 2007).

1. Though Philips Research systematically studied energy efficient buildings, the **field of buildings is not part of the Philips business.** Thus, **building research at Philips eventually faded out**. Researchers had to move to other business fields or join external building institutions. As the latter were determined by traditions (see below), most researchers looked for new challenges in other fields of work[29].
2. The **building industry** in Germany and parts of Europe **traditionally offered massive constructions**, which, however, show relatively poor insulation properties. In well-insulated houses, the massive parts can be reduced to their static minimum. Hence, the traditional building industry took a defensive approach trying to shield their traditional business field, even questioning the soundness of innovative energy efficient housing approaches[30].
3. **Traditional R&D** in Germany is strongly **coupled to the building industry**. Leading R&D institutes have to secure 70 – 80% via industry contracts[31] and thus belong to the market rather than to the public sphere (cf. Fig. 13). Hence, R&D was driven by traditional materials, questions and targets. Simulation focussed on the behaviour of individual walls and rooms during critical days – underlining possible advantages of massive structures under theses circumstances. Annual energy efficiency potentials were overlooked or underestimated[30].
4. **Political Institutions played a double role**. While politics had strongly supported the Philips project, political actors were also driven by public opinion and lobby interests. Thus, though the large potentials of energy efficient housing were evident, no vigorous measures were taken. Paying tribute to the **solar hype**, the next major project focussed on “solar buildings” (Landstuhl project, cf. Gruber 1984) - against the evidence obtained in the Philips project and against the advice given by Philips Research.
5. As far as the **public** is concerned, **“valuable” housing has traditionally been associated with massive constructions** in Mid-Europe, while “light” constructions were readily associated with “cheap” uncomfortable houses. Hence, the idea that “light” insulation should add value to a house could easily be discredited. Besides, the interest in energy **conservation measures and buildings always ranked second to renewable energies**, which were seen as the most attractive and promising solution to energy problems.
6. **Global Energy Market & Economy:** While oil prices (cf. appendix, Fig. 44) surged by a factor of 10 from the first oil crisis 1973 to the Iran-Iraq war in 1981, prices consecutively dropped by a factor of 2 to 3 making energy conservation measures

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[29] Besides, there also was a feeling that the basic technical research questions had been answered.

[30] See also Feist et al. 1997: IX: The official building research and building industry did not resume the future-oriented concepts. Fashionable subjects as solar houses, heat pumps and building biology determined the discussion. Good insulation was even discredited as “energy vegetarianism”.

[31] Cf. funding model Fraunhofer institutes (www.fraunhofer.de)

economically less attractive. Thus, a major economic driving force for innovation, which also had triggered the Philips project faded away and only came back again at the beginning of this century (cf. Fig. 44 to Fig. 46).

Thus, it appears that in Mid-Europe neither the market, nor the public and the political actors were sufficiently ready and open to realize and exploit the chances. Even worse, declining energy prices signalled declining importance of the issue, though the opposite was the case. Declining energy prices especially struck in the United States, where an abrupt turn towards deregulation strengthened the erroneous market signals (cf. section 1.1).

3.2 Passive House - A New Optimum for Eco-Efficiency & Comfort

While highly energy efficient buildings faced a drought in Germany, "low energy houses" spread out in Scandinavia. In Germany there were only a few active building owners, architects, engineers and "alternative" scientists, who kept the interest in deep energy-efficiency alive. W. Feist was one of them. Supported by the State of Hesse and the Institute for Housing and Environment (IWU) at Darmstadt, he started to build up a new "Energy Group" within the institute in 1985. In 1986 contacts to Sweden were intensified and low energy housing projects were started (Feist & Adamson 1987). The consequent extension resulted in the "passive house" concept (Feist 1988, 1993), which defines a new optimum for eco-efficiency and thermal comfort.

3.2.1 Basic Idea and Concept

The basic idea (cf. Fig. 17[32]) builds on the recognition that – by reducing the heat losses of a building – the heating demand can be reduced so much that the small amount of rest heat can be supplied without a traditional heating system. Thus, by improving the building envelope beyond a potential cost minimum, it is possible to simplify the active system so that a new cost optimum is obtained with a lower heating demand[33]. Thereby, improvement of the building envelope includes the improvement of air tightness and implies the implementation of an efficient controlled air ventilation system with heat recovery from the exhaust air.

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[32] cf. Feist 1997: IV/14 and discussion in section 2.2.4. The passive house concept is a good example how an apparent cost barrier can be "tunnelled" by synergetic measures. Note that the discontinuity shown in Fig. 17 is less abrupt in practice.

[33] Relating these findings to recent discussions on sustainability economics (cf. Schalter & Wagner 2006), Fig. 17 not only disproves the neo-classic "traditionalist" view according to which non-trivial optima do not exist (ibid: 9), but it also indicates that the "revisionist view", which relates environmental performance to economic success by U-shaped curves (ibid: 10ff) is still too restrictive. The U-shape view asserts monotonic system behaviour leading to a well defined optimum (cf. Box 2, p.31), but neglects the potential of new qualitative system properties emerging beyond certain quantitative performance improvements (cf. caveats p.31). Thus, "multiple-top"-curves and "innovative breakthroughs" have to be accounted for when discussing housing and ecomomic success factors for companies in the housing market (cf. Junkers 2007 and sections 5.1.1, 6.2, 7.5).

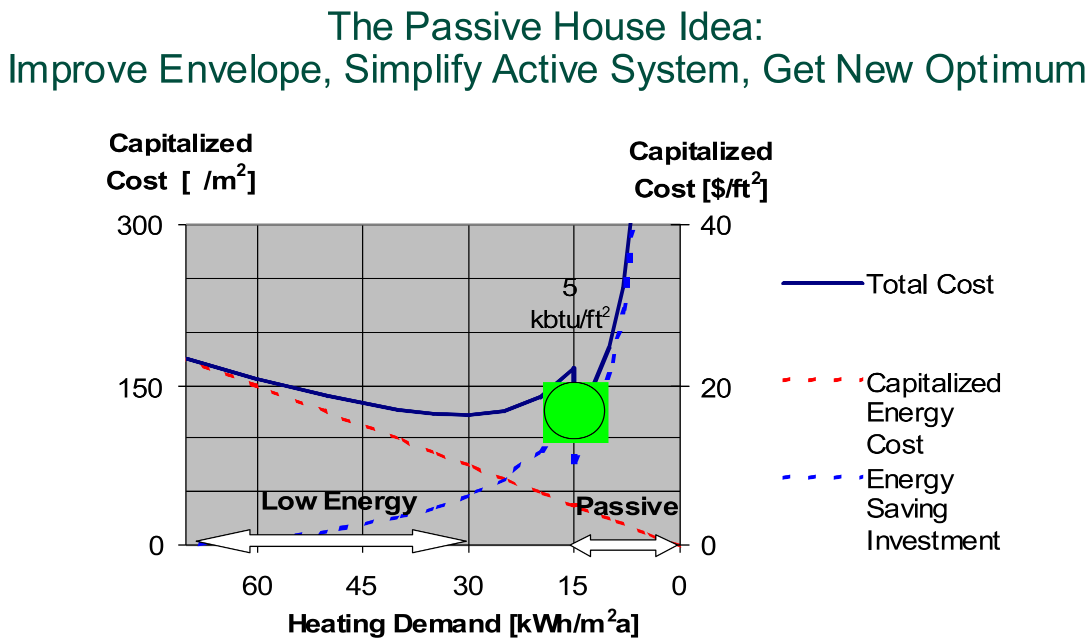

Figure 17: The Passive House Idea

The current formal definition of a passive house according to W. Feist (2006a) reads: “A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to fulfil sufficient indoor air quality conditions (DIN 1946) - without a need for re-circulated air." This definition is universal in so far, as it does not depend on external climate conditions, but only the minimum air flow necessary for securing air quality.

For residential houses, this definition can be translated into the requirements summarized in Box 3 (cf. Feist 1998 and Steinmüller 2001b, 2007a). Accordingly, a passive house is a house, whose maximum heating load does not exceed 10 W/ m^2, which is equivalent to about 1 W/ ft2 needed on site[34].

Central Requirement:

- Maximum Heating Load at Climate Extreme <= 10 W/m^2 (~ 1 W/ft^2)
  - allows omission of traditional heating system

Secondary Requirement:

- Maximum Annual Heating Demand <= 15 kWh/m^{2}a (~ 5 kBtu/ft^{2}a)
  - for south oriented buildings in Central Europe

Box 3: Residential Passive Houses - Main Requirements

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[34] The US firm Conservation Technology International CTI (www.conservationtechnologyinternational.com) recently startet the promotion of passive houses under the name “1-Watt-House” (cf. Spiegel 2007).

Thus, a 150 m^2 or 1500 ft2 passive house can be heated by fifteen 100 Watt light bulbs at the extreme heating days of the year or more appropriately by a small heat-supply unit integrated into the air supply system.

Under central European climate conditions in an optimized south-oriented building, a heating load of 10 Watt/m^2 is equivalent to an **annual heating demand of 15 kWh/m^2a** . This condition has been added as a "secondary" requirement. It represents **a factor 10 reduction with respect to average demand of the German housing stock** (cf. Fig. 7, p. 22) and thus fulfils the heating reduction target on the point. Moreover, a high insulation standard, air tightness and controlled ventilation create a new level of comfort and health so that passive houses enable a "quantum leap" from a ecological, economic, as well as social point of view.

Finally, in order to prevent that a low heating demand is wastefully obtained with heat-producing household appliances or inefficient heating, an upper limit of 120 kWh/ m^2a for the overall primary energy consumption including has been suggested by Feist. This requirement, however, is still insufficient from a sustainability point of view. The first passive house built in 1991 had primary energy requirement below 60 kWh/ m^2a (see next section). Hence, tighter overall primary energy requirements are necessary and realizable[35].

3.2.2 Realization

The first passive house was built as a house in a row for 4 families in 1990/91 (Fig. 18).

Darmstadt-Kranichstein

First Passive House in Europe/Germany 1991

- Super insulated House in a Row
  - Insulation: 10 - 18 inches, U-Value 0.1 bis 0.14 W/(m^2K) → R40 to R60
  - Optimized triple panes windows with insulated frames, south oriented
  - Ventilation with heat recovery
- Rest Energy Demand
- Overall Primary Energy Consumption <= 120 kWh/m^2a (~ 40 kBtu/ft^2a)
  - Including household appliances
  - To be lowered in the future
  - Heating: 12 kWh/(m^2a)
  - Hot water: 8 kWh/(m^2a)
  - Household appliances: 11 kWh/(m^2a)
- Covered by
  - Vacuum collectors
  - Gas condensing furnace

Source: Feist (IWU, PHI)

Figure 18: First Passive House (Measurement Data see. Feist & Werner 1994)

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[35] This means that more stringent requirements have to be put on the primary energy efficiency of household appliances and heating supply systems. As replacement cycles of theses components are short in comparison to the building structure, mistakes can be corrected more easily.

Carefully instrumented and scientifically evaluated, it showed that the concept worked in practice. This is documented in more than 10 passive house reports (cf. www.iwu.de). While the heating and primary energy demands were much lower than required (Feist & Werner 1994), social-empirical evaluations showed high user acceptance and comfort (Rohrmann 1994).

Only a few years later, the first settlement of passive and low energy houses was built (Rasch 1997, Fig. 19), which allowed a direct comparison of the two house types in practice[36]. The results convincingly confirmed the advantages of passive houses. Not only were all design goals met, but the inhabitants were highly satisfied with the dwelling conditions and the low building cost of about 1000 /m^2 (Rasch 1997, AKKP 1996/97, Ebel et al. 2001).

Wiesbaden-Lummerlund

First Passive House & Low Energy-Settlement in Europe 1997

- 46 Houses in a Row,
  - 50% Passive, 50% Low Energy
  - Building cost: 90 - 100 /ft^2
- Scientific Evaluation
  - Inhabitants highly satisfied
  - Passive Houses preferred to low energy ones
- ➢ Passive Houses enable sustainable life-style
  - Energy reduction factor 10
  - Economically attractive
  - Comfortable, healthy indoor climate
  - No sacrifices, but new degrees of freedom

Source: IWU, Rasch

Figure 19: First Settlement of Passive Houses

The Wiesbaden project marked the start of a remarkable market development. As shown in Fig. 20, the number of passive house units began to grow exponentially at a rate of about 100% with about 2500 units reached in early 2002 (Feist 2003b). Thereafter, the growth slowed down a bit – in line with a general slow down of the German housing market. Nevertheless, estimates indicate that about 10 000 units will have been reached by the end of 2007.

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[36] see also Steinmüller 2001c, 2002 and BKI 2001for economic comparisons of the two house types. Based on an observed mean cost difference of about 100 /m^2, 50 /m^2 is suggested as an achievable, competitive target.

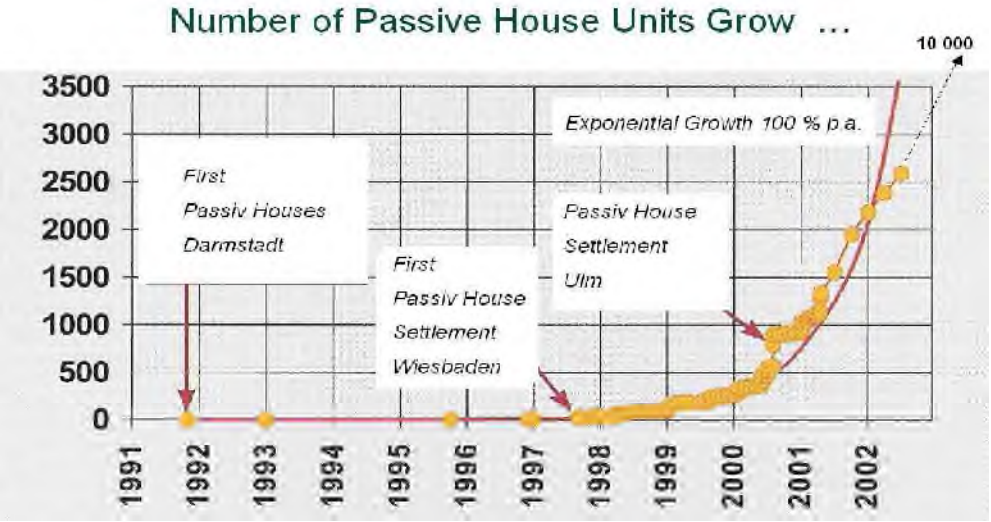

Figure 20: Growth of the Passive House Market (cf. Feist 2003b:42)

Thereby, passive house technology has spread out over a broad range of house types including single and multi family homes in various styles, as well as office buildings, mixed living and office buildings and schools (cf. reports and proceedings passive house conferences, www.passivhaustagung.de).

This development has been accompanied by a step-wise shift from hand-craft towards series-production. This is mirrored in a corresponding learning curve, which is depicted in Fig. 21 for houses in a row. Accordingly, the additional investment for passive houses with respect to low energy ones has come down to less than 80 / m^2, or about 7% of typical building cost – approaching 50 /m^2. As to multi-family homes, the additional cost has fallen to about 3 – 5% of the overall building cost - while for free standing single family homes 5 - 10% are attainable (Feist 2007b). Considering that average annual energy savings of passive with respect to standard low energy houses reach about 50 kWh/m^2 , additional investment costs can be translated into costs per kWh (cf. Fig. 21, right hand scale)[37]. Thus, a 50 /m^2 investment corresponds to a cost of 1 /(kWh/a) .

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[37] This is a conservative assumption. For houses built according to the German EnEV standard the difference and hence the savings may be even larger (Loga et al. 2001).

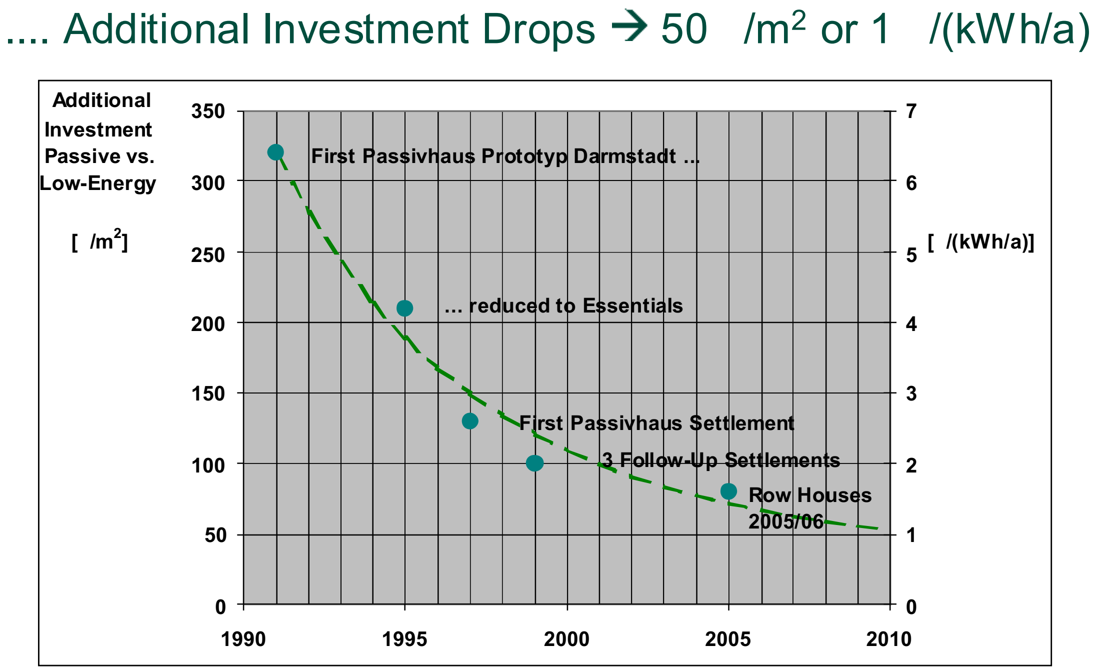


Figure 21: Decline of Additional Investment Costs (cf. Feist 2007b: 460)

This additional investment cost can easily be compared to the net present value of an annual kWh delivered (section 2.2.4, Fig. 11). Thereby, it has to be taken into account that passive house costs are mainly caused by the building envelope, i.e. high performance windows and insulated walls. Accordingly (cf. Fig. 11, p. 30), effective time factors between 30 and 50 years can be expected, which lead to net present values between 1,5 and 2,5 /(kWh/a) for initial energy prices of 0,05 /kWh. Hence, it turns out that for most cases the mere savings of delivered energy already outweigh the additional investment cost, while non-energy benefits as higher building quality and comfort, durability, high energy independence and passive survivability further increase the advantage a passive house offers. Thus, passive houses have become an attractive solution not only from an economic point of view.

3.2.3 Innovation Entering the Market

While the eighties appear as the first lost decade for energy efficient housing, the erection of the first passive house in 1991 signalled a change. Yet, as Fig. 20 indicates, it almost took another decade until the innovation has finally started to enter the market. A first assessment of the key innovation factors yields the following findings:

1. **Individual players** in the public and the market sphere with a strong vision and dedication were decisive for the continuation of energy efficiency research in Germany and the development of the passive house approach.
2. **Political support supplied by the state of Hesse** was essential for creating the organizational-financial basis necessary for energy efficient housing research and the implementation of a first passive house prototype at the beginning of the nineties.

Concerning the transformation step from pilot projects **to first practical deployment,** the following observations can be made:

Innovative private house owners and builders, who are willing to accept the higher investment costs and risks associated with innovative building projects, were necessary to incite the transformation process.

The Wiesbaden project (Fig. 19,) marked an important step from individual houses to **whole passive house settlements** and the beginning of vigorous market growth (Fig. 20). Its conception, successful completion and further developments were **decisively determined by a small innovative contractor and "ecopreneur"** Folkmar Rasch, who – supported by the AKKP (see below) - was **driven by the vision of bringing passive house construction costs down close to those of conventional buildings** by means of innovative, cost saving building techniques (Rasch 1997).

While the Wiesbaden project was starting, Wolfgang Feist moved out of the public research institute IWU. The foundation of the passive house institute **PHI as a private research institute** opened up new action spaces. The following factors a.o. supported the **further proliferation of the concept**:

The publicly and privately sponsored **working committee "cost effective passive houses**" and its members (Arbeitskreis kostengünstige Passivhäuser AKKP, see e.g. Feist 1997a, AKKP 1996 - 2008) enabled the further development and promotion of market-oriented solutions. The Wiesbaden settlement was the first project intensively supported.

The **implementation of an annual passive house conference** (see e.g. Feist 2006b) created an effective communication platform for popularizing the passive house concept beyond German borders.

A transparent **labelling scheme** (cf. Schnieders 1999, Feist 2007c) supports credibility and the quality claim of passive houses.

A **simple to use software tool-set** (see Schnieders 1999) helps the design of passive houses and the practical deployment of the idea under a wide range of climate and boundary conditions.

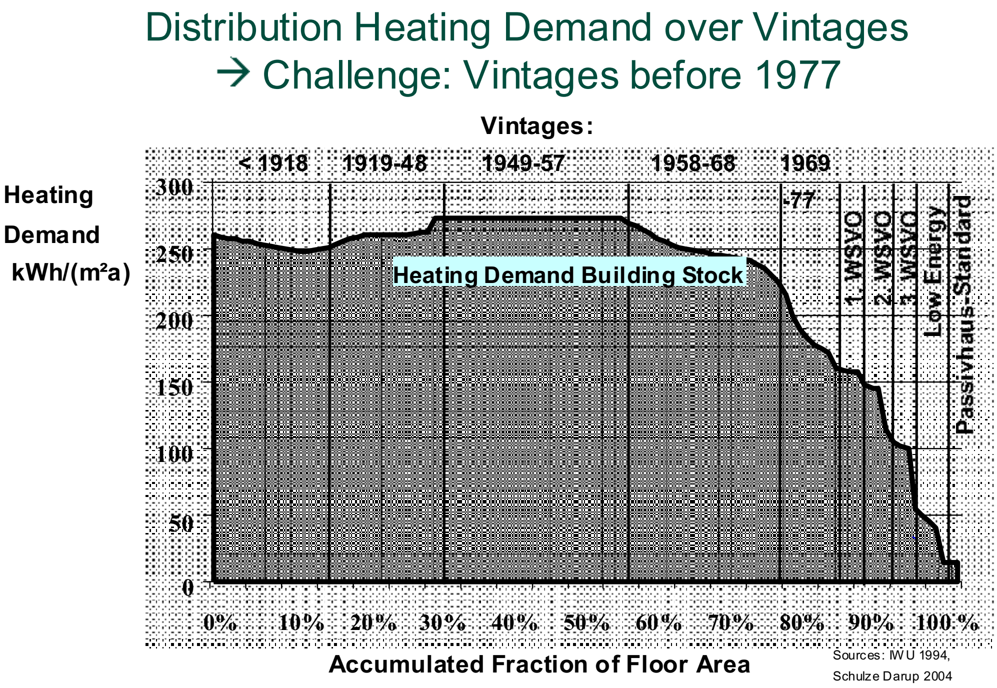
While these factors appear essential, more factors are involved, which will be discussed in chapter 4 ff.

3.3 Old Buildings - How Advanced Technologies Can Be Applied Economically

3.3.1 The Importance of the Building Stock

While passive house technology opens up promising possibilities for energy-efficient sustainable new housing, it is even more important to look at the building stock, since most of the buildings, which will be in existence by the middle of this century, have already been built. Thereby, the **buildings erected before 1977 create a particular challenge** as they constitute a large percentage of the overall buildings stock and excel by a high heating demand as shown in Fig. 22.[38]

The question, how this large potential can be activated, has already been under consideration in the late seventies (see e.g. Hörster 1980:191ff; Korsgaard 1980). A first systematic assessment covering the potential in the old and new German states was performed by the Institute Wohnen und Umwelt in the early nineties (see IWU 1994), with a focus on "low energy" or factor 2 to 4 saving strategies. While the latter were proven feasible and economic even for low oil price scenarios, **sustainable retrofi strategies targeting at factor of 10 energy reductions were increasingly promoted since the end of the nineties** (see e.g. Steinmüller 1998ff; Ebel & Steinmüller 1999, Knissel & Steinmüller 1999)[39]. First pilot projects started in Ludwigshafen (cf. Greifenhagen 2000; Schubert n. d., 2003; BASF n. d. a,b; Feist 2003a) and in the Nürnberg-Region (cf. Schulze Darup 2003, 2004, 2007)[40].



Sources: IWU 1994, Schulze Darup 2004

Figure 22: Heating Requirement Building Stock (cf. IWU 1994, Schulze Darup 2003a)

The following section summarizes the findings of a pilot project carried out by the Bielefelder Gemeinnützige Wohnungsbaugesellschaft BGW supported by the author. Thereby the question, how advanced saving technologies can be applied to the building stock in a

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[38] In 1978, 5 years after the first oil crisis, the first "Wärmeschutzverordnung WSVO" (heat insuluation ordniance) came into force introducing a stepwise reduction of heating demand.

[39] Material-flow and infrastructure has been included by the German Öko-Institut (UBA 1999, UBA 2004).

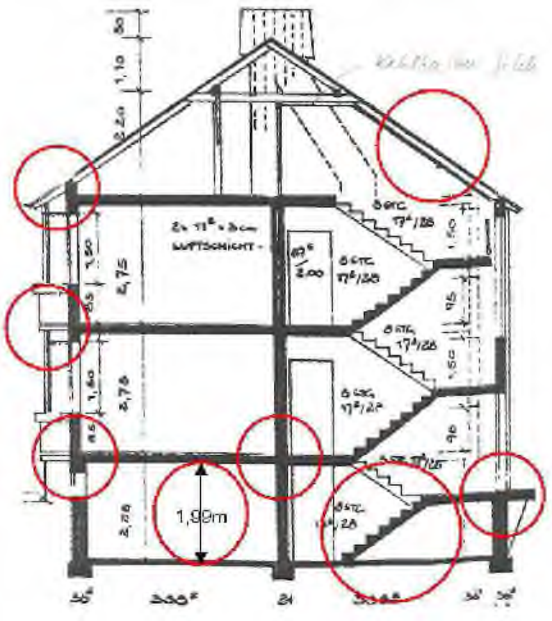
[40] A good summary of relevant retrofit passive technologies is found in PHI 2003 and 2005. An overview of "factor of 2" refurbishments is given by Reiß et al. 2002.

sustainable economic fashion, was of particular interest.

3.3.2 Factor of 10 for Energy Efficient Sustainable Retrofit

The BGW is the largest housing company in Bielefeld and Eastern Westphalia owning about 11 500 housing units. Open for regenerative energy measures and new modernization approaches (cf. Meyer & Steinmüller 2002), the company decided to go in for an ambitious factor of 10 modernization in the context of the advanced retrofit programme of the German Energy Agency DENA (see section 3.3.3).

For the project, an 8-family house - characteristic of a large part of the company's building stock and many German multi-family homes[41] - was chosen. (cf. Fig. 23 and Fig. 24 below).



- Lossy Roof

- Lack of Insulation
- Thermal Bridges
- Wrong Window Orientation
- Shading Trees ...

- Low, Lossy Cellar

- Lack of Ventilation, Mould
- Lack of Air tightness ...
- Lossy Heating Installation
- ...

Figure 23: Retrofit Problem Areas

Built in the fifties and located in a high-quality living area, the object can be attributed to the lower right hand corner of the company's portfolio matrix (Fig. 9, p 27), making it a candidate for major investments. In view of low vacancy rates and a relatively stable tenant-ship, socio-economic risks (cf. Fig. 10, p 28) appeared low, though demographic shifts towards an ageing tenant-ship had to be considered. From a technical point of view, the building was ready for modernization – though not particularly well suited for a factor of 10 saving target. A poor orientation, shading by trees and neighbour buildings limit the use of free solar gains, while low cellar ceilings and narrow stair flights restrict applicable insulation thickness (see Fig. 23). On the other hand, free chimneys allow the retrofit of an energy-eficient ventilation system in a cost-effective way. Thus, altogether, **the building shows a typical mix of**

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[41] Note that small multi-family buildings cause about 80% of the heating requirement in the multi-family domain.

boundary conditions limiting design space.

Inspite of these limitations, a factor of 10 reduction down to an equivalent of about 3 litre oil per m^2 (“3-Literhaus”) was established as a key **environmental efficiency target for the heating demand.** Moreover, a factor of 10 reduction of primary energy for heating and hot water down below 40 kWh/m^2a (“KfW40-Haus” – see also section 5.4). was set as a target. Though a pilot project, long term **economic efficiency** was striven for at the same time. The approach described in section 2.2.4 was taken as a basis, whereby relevant scenario parameters were agreed with the BGW management in advance. **Further sustainability requirements had to be integrated** including adaptability to changing demographic conditions (specifically the needs of elderly people), architectural embedding into the corresponding quarter, summer comfort, consideration of ecological materials and reduction of CO_2-emissions by 80 kg/m^2a (corresponding to a factor of 10, as well). The **solution approach and the main results** are summarized in Fig. 24 (cf. Steinmüller 2005 and 2007a).

Applying Passive House Technologies to Old Buildings:
Retrofit of 8-Family House in Bielefeld

- Sustainability Approach
  - Life-Cycle Optimization Energy and Economy
  - Long-term Usability, Adaptability
- Passive House Technologies
  - Roof 35, Wall 20, Cellar 10 cm additional high performance insulation
  - Reduction of Thermal Bridges
  - Passive House Windows
  - Ventilation 90% heat recovery
  - Solar assisted hot water
- Factor 10 Savings
  - In Energy & CO_2-Emissions
  - Economically “multipliable” and even optimum for most measures

Source: BSMC

Figure 24: Energy Efficient Sustainable Retrofit Solution

As far as insulation is concerned, it turned out that U-values characteristic of new passive houses are not only technically feasible, but even economically optimum in old buildings as well (Steinmüller 2005). Fig. 25 shows corresponding net present values derived in line with Box 1, p.28.[42] Thereby an innovative grass-based highly eco-efficient loose fill was chosen

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[42] whereby Overall Net Present value = Energy Savings – investment, Energy Savings = NPV * ΔQ, Investments = ΔI

for the ceiling (Steinmüller 2005).

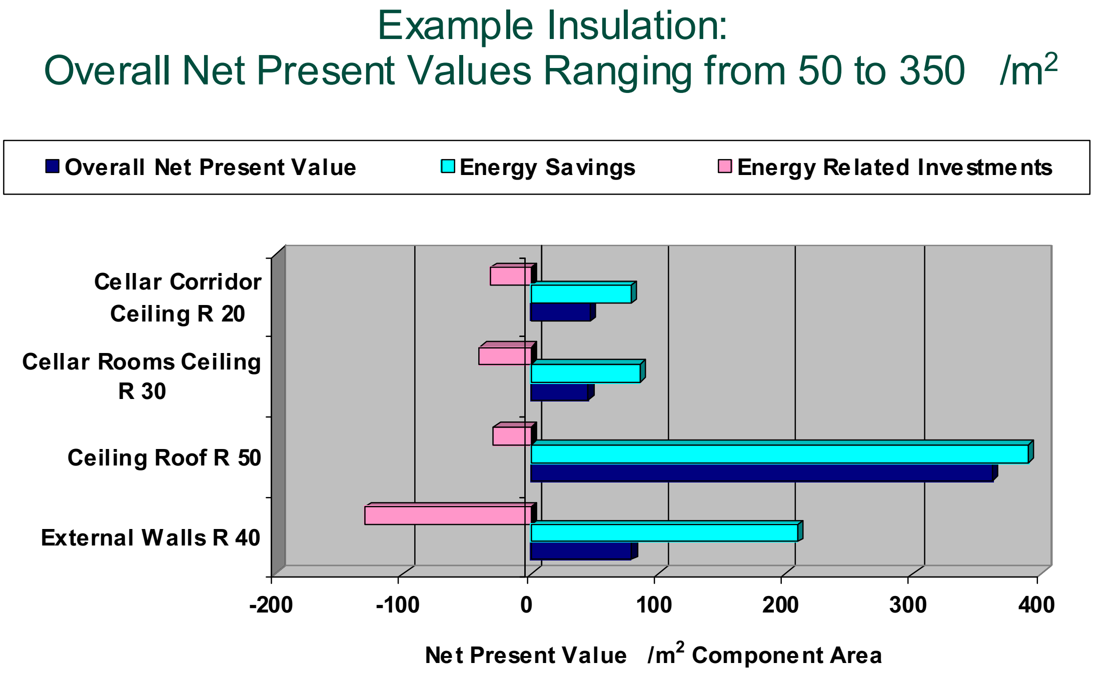

Figure 25: Positive Net Present Values for Retrofit Measures

Thermal bridges at the outer edge of the roof, as well as the large thermal bridge at the staircase footing can also be "solved" with "profit". With regard to windows, the overall net present value of "passive house windows" fell short of that offered by low-e double pane windows. However, considering non-energetic benefits (cf. also Steinmüller 2004a, Knight et al. 2006) and the cost of switching to the technology at a later time, the choice of passive house windows can already be justified today. Analogous arguments apply to the controlled ventilation system, whereby the installation on the top ceiling and the free chimneys provided an energetically and economically elegant solution. Finally, regenerative energy for hot-water production in combination with a condensing gas-burner was used as an eco-efficient energy supply.

As far as **overall eco-efficiency** is concerned, the additional energy related investments amount to 165 000 , while end energy savings are about 155 000 kWh. This yields a ratio of about 1 /(kWh/a), which is well below the net present energy value for standard scenarios (cf. section 2.2.4 and Fig. 11), as long as rest-lifetimes larger than 25 to 30 years are assumed. This indicates that from a net present value perspective the overall **energy measures are economically viable** - even under pilot conditions and without accounting for funding[43].

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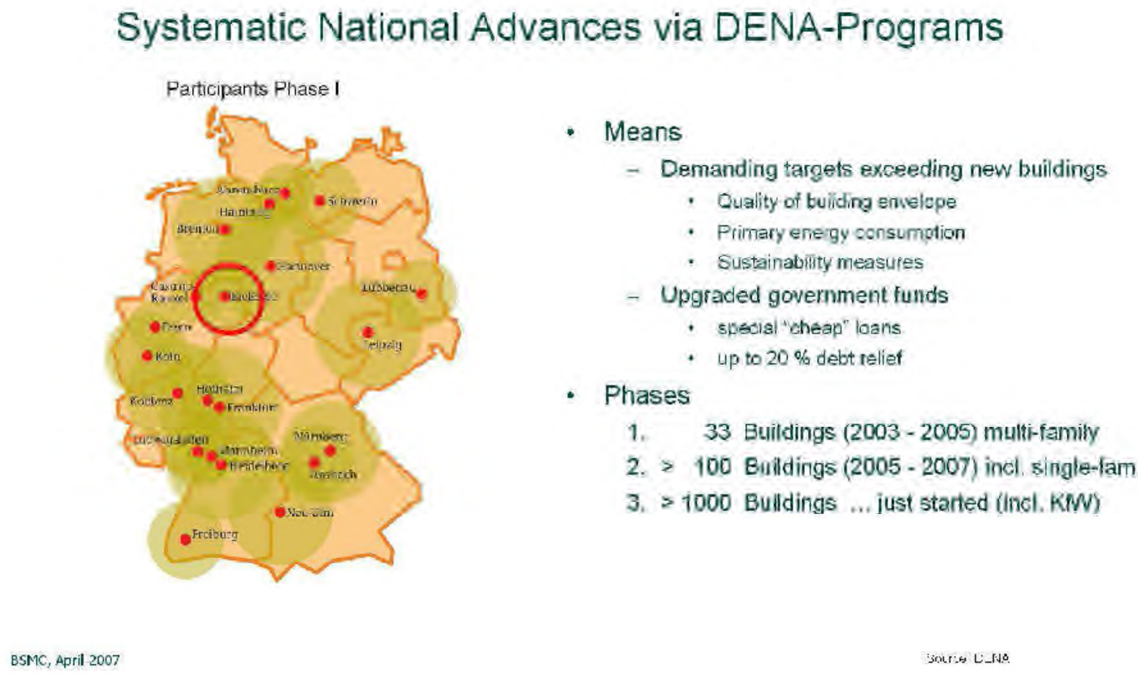
[43] It should be noted that the bulk of the costs were spent for non-energy related matters including changes of the floor plan, kitchens and sanitary installations. For assessing the yield of theses measures it is necessary to estimate its influence on future rents, which necessitates the employment of corresponding econometric models,

3.3.3 *Innovation Context and Challenges*

As indicated above, the project was executed in the context of the advanced retrofit reduction programme[44] set up by the German Energy Agency DENA in 2003 (cf. DENA 2004, 2007, Fig. 26). The programme offered upgraded government funds including special loans and up to 20% debt relieves, as well as knowledge and evaluation support. This way strong incentives were given. Pilot phase I of the programme budget supported 33 multi-family buildings. More than 100 multi- and single-family houses are included in phase 2. Phase 3 started in 2007, whereby 1000 buildings are addressed. Thereby the 100 most demanding projects are being executed under the roof of DENA, while the other projects have been transferred into the domain of the KfW (cf. section 5.4.3).

Looking at the overall results of phase 1 of the advanced retrofit programme (Fig. 27), energy savings of **a factor of 10 turned out to be the rule for all buildings rather than the exception:** Primary energy consumption was lowered by 87% from 336 kWh/ m^2a to 44 kWh/ m^2a on the average, which tops the low energy standard for corresponding new buildings by more than a factor of 2, i.e. the renovated buildings had ½ of the energy use of new buildings built according to "low energy standard."



Systematic National Advances via DENA-Programs

Participants Phase I

- Means
  - Demanding targets exceeding new buildings
    - Quality of building envelope
    - Primary energy consumption
    - Sustainability measures
  - Upgraded government funds
    - special "cheap" loans
    - up to 20 % debt relief
- Phases
  1. 33 Buildings (2003 - 2005) multi-family
  2. > 100 Buildings (2005 - 2007) incl. single-fam.
  3. > 1000 Buildings … just started (incl. KfW)

BSMC, April 2007

Source: DENA

Figure 26: Advanced National Retrofit Programme as Driving Force[45]

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partially covered by alternative calculation approaches. Corresponding economic calculations were done with the 3 alternative models offered in Enseling 2003. Though some of the assumptions in these models tend to underestimate economy, they grossly confirm the results reported above (cf. Steinmüller 2004 b).

[44] In German the programme is called "Niedrigenergiehaus im Bestand" – which, however, is a misnomer, as the retrofits go far beyond the low energy standard.

[45] Map adapted from DENA 2004:6

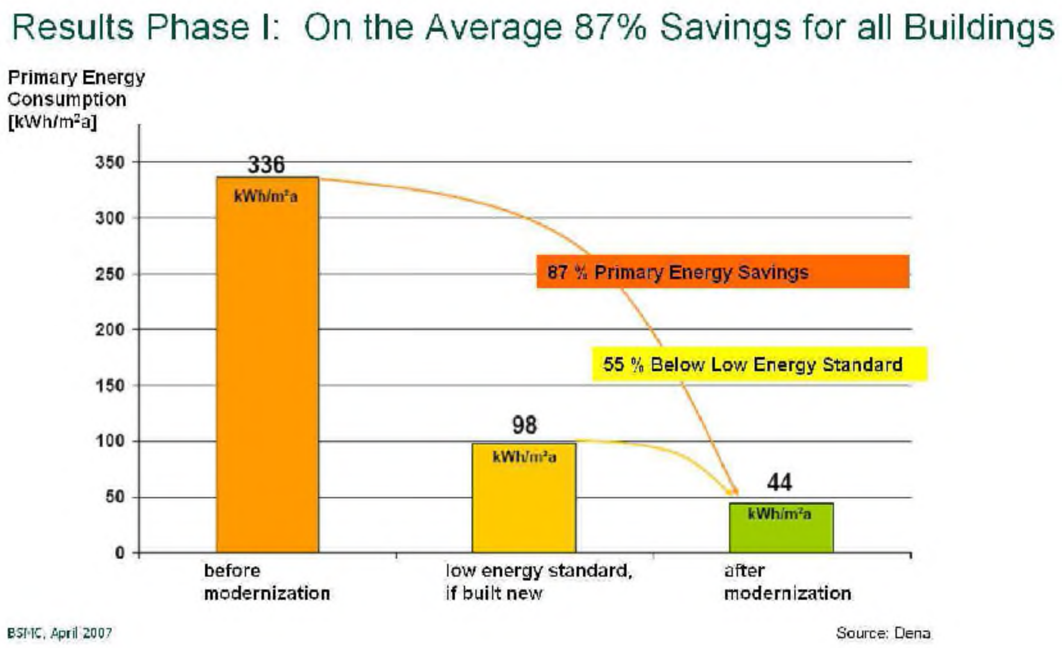

Figure 27: Overall Results of Dena Retrofit Programme Phase I (cf. Stolte 2006:25)

Thus, the use of passive house technologies enables factor of 10 reductions in retrofit sector as well, whereby many of the measures appear economic even without funding. This is basically in line with the findings by Schulze Darup (2003 - 2007) and also Enseling & Hinz (2003) – though the latter only took a calculation period of 25 years as base case.

While these **findings underline the large potential** of energy efficient sustainable retrofit, **obstacles still hinder wide-spread application**. Based on the experience gained during the pilot phase I and the judgement of the author the following observations can be made:

There is still a major **lack of knowledge** concerning the technical and economic potential of energy conservation measures in the public, market and political sphere.

Lack of experience leads to deficiencies and cost increases in the planning, as well as in the implementation phase.

It is difficult to encourage long term thinking, as long as management - in all spheres - is rewarded for short term success, while long term incentives are missing.

Energy saving measures and their optima tend to be underestimated, as long as cost benefits accumulating over the life-time of the building are not fully accounted for. In particular, measures may be severely undervalued, if depreciation periods do not cover expected life-times, if rest-values are neglected, if non-energy benefits and “soft factors” are not properly accounted for.

Overall optimization is hampered, if trade-offs between investment budgets and running expenses are impeded- e.g. if organizational responsibilities are split and investment budgets decoupled or prematurely frozen.

Retrofit of occupied dwellings leads to sub optimum results, as long as user-friendly implementation techniques are still lacking.

Most of these obstacles are not of a principal nature. Rather they form surmountable **challenges** to actors in the public, political and market sphere. The interplay of these actors, current trends and options for action will be analyzed in more detail in the subsequent chapters.

3.4 Other Approaches

As buildings form complex multi-parameter systems, they offer a broad spectrum of parameter choices and trade-offs going beyond the options discussed so far.

In particular, beside low-energy and passive houses, **zero-energy** (cf. Korsgaard et al. 1976; Anderson et al. 2006, Petit 2007) **and plus-energy houses** (cf. Disch n. d., 1999) have been proposed and realized in many variations, whereby "zero" and "plus" usually refer to the annual energy performance allowing sub-annual performance deficits[46]. Accordingly, zero-energy houses produce as much primary energy as they consume during a year, while plus-energy ones render an annual surplus[47]. Though these approaches at a first sight seem ecologically superior to passive houses, it should be noted that they may still involve a considerable environmental load during winter. Moreover, the surplus during summer is only useful as long as there are net primary energy consumers at that time. Thus, **the benefits are only scalable for a limited number of houses** rather than for whole nations. Finally, it appears difficult to achieve cost-effective solutions - especially without subsidies and under less favourable climate conditions.[48][48]

Thus, from an ecological, as well as economic point of view, the reduction of energy demand down to the **passive house level appears as a precondition** at least for Mid- and North-European type of climates. From this basis, **plus-energy passive houses may offer an answer in the future,** whereby the economic viability strongly depends on the cost-effective supply of renewable resources.[48]

Regarding **old buildings**, zero- and plus-energy strategies may be applied as well, whereby the general considerations in principle remain valid. In addition, however, it has to be taken

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[46] These deficits usually are covered by the public grid. An exception are "energy autarkic" versions , which have been proven technically feasible (cf. Stahl & Voss 1992), but economically usually out of reach

[47] Note that some definitions simply assume that zero and plus energy houses are upgraded passive houses (e.g. http://de.wikipedia.org/wiki/Nullenergiehaus and http://de.wikipedia.org/wiki/Plusenergiehaus, last access 30 Sep. 2007). This, however, is inadequate and blurs fundamental distinctions.

[48] Note that for a heating demand as low as 15 kWh/m^{2}a, the equivalent net present value left for further reductions on the active side is of the order of 15 /m^2 (cf. Fig. 11, red area), i.e. about 1500 for a 100m^2 house. This puts a distinct limit to the implementation of complicated heating supply systems **favouring simple cost-effective active solutions.** Also note that before resorting to regenerative energy supply, there are plenty of cost-effective energy saving opportunities with respect to appliances so that the overall primary energy demand of a passive house may substantially be brought under the current official limit of 120 kWh/m^{2}a (cf. section 3.2.2).

into account that modernization **strategies have to be tuned to the restricted degrees of freedom** implied by the boundary conditions in the building stock (cf. IWU 1989, 1994). In particular, energy-related renewal or modernization measures often only are cost-effective, if corresponding components or parts of the house have reached a state, where major repairs or replacement have become necessary anyway.[49]

As this typically happens asynchronously across the building, **stepwise modernization approaches play a major role.** Thereby, it is important to act according to the principle "if you do it, then do it right" ("Wenn schon – denn schon") and avoid "half measures", which may lock into sub-optimum solutions. As passive house solutions often also represent the economically optimum solution for the renewal of components (cf. Steinmüller 2005), substantial eco-efficient reductions can be achieved this way.

A potential problem of partial modernizations, however, lies in the fact that potential synergies between asynchronous measures cannot be fully exploited so that the overall result finally may be ecologically and economically suboptimal and inferior to that of a full scale renovation[50]. Thus**, whenever feasible, measures should be combined and full-scale solutions attempted.**

3.5 Factor 10 Visions & Trends

From what has been said above, it occurs that new buildings should target at the passive-house standard, while old buildings should be modernized in phase with their corresponding lifecycle observing the specific boundary conditions of the respective house type and the respective saving potentials. Thus, the **derivation of general forecasts and energy saving scenarios requires** typifying the building stock and a subsequent **tracking of individual building types through their respective lifecycle paths.**

Such a **fundamental classification and tracking has been performed by the German Institute Housing and Environment IWU** (cf. IWU 1989, 1994; Ebel et al. 1996). As the relevant part of the building stock has not changed that much since then, it still provides a valid basis for discussing general trends and saving potentials in dependence of basic scenario categories. Essentially three categories can be distinguished: a) following the trend b) following the "low-energy" path and c) following the "passive-house" path. Here a) is equivalent to "business-as-usual." b) subsumes the consequent application of energy conservation measures roughly reflected by the low energy standard. c) basically assumes that new buildings are erected according to the passive house standard, while old buildings are consequently modernized with equivalent advanced technologies – without, however, necessarily reaching the passive house standard themselves.

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[49] Then, only the incremental cost for energy efficiency improvements have to be accounted for.

[50] This holds e.g., for measures concerning the façade of a building, where insulation thickness, placement of new windows and potential adaptation roof overhangs are optimally tackled together. Moreover, downsizing of the heating system is dependent on upgrades of the envelope. Thus, in a piece-meal approach, "cost barriers" which other wise may be tunnelled through (see Fig. 17) could remain in effect.

Fig. 28 shows the resulting scenarios for the heating demand of the German housing stock including newly erected buildings (cf. Steinmüller 1999b and 2000, extended from Ebel et al. 1996:102).

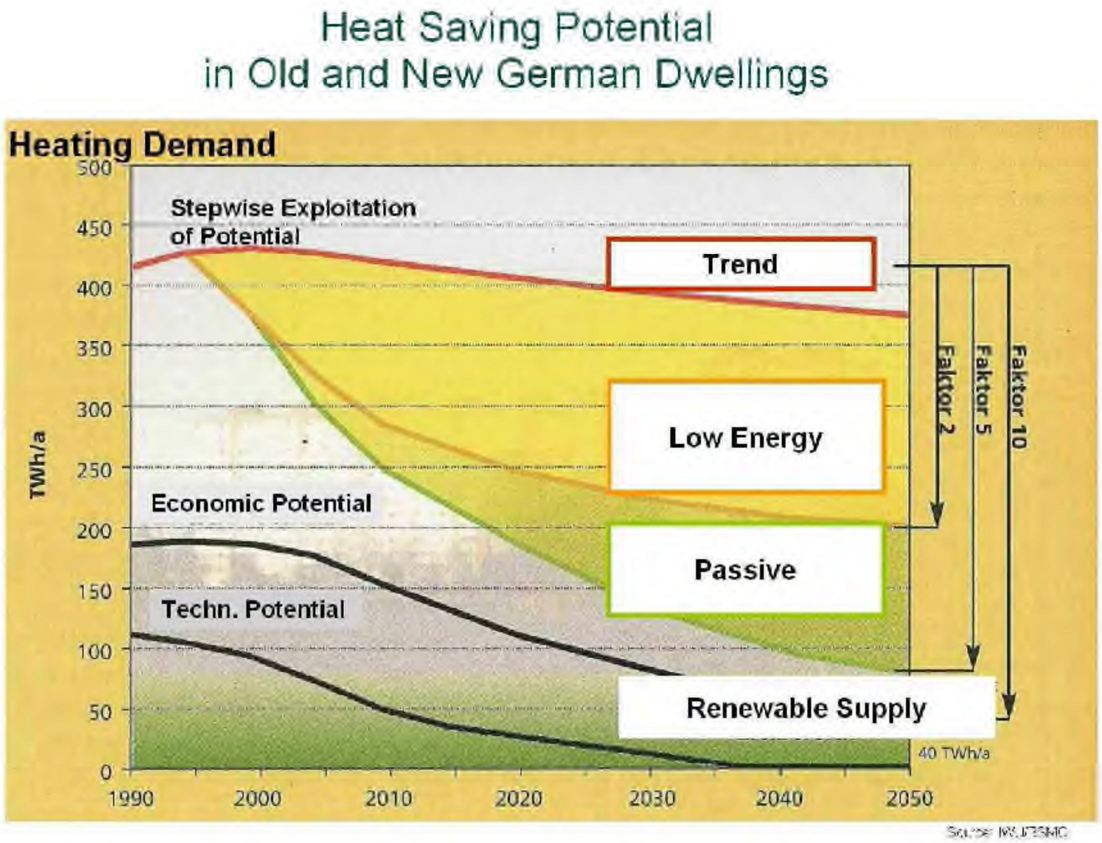

Figure 28: German Heating Demand 1990 – 2050: Trend and Saving Scenarios

Accordingly, the application of conventional low energy measures enables the reduction of the heating demand of the whole building stock by a factor of 2 until 2050 in a cost-effective way. **If advanced measures reflecting the passive house technologies are applied, even an overall factor of 5 seems possible** (Ebel et al. 1996:102; cf. also Ebel et al. 1989:47)[51]. Thereby it has to be taken into account that not all buildings can be improved by this factor so that well-suited buildings have to make up for the worse-suited ones. **In order to reach a factor of 10 for the overall primary energy supply the potential of renewable**

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[51] The technical potential is even higher, of course, and will increase over time as indicated by the lower line. The overall economic potential is also higher at a given point in time, however, it can only be exploited step by step due to the observation of renovation cycles. On the other hand, Feist 2003a:6ff points out that the life-time of components may be longer than originally anticipated and the resulting realization rate of modernization measures lower so that corresponding factors may only be reached later. This, however, does not change the overall potential and general argument. In fact, longer life-time assumptions also imply higher long-term profitability of saving measures and thus in principle higher economic attractiveness and realization rates.

energy supply has be exploited, which - on this reduced demand basis - can render another factor of 2 or more (cf. Steinmüller 1999b)[52].

Though these scenarios have been derived for Germany, it can be anticipated that similar tendencies will be found in countries with a comparable building structure and climate. This suggestion is supported by similar building age distribution in major European and Northern American countries (UNECE 2004a,b; UNEP 2007b) and analogous saving potentials in new buildings (cf. sections 6 and 7). Hence, it will be taken as sound working hypothesis[53].

Though Fig. 28 indicates that factor of 10 reductions with respect to primary energy consumption are possible, it also points to the gap between potential and trend. In fact, investigations show (Kleemann & Hansen 2005, Friedrich et al. 2007) that the trend has been effective until recently. Thus, we have to take a closer look at the market and its mechanisms.

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[52] This is a cautious estimate, as on such a reduced heating demand basis, it seems even possible to reach near to 100% coverage, e.g. by the use of cogeneration, biomass or other forms of regenerative energy supply.

[53] The high potential of energy efficiency in buildings is increasingly reflected in recent studies, though the projections still appear to dramatically underestimate the real potential. While the McKinsey study (2007:37ff) points to "2 litre" and passive houses as possible solutions for new buildings, it suggests that only 7 l can be economically achieved in retrofit – at the same time quoting an amortization period of 15 years (i.e. less than half of the rest life time!) and an expected energy price of 52$ per barrel oil in 2020 (which is about half of the current price!). For the time frame 2005 to 2020, Prognos/EWI (2007:7ff) asserts an efficiency potential for retrofit and new buildings of just 30% to 40% per touched house or about 15% for the building stock as a whole – though passive house technology renders economic saving potentials far beyond (see sections 3.2 and 3.3 above).

4 STRUCTURAL MARKET ANALYSIS

Before looking at specific markets in more detail, it is useful to understand their basic structures and generic interaction mechanisms. Starting from the end customers, we shall analyse the main goods, the supply chain and the generic demand/supply processes especially at the customer interfaces. A summary of the main structural problems bridges over to specific analyses in subsequent chapters.

4.1 Main End Customer Markets

In the area of housing we have to distinguish the following main **end customer groups**[54]:

Self-using owners (also called **"occupying owners"),**

Private and professional lessors (also called **"landlords").**

The first group typically comprises owners of single or two family homes, where the owner also occupies his property and hence is an end-consumer in the proper sense of the word. The second group typically comprises owners of multi-family homes, where ownership and usage do not coincide. Here, the true "consumer" is the tenant or lessee, who, however, only has an indirect influence on the core buying decisions, which are usually taken by the lessor. The latter acts as an investor.

As for the products and services delivered, we can distinguish the two main **end customer markets:**

1. **New housing market,**
2. **Old housing or "retrofit" market.**[55]

The main product delivered in the first case is a "new house", which may be specifically designed according to the wishes of the customer or derived from a more or less standardized template. The main products delivered in the second case span a broad spectrum ranging from full scale renovations under the control of a professional contractor down to the replacement of individual components by an owner himself. Accordingly, this market is highly heterogeneous involving a large number products, services and different customer/supplier interfaces.

In order to understand the nature of these interfaces and the processes leading to the customer/supplier interaction, it is necessary to analyse the goods and supply stages involved, and to identify the relevant structure of the supply chain[56].

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[54] cf. also BMVBS/BBR 2007 and DB 2007

[55] In the given context, the plain resale of old houses is not considered.

[56] Note that customary conceptualizations of the supply chain focus on business sectors (see e.g. Lütke-Dahldrup 2007:6) hiding the nature of goods and interactions involved. Here we take the goods as a starting point in order to carve out the relevant problem structure in a clear, transparent way. Also note that the structural and empirical

4.2 Typology of Goods and Suppliers

In the following we shall use the term "**good**" as a general term including products and services. Thereby we shall distinguish "primary" from "secondary" goods, whereby the latter have a supporting function in the overall supply process, while the former ones constitute the core value of the final good.

A. Typology of Primary Goods

1. Materials, e.g.
    - sand, lime, cement, insulation foam, paint, ….
    - raw … finished
    - organic … inorganic

2. Elements, e.g.
    - window panes, frame elements ….
    - wall elements, bricks, insulation blocs, …
    - pipes, nozzels

3. Components, e.g.
    - norm windows
    - wall element, WDVS-systems
    - heating unit, heat exchanger, solar panels, …
    - with … without application instructions

4. Solutions or "sub-projects", e.g.
    - customized and/or installed windows
    - walls insulated/installed
    - heating systems installed

5. Projects or "super-solutions", e.g.
    - new houses or partial … full-scale retrofit
    - standard …customer-specific … experimental/pilot level
    - with/without costumer assistance

Box 4: Typology of Primary Goods

Looking at the nature of **primary goods** (see Box 4), it is found that the good "house" is **based on** a broad spectrum of 1. **materials , 2. elements and 3. components**, which can be further characterized by a broad range of subtypes and customer relevant attributes, as indicated in Box 4. What appears characteristic of the field of housing, is a large degree of customization determining the value on the stages above. While materials, elements and components appear as fairly standardized "products" in the proper sense of the word, the goods **on the next stage** take on the form of what is often called a **"solution"** in other business fields[57]. Finally, when looking at a new and in particular modernized houses, the

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deficits have been generally recognized so that a project call has been issued by BBR in Sep. 2007 (BBR 2007) to investigate the supply chain in more detail. The results, however, will only become available in 2008.

[57] e.g. in the electronics and transportation industry.

degree of customization and planning take the form typical for a **"project business"**. While these terms may appear a little artificial in the field of housing, they point to **important characteristics** of the nature of the goods supplied with implications for the supply process. Thus, they shall be used here and in the sequel.

Considering the typology of **secondary goods**, a distinction between **"soft services"** and **"infrastructure goods"** can be made as follows:

B. Typology of Secondary Goods

1. Soft Services
    - engineering, architecture, financial
    - standardization, certification, quality control
    - education, communication, general consultation & advise, R&D
    - overall management and coordination support

2. Infrastructure Goods
    - building equipment, machinery
    - electronic hardware & software services, planning & design tools
    - hobby …semi-professional …professional
    - buying … leasing

Box 5: Typology of Secondary Goods

Here the first group mainly embraces human services, whereas the latter mainly includes the equipment and tools needed for supporting the building process.

The typology of goods maps to the following aggregated **typology of suppliers** (see Box 6), who provide the primary and secondary goods described above. Thereby it is sensible to map the production of materials, elements and components to a group called **"producers"** and introduce a distinction with respect to the group of **"retailers"** '(cf. also Schaltegger 2006a:18). Note that retailers often offer primary, as well as secondary goods under one roof. **"Solution providers"** include the broad spectrum of craftsmen, which – in large housing projects – often assume the role of "sub-contractors." Finally, **"project providers"** include main contractors and building, as well as housing companies. Note that housing companies may also turn up as end-customers and lessors in the building process. Thus, they often fill in multiple roles.

As far as **secondary good providers** are concerned, corresponding provider types can be directly derived from the typology of goods specified above.

A. Primary Good Providers

1. Producers
    - building components, elements, materials (and secondary hard & software products)
    - window elements/components, insulation materials and WDV-Systems;
    - heating, cooling and ventilation equipment.

2. Retailers or product providers
    - see products above
    - public … professional

3. Solution providers
    - craftsmen, painters, carpenters, window builders/installers
    - sub-contractors …

4. Project providers
    - building (& housing!) companies
    - general/main contractors

B. Secondary Good Providers

1. Soft service providers

2. Infrastructure providers

Box 6: Typology of Suppliers

4.3 The Supply Chain Structure

The typology of suppliers developed above, can now be used to derive the basic **structure of the supply chain** in a straight forward way (see Fig. 29). The “primary chain” is shown in the middle, flanked by the “secondary chains” on the top and at the bottom. The shape of the elements indicate the main flow of goods. The black arrows indicate important interactions orthogonal or parallel to the main flow of goods. In the following, we shall explain the relevant elements and give a first tentative description of the main interaction mechanisms, which will be substantiated and extended in the following sections and chapters.

According to Fig. 29, the **secondary supply chains** render support to the primary chain along all supply chain stages. Moreover, they may directly interact with the end customer. Here the interaction with soft services can be of major relevance (solid line), whereas interactions between end customers and infrastructure suppliers are of minor importance (dashed line). Examples of the former include architectural consultancy and coordination support, energy certification and consultancy, as well as financial consultancy and support.

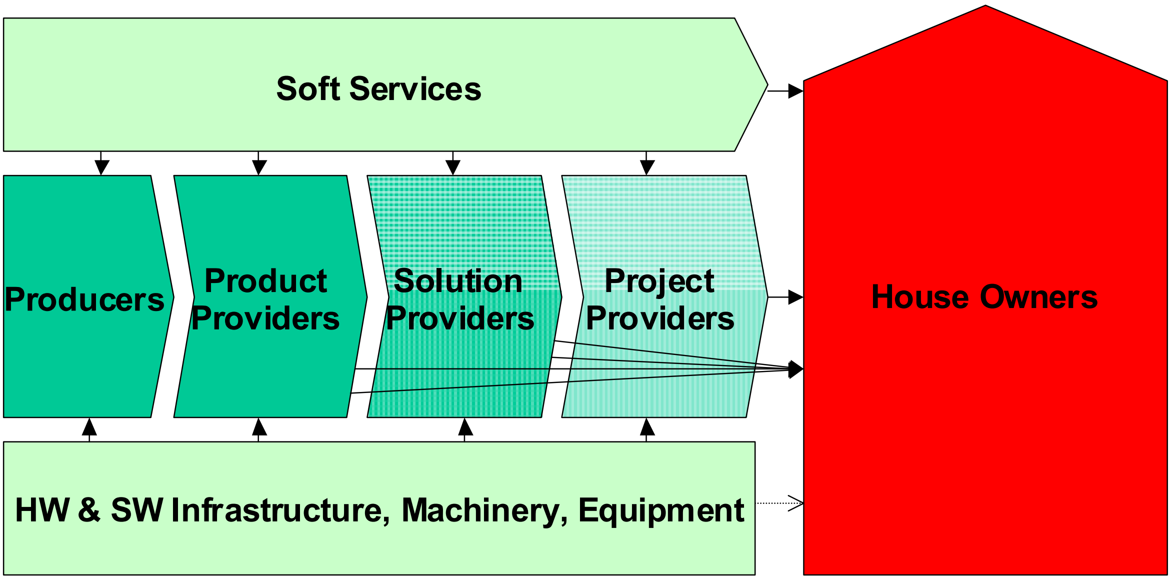

Figure 29: Supply Chain

The **primary chain** consists of four major stages: producers and product, solution, project providers. In the simplest case – not untypical when buying a **new house** - the end customer only interacts with a single project provider, e.g. a real estate developer. However, as soon as he mandates an architect with the overall design and organization, an owner usually will also deal with solution providers (e.g. craftsmen) to a certain extent. In the case of **modernization or retrofit** this even becomes the rule. Here, a rather typical situation is that the house owner interacts with **several solution providers** (craftsmen) to specify and implement the tasks at hand. When taking a more active role himself, the owner might also interface to one or several **product providers** and buy specific retrofit products. The commissioning of a **project provider** for specifying and executing the modernization in “one stop” here is the exception rather than the rule. One-stop retrofit providers are still rare (see also section 5.1), i.e. an **equivalent to real estate developers is virtually absent in the retrofit market.** As a resort - especially for full scale modernizations - “soft” coordinative services offered by the secondary supply chain may be used, which, however, do not fully relief the end customer from interactions with solution providers[58].

As already indicated above, the supply chain is predominantly made up of a large spectrum of small or medium-sized suppliers with heterogeneous capabilities and company profiles (see also section 5.1 and 7.3). Especially at the end of the supply chain **“goliaths” are missing.** Big companies are predominantly found at the beginning of the chain. These, however, to a large extent are invisible and of reduced relevance for the end-customer. Considering the interfaces and relations between suppliers, it appears that especially

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[58] A similar approach was also taken in the BGW project, described in section 3.3.2, where energy consultancy, as well as specific engineering support were bought in, while overall project control and coordination of solution providers was taken over by the BGW itself.

towards the end of the chain multiple-interfaces parallel and orthogonal to the supply chain exist. Thus, the "domino chain" partially degenerates into a **domino mesh,** with many small chain segments influencing each other. Thereby cooperative, as well as competitive relations exist. Competition is strong in the new housing market, competition in retrofit is much weaker. This holds to a varying degree depending on the local market and market cycle. In the new housing market goods and products tend to be more comparable so that interregional or even global tenders are possible. On the other hand, the retrofit market is less transparent, of lower volume and more fragmented so that competition is usually restricted to regional or local players. On the whole, the profile of the players and their offers **lack** the **clear contours** found in industrial mass markets and hence lack points of leverage for bringing **Porter's five forces** (cf. section 2.3.2) into action.

Thus, though simple at first sight, when looked at in detail, the supply chain unveils a fairly **complicated structure with multiple interfaces to the end customers**. Hence, for the greening of the chain in the direction of energy efficient sustainable housing a large number of **intermeshed dominos have to be moved.** Here the end customers play a key role as their market pull can substantially influence the greening of the whole chain, while a lack of pull or even "resistance" can act as a major inhibitor. Thus, it is necessary to consider the main dimensions of demand and decision behaviour at the end of the supply chain.

4.4 Dimensions of End Customer Behaviour

According to Schaltegger et al. 2003:210, demand behaviour is determined by the level of cognitive and emotional involvement of the buyer so that **four basic types of demand behaviour** can be distinguished:

Table 1: Basic Forms of Demand Behaviour (Schaltegger et al 2003)

	Cognitive Involvement	
Emotional involvement	**Low**	**High**
Low	Habitual	Limited
High	Impulsive	Extensive

Thereby the actualization of a specific behavioural pattern may **depend on the type of good, purchasing context and customer** (ibid.). As the housing business is associated with a multitude of goods and purchasing contexts and at least two major customer groups, behavioural demand is dependent on a **multidimensional parameter field**, whose full investigation is beyond the scope of this study. In the following, we shall focus on houses as a whole (i.e. projects), as well as major solutions relevant in the context of energy efficiency and abstract from specific purchasing contexts. **Customers are taken as the main parameter**. Thereby, we shall explicitly **split the group of lessors** into private and professional ones, as their demand behaviour shows relevant differences (see Tab. 2)

For **self-occupying owners** - as generally known - fundamental housing decisions usually are loaded with considerable emotions and high cognitive involvement, which implies extensive demand behaviour (cf. Tab. 1 and Tab. 2). With regard to energy, certain measures such as solar collectors and PV-panels can also evoke strong emotions so that demand behaviour may be "extensive" or even just "impulsive" (if the cognitive content is low). Less spectacular efficiency measures, however, usually have a low emotional content so that demand behaviour is "limited" or even only "habitual" (if cognitive involvement is low).

Private lessors sometimes behave as self-occupying owners. Still, there prime motivation for buying and running a house is usually given by economic considerations so that the cognitive involvement tends to be higher, while the emotional one tends to be lower. Thus, "extensive" and "impulsive" demand behaviour is less probable. This in particular applies to energy saving measures, where cognitive involvement should dominate, which in practice – however- often turns out to be quite low, as well (cf. Schneider et al. 2003).

Going to **professional lessors** emotional involvement should show a further decline, with economic analysis being the main determinant of behaviour. Thus, high value decisions usually are "limited" ones for housing, as well as important energy aspects.

Nevertheless, it appears that also professional lessors show habitual behaviour in the energy context (cf. Schneider et al. 2003) so that sub-optimum decisions are no exception.

The results of this short analysis are summarized in Tab. 2.

Table 2: Demand Behaviour of End Customer Groups

	Demand Behaviour with respect to …	
	Housing in General	**Specific Energy Aspects**
Self-occupying Owners	extensive	habitual … extensive
Private Lessors	limited (extensive)	habitual, limited
Professional Lessors	limited	habitual, limited

According to Schaltegger et al. (2003:211) habitual consumption can be enriched environmentally only when consumer behaviour is unfrozen by means of strong incentives and stabilized by subsequent refreezing processes. In the case of limited decision processes, the presentation of **key information** among a narrow spectrum of alternative choices is particularly important, whereas **prospects of pleasure, status, vitality, innovation or social recognition** are relevant in impulsive processes.

Only in extensive decision processes is the consumer ready to reflect on needs, lifestyle and innovative products.

Thus, while limited behaviour is treatable on a rational base, **habitual demand behaviour appears as the main structural barrier** for energy efficient sustainable housing, followed by limited and impulsive demand patterns, with potential **corrective strategies indicated above**.

Breaking down demand behaviour into its facets, environmentally relevant decisions can be separated into seven **sub decisions** about budget, time, product group, brand, volume, purchase place and disposal (see Schaltegger et al. 2003:212 f and Pepels 1996). Here, due to their importance for energy efficient sustainable housing, "lifecycle costs and benefits" should be added as an eights facet. From general experience, the following **specific problems** appear to be typically attached with sub decision making in energy efficient sustainable housing:

1. Budget decisions require tradeoffs between short- and long-term benefits
2. Information gathering can be costly and time-consuming
3. The spectrum of product groups is large
4. Well known brands are rare
5. The optimum volume of a measure is not always obvious
6. Purchase places may lack clear structure and decision support
7. Disposal choices may lack transparency
8. Lifecycle costs and benefits not obvious for laymen

Again, the way customers deal with theses **questions depend a large number of interrelated customer aspects/attributes** (Schaltegger et al. 2003:213, 214) including demographics, perceptions of reality, needs, values, wishes, competence, as well as associated conflict and satisfaction potential/experience (cf. also Schaltegger 2006b:20ff). Here consumer **demographics, needs, values and competences appear of particular relevance** with different weightings for self-occupying owners and lessors. While elderly people tend to avoid large investments in their houses, housing companies have to position and prepare their stock for demographic shifts. Emotional needs and values are present in the housing context and hence bear potential for being carried over to energy efficient sustainable housing strategies. On the other hand, the lack of competence to judge lifetime costs and benefits is a problem limiting the rationality of choices and thus needs special awareness.

In their analysis of consumer behaviour Schaltegger et al. conclude (Schaltegger et al. 2003: 215): "If eco-marketing wants to attract broader customer groups, it must facilitate the evaluation of **personal advantages** and the desire for consumers to receive **simple instructions** …." and (ibid.:220) "Consumers need **easy-to-understand basic information** in plain language through advertisements that reach new consumers in the competitive" jungle of advertisements."

These suggestions carry over to energy efficient sustainable housing, especially with respect to self-occupying owners. As far as lessors are concerned, the suggestions especially hold with respect to their customers, i.e. the tenants and renters of their property, whose openness for energy efficient sustainable housing measures and readiness to pay an increased rent finally is decisive for the overall viability of corresponding measures.

4.5 Dimensions of Supplier Behaviour

Some observations made for end customer behaviour naturally carry over to supplier behaviour. In particular, also suppliers have emotions and cognition and thus may show signs of habitual, limited, impulsive and extensive behaviour in their demand, but also in their supply patterns. All together, the decision process and its sub decisions[59] may involve similar problems for professionals in the supply chain as for laymen on the customer side (cf. e.g. Schneider et al. 2003). Hence, **also suppliers may have to be "unfrozen" and educated to adapt new behavioural patterns[60].** Having this in mind, we shall now look at "rational suppliers" who possess a high degree of cognitive involvement and emotional sensitivity in order to understand their customers and supply market-oriented solutions in a systematic way.

4.5.1 Dimensions of a Systematic Supplier Approach

The basic elements of a systematic approach are shown in Fig. 30 (Schaltegger et al. 2003:221), whereby the strategic eco-marketing circle is high-lighted in green.

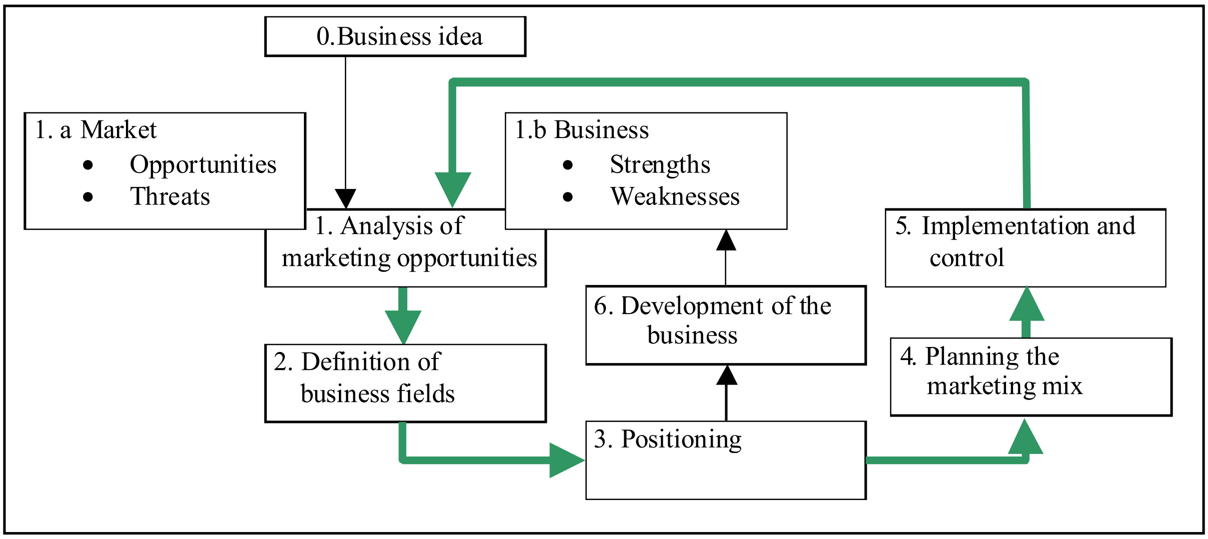

Figure 30: The Process of Strategic Eco-Marketing (cf. Schaltegger et al. 2003)

As far as 0., 1., and 2. are concerned, the discussion in the previous chapter and sections shows that the field of energy efficient sustainable housing offers a broad spectrum of market opportunities in the new, as well as in the retrofit market. In particular, it appears that strong, trustworthy **"one-stop" solution and whole "project" suppliers** are missing in the retrofit market. This points to a specific **market opportunity** and **new business field,** whose

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[59] a.o. short-/long trade offs, determination of optima and lifecycle costing (see p. 47)

[60] In theory, the market should work as an effective unfreezing and education machine, which - however - in the case of imperfect markets may not supply temperatures hot enough. The resulting "market failure" usually calls for political intervention (see below).

successful implementation may greatly promote the field of energy efficient sustainable housing as a whole. Thereby, market **penetration, diffusion, geographic extension and market development represent the four main dimensions of growth and expansion** (Petersen 2006).

The increasing global need for energy efficient solutions and the factor of 10 gap between current status and sustainability targets points to a **huge expansion potential** and need along all four dimensions. In view of this potential and customer behaviour the central question is not whether marketing opportunities exist, but

- **how and where customer attention can be captured**
- **how information deficiencies and asymmetries can be diminished**
- **how trustful key information and messages can be created and communicated** to those customer groups, which have a potential demand in the near future.

While the closure of knowledge gaps on the supplier's side and consequent development of professional competences is preconditions for answering these questions, the right **marketing mix** (4.) appears as the key instrument for getting through to the customer (see 1.1.1).

As far as the other elements of the cycle are concerned, the **positioning** (3.) of the individual suppliers will be strongly dependent on the individual contexts. From an overall point of view, mutual "closeness" is desirable so as to reduce targeting and information costs of the customers. On the other hand "distance" to "bad" traditions is needed in order to enable the transport of "new, positive emotions" – which again is a question in the marketing mix. Implementation and control (5.), as well as the development of the business (6.) are quite business specific and thus outside this structural analysis.

4.5.2 Dimensions of the Marketing Mix

The goal of the conventional marketing mix is to offer the targeted customer group the desirable product quality in the right place, at the right time, with the appropriate price (Schaltegger et al. 2003:230). When expanding eco-niches into mass markets, offensive ecological competition strategies are needed to progressively gain more "difficult" customer groups (cf. section 2.3.2, Dyllick et al. 1997:76, Wüstenhagen 2006:33), which requires a conscious adaptation of the overall marketing strategy and marketing-mix. While "promotion" is the core of the classical "4 P" ecological marketing mix, "politics" and "public opinion" become important marketing issues (see Wüstenhagen 2006:37ff, Schaltegger et al. 2003:246ff, Kotler 1986, Kotler & Bliemel 2006).

In the following, we shall map Wüstenhagen's suggestions (ibid.:44) to the promotion of energy efficient sustainable housing and briefly characterize the resulting dimensions of the marketing mix (see Tab. 3). Thereby, we shall also blend in considerations by Schaltegger et al. (2003:230ff).

Table 3: Eco-Marketing beyond the Eco-Niche (based on Wüstenhagen 2006)[61].

	Elements	Transitional Problems/Tasks
Product	• Balanced optimization of ecological and other product qualities • *Standardized product/service combinations* • *Attractive packaging of information* • *Branding (see also promotion)*	
Price	• Cost advantage by scale and chain cooperation • *Public funding, financing, incentives* • *Reduce transaction cost*	
Place	• Choice of locations • *Customer location in space-time*	• Distribution structure
Promotion	• Amplification of "animation value" • Creation of positive images • Segmentation of communication activities according to target group, as well as content, emotion and media • Support by independent certifiers • *Strong incentives* • *Presentation of key information* • *Labelling* • *Two-way communication*	• branding
Public Opinion	• Stakeholder management • Sponsoring • Cooperation	• Credibility
Politics	• Active structure-oriented politics • Bundling of power potentials	• know-how, networking

Beyond niche-markets, **product** qualities should be balanced in such a way as to meet the expectations of a broad customer group (see Wüstenhagen 2006 and Tab. 3). Moreover, when considering the relevance of complex customized "solutions" and "projects" in the housing market (see above), the offer of more standardized product/service combinations along with attractive "packaging" and "branding" (Schaltenegger et al. 2003:235, 236) appears important for cost-reduction, emotional uploading, easy recognition and trust building. As quality assurance and adequate guarantees create a special problem in the building industry, easily recognizable quality labels should be integrated into the branding and information packaging strategy (section 3.2.3 and "promotion" below)

Prices have to be competitive, whereby economies of scale (Wüstenhagen) have to be exploited. As funding and financing questions play an important role in the building sector, it is important to include corresponding incentives in the price policy. Moreover, as acquisition, information and education cost being relatively high, it appears of special importance to reduce such transactions costs (e.g. by collaborative promotion and public opinion strategies)

Place: Locations and large-scale distribution structures are essential for overcoming typical regional limitations of the building industry and the building craft in particular. As houses are

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[61] in normal face: key words suggested by Wüstenhagen 2006: 44 (subset), cursive face: additions by the author

"immobile", the place – but also the "time" problem – create a particular marketing challenge especially in the retrofit market. If the places and times of specific retrofit demand would be known, the retrofit market could be tackled in a much more targeted way. In particular, this knowledge could be used for developing a targeted "promotion logistics."

Promotion is the key element of any marketing mix[62]. This holds especially for energy efficient sustainable housing, where in spite of the availability of economically attractive solutions, market penetration is still low. Information asymmetries create a particular challenge (Meffert 2000:24f). Thus, besides the creation of positive images and the amplification of "animation value" (see Wüstenhagen and section 4.4.), fully segmented communication strategies are needed, which have to be tuned to the different forms of demand behaviour described above. Thus, strong incentives are needed to break up habitual behaviour, while key information may influence limited behavioural patterns and many sub decisions (see section 4.4 1., 2., 5., 8.). Trustworthy, easy identifiable labels controlled by independent certifiers and consistent branding greatly support the presentation and promotion process[63]. Moreover, emotional enrichment is needed especially for convincing private house-owners[64]. Instruments of monologue should be supplemented by instruments of dialogue, where by the general availability of internet-based communication infrastructures eases the introduction of such instruments (Schaltegger et al. 2003:245).

Public Opinion building can be seen a **consequent extension of promotion activities** beyond the sphere of direct clients and customers. It embraces an active management of all relevant stakeholders including the media whereby a close cooperation with independent research institutes and NGOs can substantially support credibility and create a sound basis for effective campaigns. Moreover, considering the limited power of predominantly small and medium sized companies, sector overarching cooperation (cf. Schaltegger & Petersen 2005a:13ff) is needed for gaining public, as well as political attention (cf. Wüstenhagen 2006:41, Cremer et al. 2007 and sections 5.2 and 7.3 below).

Politics: The political "control system" - due to its influence on regulatory and economic boundary conditions - is of utmost importance for the building industry. This is especially true for the domain of energy efficiency. Thus, influencing of these boundary conditions becomes a central marketing issue. The bundling of power potentials, as well as know-how and network creation (cf. Schaltegger & Petersen 2005a:22ff) appear essential for creating an impact (cf. Wüstenhagen 2006:41, Jakob & Jochem 2006, Cremer et al. 2007 and sections 5.3, 6.1 and 7.2 below).

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[62] Or even stronger: "Marketing is synonymous with communicating" … "all elements of the marketing mix can be seen as components of business communication", /p.244/)

[63] Here the "passive house" certificate for projects and the label "passive house compliant" for components/solutions (issued by the Passivhaus Institut, cf. section 3.2.3) may serve as an example.

[64] Note that the passive house entails an emotional component closely associated with the concept of "wellness", while at the same time assisting "limited" decision behaviour by means of its simple definition concept. Hence, informational difficulties in the sub decisions 1,2, 5 and 8 can be diminished, whereby a clear label and support structure help in the sub-decisions 3, 4 and 6.

Thus, rational suppliers in principle have a broad set of tools and concepts to promote energy efficient sustainable housing and to address market problems in a systematic way.

4.6 Main Structural Market Problems

From what has been said above, it appears that **a key structural market problem** for the housing market in general and the market for energy efficient sustainable housing in particular is its **high fragmentation** (cf. also ZDV 2007:25ff; EC 2000 and 2006, US DOE 2007b:1-3ff). Accordingly, the market is characterized by a

1. complex mixture of products and services customized to a varying degree
2. heterogeneous set of predominantly small or medium-sized suppliers
3. heterogeneous set of self-occupying owners and lessors
4. broad spectrum of supplier/customer interfaces at different stages of the supply chain

In particular, with respect to energy-related goods, this fragmentation is **combined with problematic information, demand and decision processes.** As shown above,

5. demand behaviour tends to be habitual or limited
6. decision processes involve problematic sub-decisions
7. sub decisions are hampered by information acquisition and processing difficulties

Thereby, the **problems appear to be particularly significant in the retrofit market**, which **shows strong signs of market failure** (cf. Jochem 2005, UBA 2004b) as underlined by empirical studies (cf. e.g. Schneider et al. 2003, Technomar 2005, Friedrich et al. 2007).

As for the **demand side**, Schneider et al. found that in many cases even the most simple, cost-effective energy-saving measures are omitted due to a lack of knowledge or the assumption that energy saving measures are costly and elaborate. At the same time, considerable levels of discomfort and health risks are “accepted”, which to a large extent could have been addressed with energy saving in a synergistic cost-effective way. Unfortunately, openness with respect to external advice appears very limited – especially among the large group of self-occupying house owners (Schneider et al. 2003). The readiness to pay for professional advice is very low (Technomar 2005). Short-term thinking and request of short pay-back times supersede long term considerations (Friedrich et al. 2007). Consequently, the **market pull** for the development of corresponding services - and for energy efficiency goods in general - **remains low**. The lack of openness for advice even creates the **danger that the lack of knowledge and misjudgements gets stabilized** and the **retrofit market gets blocked** (Schneider et al. 2003).

Considering the **supply side**, it turns out that a **serious lack of competence and knowledge with respect to energy issues** is found especially at the customer interface

(Schneider et al. 2003; Hoffmann et al. 2004). Consequently, deficits in customer consultation, retrofit planning and execution are not unusual. Craftsmen often wait for orders, instead of taking an active acquisition role (Schneider et al. 2003). Thus, **market push is deficient as well**, which stabilizes the dilemma at hand.

A further **structural market problem** shows up **in the lessor market** due to the so-called **"user-investor-dilemma."** This dilemma arises, when the lessor invests into energy-saving measures, which in the first instance increase his costs, while the user profits by means of reduced energy bills. Though the profits may outweigh the costs, there is no incentive for carrying out such measures, as long as costs and profits remain with the investor and user respectively. Clearly, this dilemma can be solved, if the lessor can shift the costs to the user by increasing the rent. This, however, is not always possible due to regulative or market barriers. In Germany, from a legal point of view, this **dilemma is largely restricted to situations, where the rent has reached limits defined by a local "rent table"** ("Mietspiegel") and the flat is not let to new tenants. Yet, even in this case, it is possible to apportion 11% of the modernization cost onto the rent so that a part can be directly earned back. Evaluations of statistically relevant aggregates in a local German test market (Knissel & Alles 2003) have shown that - on the average - energy savings are actually reflected in a correspondingly elevated the cold rent. Thus, "on the average" the dilemma appears less significant in prac**tice than in theory.**

Besides the "user-investor-dilemma", other factors like market demand, vacancy problems, pressure on rents, lack of equity capital, restrictive financing conditions (Technomar 2005, Jakob & Jochem 2006, Waden et al. 2006) may hinder otherwise sensible energy conservation measures. The market situation and public-political influence factors varies from country to country and region to region.

Thus, **for a more detailed analysis, it is necessary to look a specific markets in more detail and include the influence of the corresponding public and political spheres.**

5 PROMOTION IN GERMANY

The development of energy efficient sustainable housing in Germany has been particularly promoted by a limited number of actors in the market and public sphere with varying support from the political side (cf. chapter 3). Thereby, the distinction between the spheres is not always a sharp one. Actors and actor groups may move between them or may be active in several spheres in parallel ways (cf. discussion in 2.3.1, 5.2, 5.3). In the following we shall examine the spheres in more detail in order to identify relevant drivers and driving forces, as well as key obstacles. Then we shall evaluate current efficiency niches and strategies for turning niches into mass markets and finish with a short summary and main implications.

5.1 Main Drivers in the Market and the Supply Chain

5.1.1 From Pioneers to Critical Mass

As outlined in 3.1, **researchers outside the building market** acted as a **pioneering group** giving impulses to the public, political and market sphere. Subsequently, it was the merit of a few **engaged individuals mainly in the public sphere** to keep the ideas alive and further develop the key concepts of energy efficient sustainable housing (see sections 3.1 and 3.2). One of the key actors, Wolfgang Feist, introduced the passive house concept as a member of the **public** Institut Wohnen und Umwelt IWU. In the mid nineties he moved into the **market** and founded the private Passivhaus Institut PHI[65], which, however, kept a strong public orientation. Thus, the pioneering phase was characterized by a close interplay between a few public and market actors supported by **politics** via public funding.

From a **supply chain perspective** (cf. section 4.3) Feist and the PHI can be **attributed to the secondary supply chain** providing “soft services” and acting as a driving force from the periphery of market. Regarding the **primary supply chain**, a first important push and pull was due to **small pioneering project providers or “Davids”** – like Rasch & Partner (cf. sections 2.3.2 and 3.2.3). As a result, a large step from individual passive houses to whole **passive house settlements** was done so that the market for highly energy efficient houses was slowly set in motion (see section 3.2).

As already mentioned, the housing market is **dominated by small and medium sized companies**, whereby the interest group **IG Passivhaus** (www.ig-passivhaus.de) provides a common forum for information exchange and the promotion of energy efficient sustainable housing. **Goliaths**, which could move niches towards mass markets, are **almost absent in the residential construction buisiness**. (cf. Fig. 31).

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[65] www.passiv.de

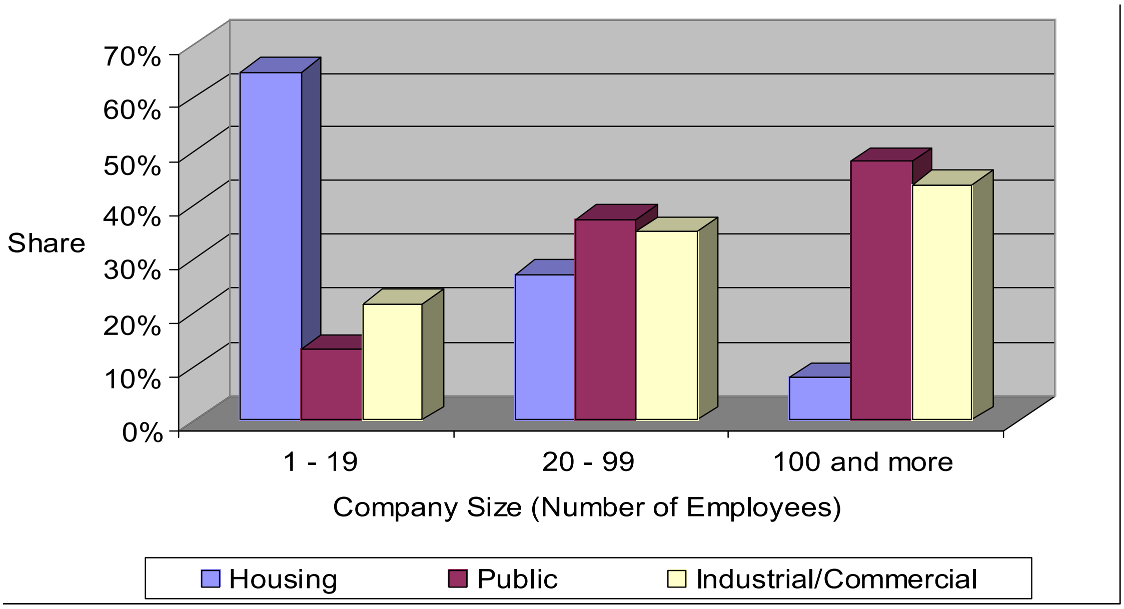

Figure 31: Structure of German Main Construction Business (ZDV 2007:25ff)

Against this background the recent formation of **strong driving forces at the end of the supply chain** on the **customer side** is most important. In particular, the **city of Frankfurt** has decided that new public buildings essentially have to be passive houses and has issued corresponding guidelines (Stadt Frankfurt 2007:3). In parallel, the largest **Frankfurt building company** ABG Frankfurt Holding GmbH with its daughter FAAG started the adoption of the passive house standard for their new projects (FAAG2006, Feist 2007a, Junkers 2007) 66. Similar trends can be observed in other large cities, whereby old buildings are getting included (cf. Stadt Freiburg 2007). It can be expected that these developments **mobilize critical mass** leading to a **forceful market pull.**

The last years have seen the rise of **large financial investors** aggressively buying into public and private multi-family housing stock with very short-term investment goals (Walter & Just 2007, Pieper 2007, BMVBS/BBR 2007). These companies **may seriously hinder energy-efficient sustainable housing approaches** requiring a long-term vision. As the first acquisition wave has come to an end (Höninghaus 2007, Pieper 2007), the **negative impact may remain limited.**

In the **retrofit market** Knauf, Marmorit, Maico, Rehau set up the cooperation **ARGE Faktor 10** striving for factor 10 energy reductions in old buildings (cf. ARGE Faktor 10 n. d.). Though the founding members mainly are producers, they promote an integral modernization

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[66] The example also shows how synergies can be exploited between the political and market sphere, as well as between the non-residential and the residential market. Moreover, the direct impact of light tower pioneering projects in Wiesbaden, Geisenheim und Kassel (cf. Rasch 1997, www.factor10.com, Pfluger 2001) can be traced. CEO Junkers in his Berlin presentation 2007 pointed out that these examples played a decisive role in convincing him that passive houses were the way to go.

approach and offer assistance in contacting corresponding soft-service, solution and project providers. This includes architectural, as well as engineering services by other renowned pioneer "Davids", namely Architecture Office Schulze Darup, Engineering Office ebök[67]. However, the depth and breadth of the **cooperation is limited**, focusing on a restricted number of special projects **without offering true one-stop services** (cf. sections 4.3 and 4.5).

Here, the **recently founded company LouRius**[68] could fill an important market gap by offering energy-efficient **one-stop modernization** all over Germany. With a single interface towards the customer, advanced solutions and whole projects shall be offered in a more standardized time- and cost-effective manner. At the same time, forces towards upstream suppliers are bundled. Thus, one-stop businesses might become key dominos in the supply chain with a high synchronization and greening potential.

5.1.2 The Role of Giants

Apart from big customers and housing companies at the end of the supply chain, **Goliaths** or even **"Giants"** are found at the **beginning of the supply chain** and among the infrastructure and service providers in the **secondary supply chain**. Many of these giants promote energy efficient housing on different levels including sponsoring, consultancy, brochures and campaigns. Equipped with large funds, they have a very high promotion potential, which has no counterpart in the otherwise highly fragmented building and housing business.

Giants typically operate on an **international basis.** France-based **St. Gobain**[69] **is the largest global player** in the construction markets with a broad product spectrum including glass products and mineral-based insulation materials. In its home country the four Saint-Gobain companies Saint-Gobain Isover, Ecophon, Eurocoustic and Saint-Gobain Glass together with four other companies have formed the "Insulate the Earth Against CO_2" association with the aim "to put forward an action plan that will contribute to France meeting its commitment to reduce greenhouse gas emissions by 75 percent before 2050"[70]. In Germany St. Gobain Isover funds the energy efficient modernization of 100 houses. Besides, passive housing techniques are promoted in Germany and other European countries (cf. ISOVER 2007)[71]. Yet, the promotional efforts appear moderate.

BASF as the **worlds largest chemical company** is a **giant with a German home basis**. It is one of the largest suppliers of basic materials for oil based **insulation products** and owner of the German **housing company** LUWOGE/GEWOGE with associated housing

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[67] www.schulze-darup.de, www.eboek.de

[68] www.lourius.de, founded in spring 2007 with head quarters in Hamburg and first dependencies in Paderborn

[69] www.saint-gobain.com, www.saint-gobain.de

[70] which corresponds to a factor of 4 target. See also: www.saint-gobain.com/en/html/presse/dossier_14.asp, www.isolonslaterre.org

[71] see also: http://www3.isover.de/desktopdefault.aspx/tabid-5/252_read-891/, http://www.wohnnet.at/www/ireds/P-51572.html

consultancy services. At the same time, BASF supplies are broad range of other products. Amazingly, **the energy supply business** recently has become the largest profit yielder (BASF 2007a, b). This will not remain without consequences for BASF's focus and interests.

The **positioning of BASF as a sustainable enterprise** has been the subject of a number of unpublished CSM studies originating from a joint BASF/CSM workshop in the first quarter of 2007. On the product side, BASF promotes NEOPOR as a particularly eco-efficient insulation product (Cremer et al. 2007, Hinz & Feldmann 2001, BASF n. d. a,b,c). In order to address existing market barriers, a **mega-marketing strategy** for NEOPOR, BASF and highly energy efficient housing was conceived with a special focus on German **politics and public opinion** (Cremer et al. 2007). Thereby, it has to be acknowledged that **BASF has already actively promoted energy efficient housing** since the late nineties via its housing company LUWOGE sponsoring the DENA, as well as the PHI working group on cost-effective passive houses (see also section 3.3.1).

While BASF is engaged in mega marketing energy efficiency with the German Energy Agency DENA, a major **inconsistency became visible in the national energy dialogue** (Krägenow 2007a, Krägenow & Marschall 2007). Here BASF CEO Hambrecht - together with major leaders from the energy supply industry and the labor unions - strongly questioned government ambitions to raise national annual energy efficiency gains from 1% to a 3% rate. This indicates that the **"giants" currently do not use their power for promoting energy efficiency to the extent required.** Rather, it needed the determination of the German chancellor not to give in and push ahead.

Energy suppliers belong to the most important giants. They command over a particularly broad and deep spectrum of communication channels on different geographic levels. In particular, they have superior access to housing and building owners. Their regional daughters often are still closely connected to the respective communities and local governments, which strengthens their regional presence and communicative power. Thus, their **channels appear particularly attractive for the promotion of energy efficient sustainable housing.** While various energy efficiency campaigns have used these channels[72], there remains the problem that these companies are seen as energy suppliers in the first place so that endeavours in the direction of energy savings are received with some scepticism. On the other hand, most of them have recognized that in the long run the conventional sale of energy has to be replaced by efficient energy services. Yet, the **difficulty to bridge** the two **polarizing goals** hinders a stronger overall support for factor of 10 reductions.

Besides the energy suppliers, **financing institutions** have a privileged access to house owners, which can be used to promote energy efficient sustainable housing in various ways, whereby the offering of **special financing conditions** and bonuses is the most direct, market-oriented one. As already indicated by Koller (1995:163), however, this tool is hardly

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[72] see e.g. recent campaigns by RWE (Stern & RWE 2007) and E.ON (E.ON Westfalen Weser 2006 and 2007, Steinmüller 2007d). Note that E.ON also acts as co-sponsor of the DENA-campaign.

used. One of the exceptions in Germany is the Umweltbank[73], whose influence is restricted. A **substantially rising impact is exerted by the state-owned KfW**, which will be discussed as institution of the political sphere in 5.3 and 5.4.

Furthermore, **financing institutions can offer advice and support** campaigns for energy efficient sustainable housing. Here the German HypoVereinsbank - since 2005 part of Italy based Unicredito - may serve as a good example of a private bank. Promoting sustainable building via certified passes on a national scale (Hypovereinsbank 2000, 2001), it also supported specific energy efficient housing campaigns via its regional daughters (Hypovereinsbank 2004)[74]. State building and loan associations (Landesbausparkassen) mention passive houses as one of four building concepts[75] and offer special modernization advice (LBS 2007), however, without marketing energy efficient sustainable housing as “the way to go.“ On their home pages the big private building and loan associations in this respect appear even more discrete. On the other hand, Schwäbisch-Hall as the biggest German building and loan association even sponsors a chair for sustainable housing[76] and a diversity of public campaigns.

5.2 The Public Sphere

As pointed out above, the distinction between the market and the public sphere is not a sharp one. In particular, many pioneers and scientific institutions may play a role in both of them.

5.2.1 Non-Profit Multipliers

As far as **scientific organizations** are concerned, the Institut Wohnen und Umwelt IWU has a long tradition in interdisciplinary research covering social, economic, as well as environmental and urban planning aspects, i.e. basic dimensions of sustainable housing research. Being the birthplace of the passive house, the institute has been acting as a major driving force for the promotion of energy efficient sustainable housing in the political, market and public sphere, e.g. by expertises (cf. IWU 1989 – 2007a, Diefenbach et al. 2001, 2002), workshops, workshop series and public campaigns (e.g. Steinmüller 1998, HMWVL & IWU 2001, Hessische Energiesparaktion or “Impulsprogramm”[77]) and a wide range of brochures (see e.g. IWU 2007b). The promotion, however, sometimes is shaded by “understatement”, when e.g. “factor of 2” concepts[77] appear as a final target rather than a temporary compromise for buildings with short rest life-times. Here, the offspring PHI, conveys a clearer vision (see above).

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[73] www.umweltbank.de

[74] both campaigns were also supported by the author

[75] see www.lbs.de for overview and e.g. http://www.lbs.de/west/immobilien/hauskonzepte for housing concepts, whereby the “Solarcomforthaus” entails the passive house concept

[76] Chair Sustainable Management of Housing & Real Estate (Lützkendorf) http://housing.wiwi.uni-karlsruhe.de

[77] http://www.impulsprogramm.de/

Ecologically oriented institutes like the Öko-, Wuppertal- and IFEU-Institute actively support sustainable housing approaches, as well[78]. The Fraunhofer Institute of Building Physics IBP[79] - though historically more strongly connected to the traditional building industry - has evolved as progressive promoter for energy efficient buildings. The technical university of Karlsruhe as one of the leading technical research institutions in Germany even houses a special chair for ecological building[76]. Stuttgart, Kassel, Hannover, Berlin and Braunschweig are further important centres with well known academic bodies. Thus, there is a wide range of institutions, which in many respects make similar contributions as IWU, whereby the specifics may vary considerably.

In the **non-scientific** area **environmental organizations** such as WWF, Greenpeace, BUND, NABU, Kathy Beys[80] have acted as a sounding boards and supporters for energy efficient sustainable housing, whereby corresponding campaigns often are carried out in close cooperation with science (see e.g. BUND & Misereor 1996, IWU 1997, WWF 2001, NABU 2001). In general, however, the topic of housing is not a focal point of their activities.

German **consumer organizations** and the national roof VZBV play an active role in supplying corresponding user advice. VZBV advice used to favour more "moderate" measures. Support for advanced passive housing techniques has recently become apparent – which, however, still is not reflected in the relevant brochures[81].

Unions, churches, political parties and associated foundations[82] promote energy efficient sustainable housing to a varying degree. While groupings and foundations with a "green" touch, such as the Böll-foundation[83], have shown dedication for a long time, the renewal of the climate debate has stimulated a more active support for energy efficiency including energy efficient housing among the other groupings as well.

Public **energy agencies**, which usually are **closely associated with the political sphere**, offer pre-competitive support and advice. On the national level, the German Energy Foundation DENA has already been mentioned above and is considered in more detail in section 5.3. On the level of states, several energy agencies have been closed or privatized. The energy agency of the largest German state North Rhine Westphalia, however, still is operational.

Besides the more permanent institutions named above, **special interest groups and initiatives** have formed, which include a broad spectrum of players . An example is the

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[78] www.oeko.de, www.wupperinst.org, www.ifeu.de

[79] www.ibp.fhg.de

[80] www.wwf.de, www.greenpeace.de, www.bund.de, www.nabu.de, www.aachener-stiftung.de

[81] See e.g. guidebook "Insulation" (VZBV 2006), which details on constructions details and secondary properties as thermal capacity and primary energy content – neglecting the question of optimum insulation thickness.

The role of the parties is a broad subject, which cannot be covered here. The relevant political forces, however, will be discussed in Section 5.4.

[83] www.boell.de

initiative “Gebäudemodernisierung Jetzt!”, which was in 2000 on a **national scale** to push the energy efficient renewal of buildings. It ended its official work in 2006, when the government started its new KfW funding offensive, but has continued on an informal basis. Last but not least, there is a large number of **regional initiatives.** Some of them cooperate with private and public stakeholders offering special support to private house owners and builders (e.g. regional networks like “Bau und Energie” Mittelfranken, “Altbauneu” NRW, “Energie-Impuls OWL” and local round tables and initiatives for the energy efficient renewal of old buildings[84]).

5.2.2 The Role of the Media

As outlined in section 2.3.1, the “media” take on a central role in the public control system with a an important reporting function in the public “arenas”. Thereby, the **mediating actors are embedded in economic and political interests, which strongly influence the transformation of ecological problems to public claims,** not only with respect to the intensity of reporting and awareness, but also with respect to the contents and truthfulness of the transformation itself (cf. also Schaltegger & Petersen 2005b: 94). One of the insiders of the media scene, G. Rosenkranz[85], describes the recent role of the media and even talks about the **“anti-enlightenment”** (“Anti-aufklärung”) as a reason for **“the** [last] **lost decade of energy efficiency”** (Rosenkranz 2007).

Looking back **three and a half decades**, the reporting intensity and contents has varied drastically. The following observations can be made:

In Germany, the **first oil crisis created enormous public awareness** so that pioneering projects dealing with the energy issue covered the front-pages of the newspapers. This also was true for the Philips Experimental House, which received a lot of attention far beyond Germany. However, already at that time, the “visible features” of the house, i.e. the solar collectors received much more attention than the “invisible” ones hidden in the building envelope. Exploiting positive emotional associations, the **media readily zoomed into solar energy,** creating a strongly distorted picture of real priorities and guiding public opinion and politics to wrong strategic decisions. The supply view and interest in alternative energies was further strengthened by the nuclear Tschernobyl disaster 1986, while energy efficiency almost was absent from the agenda. Then low energy prices decreased interest in energy issues. Since the end of the nineties oil prices have been rising again. In parallel, global warming and climate change have become a public issue**, whereby weather disasters have been a main trigger for doubtful media reports** (e.g. in Germany: flooding of major rivers, in the World: flooding of New Orleans). Though **the scientific community has arrived at an almost unanimous picture** of the trends and upcoming dangers - **media has been carrying on with drawing picture of uncertainty** (see also Rahmstorf & Schellnhuber 2006:82ff). Fittingly, in October 2007 the Financial Times Germany FTD, Schütte comments: “Der Friedensnobelpreis für Al Gore ist ein schlechter PR-Stunt” (The

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[84] www.newebauen.de, www.alt-bau-neu.de, www.ei-owl.de, www.gebaeudesanierung-pb.de

[85] former Spiegel correspondent and current spokesman and director politics of DUH

peace noble price for Al Gore's is a bad PR-Stunt") and discredits Al Gore's climate warnings and the priority of the precaution principle (Schütte 2007, chief commentator FTD)[86].

Nevertheless in 2007, Rosenkranz (2007) expressed **optimism with respect to the next decade** and pointed to the encouraging changes in the first months of the year: "'Der Stern-Report', ähnliche Untersuchungen des DIW für Deutschland und ein ausgefallener Winter ('Klimawandel zum Anfassen') haben die Klimadebatte endgültig aus der ökologischen Isolation befreit und in der Sphäre der Ökonomie verankert. Sie findet nun dort statt, wo sie längst hingehört: Auf den Titelseiten der Medien und – noch wichtiger – ganz oben auf der politischen Tagesordnung… Die zuletzt gefassten Beschlüsse … zur Energieeffizienz .. sind ermutigend". Still, Rosenkranz also points out that backlashes are possible so that an **active participation in the public debate is necessary.**

Mega marketing (cf. section 2.3) is one option and consequently has been suggested as a means in one of the BASF-studies (Cremer et al. 2007). A precondition, however, is a clear management support, which the German energy giants often fell short of (cf. section 5.1.2, Krägow 2007, Rosenkranz 2007). Thus, more work is necessary to make this tool effective.

As for **media channels**, the **traditional media like newspapers and TV are still decisive for public opinion building on the large scale**. Compatibly, newspapers still appear as a preferred medium also for suppliers in the retrofit market (see e.g. Steinmüller 2006b). As far as TV is concerned, the first public channel ARD promotes building and energy in its third programmes, however, centring on "moderate" measures with occasional side-blows on more far reaching ones[87]. The second public channel ZDF has put a major focus on sustainability and the subject of energy efficient housing together with CO_2-Online[88]. Currently, Roland Meyer, an engaged individual, promotes a new "alternative" concept integrating a "rock-tour" with classic media and TV-events[89].

Clearly, the internet has to be mentioned as a most powerful knowledge and information network giving specialists and the interested public fast and direct access to almost any relevant information source. It will play a prominent role in the future.

In conclusion, the **media play an extremely important role**, which, however, in the past had been an **ambiguous** one. Yet, there is hope for a change, which **offers a new chance** for an effective promotion of energy efficient sustainable housing.

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[86] It has to be pointed out that a minority of public media (e.g. "Die Zeit" with Fritz Vorholz) have drawn a clear picture for a very long time and thus kept spreading the information necessary for initiating a change.

[87] c.f. www.wdr.de/tv/ardbauen and www.wdr.de/tv/ardbauen/sendungen/2006/januar/060115_1.phtm

[88] www.zdf-jahrbuch.de/2006/programmarbeit/angres.html and http://www.co2online.de/1073.0.html. The latter also provides internet services and efficiency online check (www.co2online.net/index.php?id=33) centred, however, on more "conventional" measures

[89] www.ronald-meyer.com and www.ronald-meyer.com/aktuell_kaffeeodertee.html

5.3 The Role of Politics

In an increasingly globalized economy, politics has steadily lost control power. As buildings are “immobile”, however, politics - flanked by the rising need for effective climate measures - **can exert considerable influence** on the issues at hand. Recent studies indicate (Friedrich et al. 2007) that this is increasingly **accepted and expected by the population**.

5.3.1 International Background

As far as international politics is concerned, after years of stagnation, **the international climate debate got a new impulse** at the G8-summit hosted by Germany in Heiligendamm, where the necessity of coordinated measures under the umbrella of the UN towards a cut of global CO_2-emissions by a factor of 2 was finally conceded by all participants including the US (Bundesregierung Deutschland 2007b, Krägenow 2007b, Marshall et al. 2007, Landler & Dempsey 2007). The impact created by chancellor Merkel already became visible at the UN-conference in September (Krägenow 2007c). Further progress is expected from the 13th Climate Change Conference in Bali in December 2007 (cf. BMU 2007d, e).

On the European level, the first half of 2007 was marked by Germany’s presidency in the European Union. Also here, **a major break-through was achieved** by obtaining commitments to more demanding energy measures, in particular in the area of energy efficiency (see section 6, EC 2007b, Ehrlich & Proissl 2007).

These **successes also strengthened the position of the German government** and the position of chancellor Merkel in the internal debate (FTD 2007 and Krägenow 2007c).

5.3.2 National Level

Targets:

As outlined in **1.2.1**, the necessity of **global factor 2 reductions in CO_2-emissions has been recognized in Germany** since the early nineties, whereby a national factor of 5 (80%) was considered minimum for industrialized nations. While Germany joined the Kyoto protocol committing to a 21% reduction, it currently develops plans to reach a **40% reduction until 2020 (Bundesregierung Deutschland 2007a)**. Thereby energy efficiency shall improve by 3% p.a. The modernization rate of buildings shall be doubled on a demanding energetic level.

Main Actors & Instruments:

The federal government with its **ministries and subordinate bodies** constitutes the main political power on the national level. The main actors in the context of energy efficient sustainable housing are – besides the chancellor - the ministries for transport, buildings and urban affairs (BMVBS), environment (BMU), economy (BMWI), education and research (BMBF), finances (BMF) supported by the bodies federal office for building and regional planning (BBR), federal environmental protection agency (UBA), reconstruction loan corporation Kreditanstalt für Wiederaufbau KfW and German energy agency (DENA).

Besides, the government has created the state secretaries' committee on sustainable development and the German Council on Sustainable Development. („Rat für Nachhaltigkeit“), whereby the latter primarily works as an independent experts’ council and mediator between the public and political sphere.[90]

As for the federal ministries, the **main responsibility for the area of buildings rests with the BMVBS.** This includes competences for building codes and central areas of building research. The BMWI - being competent for economic and energy policies - can also exert substantial influence, as soon as economic and strategic energetic aspects are touched, whereas the BMU has a say in ecological aspects of building poltics. BBR supports BMVBS, while UBA assists BMU. **Only DENA has a cross-sectional function,** serving BMVBS, BWWI and BMU and KfW[91]. DENA strongly **interacts with the public and the market sphere.** Here, the campaign “Future of the House“ forms the roof for promoting the advanced energy efficient renewal of buildings and the introduction of energy performance certificates. At the same time - in cooperation with KfW and external experts - new funding models are designed and tested.

Thereby, the **“KfW Förderbank” transforms political will into financing incentives** for the market. The **main political instruments** embrace regulative, market-oriented and informational measures as summarized in Box 7[92]. Concerning regulations for new buildings, the **energy saving ordinance EnEV** (cf. EnEV 2001, 2007), which was conceived in the late nineties, basically prescribes a low energy standard in a relaxed form (Loga et al. 2001). Old buildings may stay 40% below the standard for new buildings, if modernized. If only a limited number of components are touched, moderate component standards have to be observed. As far as **market instruments** are concerned, energy taxes and fees raise energy prices by about 30%-40% for fossil heating, 60% for household electricy and more than 150% for gasoline[93]. This includes an “ecological tax” worth almost 20 billion p.a. or 220 p.a. p.c. One of the key instruments is the federal housing program, which has been expanded by a factor of 4 in 2006 reaching a volume of about 1.5 billion p.a. or 20 p.a. p.c.[94] This programme includes special loans, debt reductions, subsidies and tax reductions with special conditions for new passive houses and low energy modernization measures. It is flanked and supported by **information and innovation campaigns** of the German Energy Agency DENA, whereby the Advanced Retrofit Programme has been used to promote pilot projects (see section 3.3), which can be seen as a forerunner for later KfW programmes.

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[90] www.bmvbs.de, www.bmu.de, www.bmwi.de, www.bmf.de, www.dena.de, www.bbr.bund.de, www.kfw.de, www.umweltbundesamt.de

[91] The ministers, the managing directors of KFW and Deutsche Bank have a seat in the supervisory board

[92] for a comprehensive assessment of climate policy scenarios covering all sectors cf. Diekmann et al. 2004.

[93] www.bundesfinanzministerium.de/cln_06/nn_3380/DE/Steuern/Energiebesteuerung/node.html__nnn=true

[94] www.bundesregierung.de/Webs/Breg/DE/ThemenAZ/Gebaeudesanierungsprogramm/gebaeudesanierungsprogramm

- Regulative
  - New Buildings: “Energieeinsparverordnung EnEV” (approx. low energy standard)
  - Old buildings: EnEV prescribed in case of major modernization (approx. 40% above new housing standards). Additional standards hold for replacement of individual components
- Market Instruments
  - Levies: 30-40% (heating oil, gas), 60% (electricity), >150% (gasoline) –including VAT, concessions, cogeneration, ecological tax; percentages: on top
  - Ecological Tax: up to 2 Cent/kWh → 18 bn /a (220 p.a. p.c.)
  - Federal Housing Programme upsized by a factor of 4 in 2006: special loans, subsidies, tax reductions 1.5 bn /a (almost 20 p.a. p.c.)
- Information and Innovation Campaigns
  - DENA “Future of the House” („Zukunft Haus“)
  - Energy Performance Certificate (inline with EU-directive)
  - DENA Advanced Retrofit Programme (“Niedrigenergiehaus im Bestand”)
- Funded Research: BMVBS/BBR Initiative „Future Building“ < 10 Mill. /a until 2009

Box 7: Political Instruments

Problems and Chances:

The **„EnEV“ ordinance is based on the energy saving act** (Energieeinspargesetz EnEG) requiring “economic viability”. However, in this act

the definition of economic viability is **ill-defined**[95] supporting cautious interpretations

- **neither external costs nor non-energy benefits are accounted for.**

Hence, scenario parameters prescribed for the commissioned derivation of EnEV (Feist 1997) do not reflect “real” values, but one-sided “cautious” assumptions, which do not consider any external effects and which meanwhile have been fully overtaken by reality[96]. **The paradoxical result is that EnEV drastically misses economic optima under the banner of economy** leading investors into the wrong direction.

This also has been recognized by the government – at least in part. **The new Energy & Climate Progamme announced in August (BMU 2007c) suggests to progressively adjust energy efficiency requirements in EnEV** starting with 30% in 2008/2009 and another 30% in 2012 so that by “2020, new buildings should be heated as far as possible without the use of fossil energy sources” (ibid:22). In parallel, the level of retrofitting obligations and compliance requirements will be raised. Though these steps are still too hesitant and do not touch the relevant definitions of EnEG, they **point into the right**

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[95] EnEG §5 (1): “Anforderungen gelten als wirtschaftlich vertretbar, wenn generell die erforderlichen Aufwendungen innerhalb der üblichen Nutzungsdauer durch die eintretenden Einsparungen erwirtschaftet werden können. Bei bestehenden Gebäuden ist die noch zu erwartende Nutzungsdauer zu berücksichtigen.”

[96] A low mean energy price of 0,0266 /kWh, overcautious component life times according to VDI 2067 and a real interest rate of 4% were taken and partially already criticized by the author himself (Feist 1997:40).

direction. The new building 2020 target – depending on its interpretation – could even meet the necessary climate goals, while the old building targets still remain vague.

As for old buildings, the new programme (ibid:22) also suggests a **revision of the Heating Cost Ordinance** in order to accelerate energy-efficient modernisation in rented **multi-familiy houses** by fine-tuning consumption dependent cost distribution and by equipping the tenant with the right to withhold payment in case of serious infringement of retrofit obligations. Unfortunately, the revision **does not address the user-investor-dilemma**, which – though virtual in the practical average – still exists as a regulative hurdle (cf. section 4.6).

As far as the **market-oriented instruments** are concerned, the **steering effect** of ecological **levies and taxes** is well known (see e.g. UBA 2004c, Hamm & Nill 2004; Knigge & Görlach 2005). The large spread between heating energy and gasoline levies and eco-taxes, inidicates that there is still considerable **room for further adjustments** and balancing (e.g. tax increases for domestic energy consumption).

As regards the **incentive programmes** it can be stated that the federal KfW programmes had been **ineffective in the past:**

- Modernization rates and efficiencies remained low (see Kleemann & Hansen 2005)
- Private owners were hardly reached (cf. also Technomar 2005)
- Saving targets did not address long term requirements and stimulate low-level savings so that possible and necessary saving measures had been blocked for many decades.

Since 2006, however, the programme has been restructured and upgraded in financial volume by about a factor of 4 so that **first changes from "niches" towards mass markets can be observed** (see section 5.4). Still, the financial volume of the programme is a factor of 10 lower than that of the eco-tax, which itself is only a fraction of the energy-related taxes and levies. This indicates that there is a disbalance between negative and positive incentives and again considerable **room for improvement**.

Information and innovation campaigns help unveiling the real saving potentials especially in old buildings (cf. section 3.3) and reshaping incentive programmes (see above). Recently published handbooks (Schulze Darup 2006) after all have become sufficiently forward-oriented. The task is to further spread the information and make it a common base for all relevant actors in the market. Energy performance certificates in their present form appear highly problematic and counter-productive (appendix 10.4).

Though there appears no major need for basic research in the building sector, it is obious that many market-related questions still need scientific investigation. The volume of the current **BMVBS/BBR research initiative** is several orders of magnitude smaller than the associated market and **mismatches the size of the problem**, if more than superficial answers are expected.

Finally, all instruments threaten to remain blunt as long as the Federal Government does not set a good example itself. Here, the latest report of the Federal Audit Court points to **a serious lack of efficiency assessment in federal buildings, absence of economic life**

cycle costing, professional planning & control (a.o. BRH 2007:18, 29, 175ff; Marschall 2007b).

5.3.3 Sub-National Level

In the building sector the sub-national level plays an important role too. Here **the federal states carry a key responsibility for the specification of national framework legislation including compliance control.** Moreover, the states provide special funding, information and education programmes, which partially are supported by state-owned energy agencies and institutes (cf. section 5.2.1). In particular, education is state responsibility.

While the subsidiary practiced here allows for the adaptation to regional specificities and may be used to compensate potential deficits on the national level, it also **produces inconsistencies and extra costs on the regulative, as well as on the application side.** "It burns different in each state" has become a general idiom pointing to the unnessesarily different safety rules, which require special planning and design. This also hinders the quick proliferation and uniform, cost-effective application of innovative techniques - such as highly energy efficient heat recovering ventilation systems.

With regard to rule compliance, the low implementation efficiency observed by (cf. Kleemann & Hansen 2005:11 and section 5.4) points to another serious problem. The **adherence to standards factually is not controlled, which drives a downward-oriented quality spiral** punishing quality conscious supplies, unaware customers, environment and society, while free-riders taking quality short-cuts are awarded and finally may be the only survivors in a competitive market. The new Energy and Climate programme also touches this point intending to introduce "provisions concerning fines for non-compliance" and to intensify "private duties to demonstrate compliance" (BMU 2007c:22,23).

Finally, the **communities** can influence energy efficient housing by local planning directives, as well as funding und information initiatives, whereby the latter often are performed in cooperation with other public and market actors. These activities can provide significant help to local actors, stimulate future-oriented behaviour and act as crystallization points and "light towers."[97]

However, they have to be supported by an overarching framework, if factor of 10 reductions are to be achieved on a national scale.

The role of cities and **communities as investors** has already been touched upon in section 5.1.1. Obviously, there are high potential synergies between investment and information/regulation behaviour, which hardly have been exploited yet. Again recent national initiatives targeting and the energy-efficient modernisation of social infrastructure and federal buildings (cf. BMU 2007c) could give an important impulse. At the same time, however, it is

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[97] The activities in the communities of Frankfurt and Freiburg have already been indicated above. Furthermore, there are numerous regional and communal initiatives including cooperative efforts/networks, the most prominent of which is the Climate Alliance (www.klimabuendnis.org) comprising about 1500 cities, local and regional communities. A detailed evaluation is beyond the scope of this study - further examples can be found in Hinz et al. 2002; Schneider et al. 2003; Steinmüller 2006a.

important to redefine public fiscal accountance ("cameralistics") so that future-directed investments get the value and credit they deserve.

5.4 From Eco-Niches to Mass Markets

In the following we shall analyse the current status of the German housing market and explore trends and strategies to expand energy efficiency niches towards mass-markets.

5.4.1 General Market

The German housing market can be characterized as follows:

The German housing market comprises about 40 million **dwelling units** or "homes" for 82,5 mill. Inhabitants (BMWi 2007), whereby about 40% of the homes are owner-occupied, 35% let by small private lessors and about 25% by professional lessors (Walter & Just 2007). After peaking in the nineties net growth rate has come down from almost 600 000 new units p.a. to about 200 000 units p.a. (0,5% of the stock), whereby about 2/3 of the growth takes place in one and two family buildings (Statistisches Bundesamt 2007a-c, UBA2006). Thus, owner-occupied homes form the most important, still growing market share.

Housing investments amounted to about 126 billion (2006 in year 2000 prices). Modernization has become dominant in the nineties reaching a share of almost 60% in 2006, whereof more than 60% are spent in one and two family homes (Heinze 2006, BAKA 2007). The overall gross fixed asset housing value amounts to about 5,5 trillion . Thus, current annual modernization investments are less than 1,5% of the housing stock value.

The average per capita **living space** in 2005 (1996) amounted to 39,7 (37,3) m^2 as compared to 35 m^2 in 1990 (BMWi 2007). Hence, living space p.c. has grown by about 13% p.a. since German reunification. However, the main growth occurred between 1994 and 2000. Since 2000 living space has almost been constant[98].

Final energy use in 2005 (1996) reached 232 (274) kWh/m^2a, with 75% (78,6%) attributed to heating, 11,5% (10,7%) to warm water and about 13,5% (10,7%) to household appliances (derived from BMWi 2007). The corresponding figures corrected for temperature effects are 245 (255), 77% (76,3%), 11,5% (10,9%), 11,5% (12,8%)[99]. Roughly 60% of the final energy use can be attributed to one and two family homes, 30 % to small multifamily and about 10% to large family buildings (IWU 1994). Taking into account the growth of living space and temperature corrections final energy use has continued to grow by about 0,3% p.a. over this

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[98] The Energy Saving Ordinance EnEV (unfortunately) introduces an artifical standard floor space parameter, which is derived from volume. Therefore, when referering to "EnEV floor space" we shall use the unit "M^2" instead of "m^2" for clarity. Note that there is no simple one-to-one mapping between the two (cf. IWU 2001). However, for typical buildings (without heated cellar), "1,2 M^2 = 1m^2 " can be assumed as average conversion (cf. EnEV 2007, §19). This means that energy intensities with respect to living space are about 20% larger than corresponding EnEV intensities with respect to EnEV floor space. As we are focussing on "orders of magnitude" and "factors of 10" rather than on percentages, the differernce usually will not be decisive.

[99] Own calculations with heating degree day corrections

ten year period. The temperature adjusted **primary energy use** in 2005 (1996) for heating is estimated as 202 (220) kWh/m^{2}a, for warm water 37 (41) kWh/m^{2}a respectively, i.e. about 240 (260) kWh/m^{2}a in total[100].

The net present energy values for heating, warm water and electrical appliances are equivalent to about 375, 25 and 50 /m^2, if initial energy prices of 0,05, 0,05 and 0,15 /kWh and time factors of about 40, 20 and 10 years are assumed respectively (cf. Fig. 11, section 2.2.4) [101]. This **adds up to about 450 /m^2 or 18 000 /person or about 1,5 trillion for Germany**, which is equivalent to about a quarter of the total housing stock value **signalling an extraordinary economic saving potential.**

Against this general background, we shall now take a closer look at "efficiency-niches" and potential base strategies to expand them towards mass-markets. The **"map of the ecological mass market"** – called **eco-map** in the sequel – shall be used as a template for the following discussion (cf. Fig. 32, Wüstenhagen et al. 1999, 2006 and section 2.3.2).

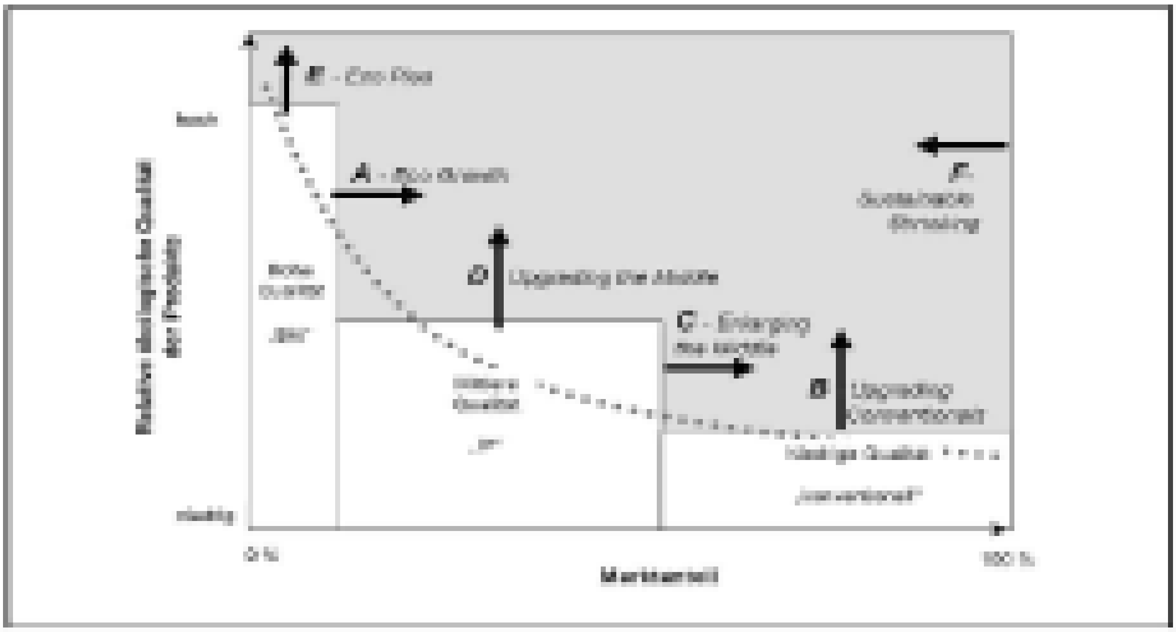

Figure 32: Map of the Ecological Mass Market (Wüstenhagen et al. 1999:27)

As outlined in section 2.3.2, eco-maps assume that ecological quality can be described on a one-dimensional scale. The choice of the scaling function strongly influences the appearance

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[100] Own calculations based on (BMWi 2007) and standard primary energy factors, whereby the electricity share for hot water production was assumed to be 20%. The latter figures for 2005 transform to about 200 kWh/M^{2}a.

[101] Net present values are obtained by multiplying final energy use values (4.) with energy prices and time factors.

of the map. Here, a map with meaningful areas can be obtained, if the relative **eco quality** is chosen proportional to **energy intensity** on a mirrored scale so that small intensity values correspond to high quality ones (cf. Fig. 33). Thereby we shall use “kWh/M^{2}a” as main reference unit[9898]. A possible **choice for the upper end is “0”,** a feasible choice for the **lower end is the average energy intensity of the building stock.** In this case the remaining **“grey area”** is proportional to the energy consumption of a given market scenario and **reflects the total saving potential with respect to zero energy use.** As zero-energy use may be to ambitious, other target lines can be taken. As far as the definition of market shares is concerned, a consideration period has to be specified. In the following the **basic period is one year.**

5.4.2 New Housing

Basic Observations:

Before analysing specific markets segments in more detail, it is useful to discuss **energy intensities of new houses in comparison to theoretical intensities defined by regulative requirements.** This can be done by constructing a simple eco-map, see Fig. 33 .

The y-axis depicts energetic intensity in absolute (left) and relative terms (right hand side), whereby the average regulative minimum defined by new housing codes (EnEV, formerly WSchV) happens to coincide with about 100 kWh/M^{2}a, when interpreted as heating for WSchV and heating plus hot water for EnEV (see dashed black line in the middle). The “factor of 10 sustainability target” roughly corresponds to 20 kWh/M^{2}a, i.e. a tenth of the average intensity of the building stock (200 kWh/M^{2}a). A market share of 100% (x.-axis) here is taken equivalent to the number of new housing units sold per year (about 200 000 units/a) [102].

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[102] In 2006 (2005) 216 311 (211 670) new units have been permitted, 219 777 (210 752) completed.

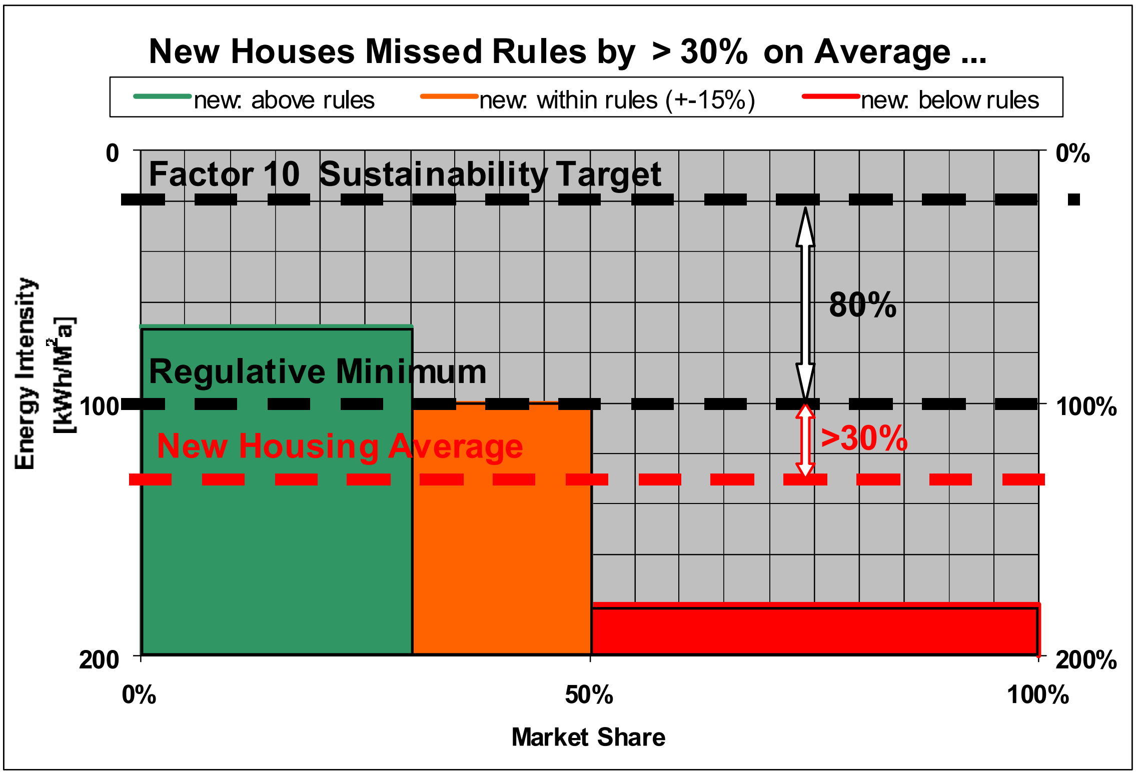

Figure 33: New Houses Miss Rules and Sustainability Targets

In a market, where all new houses meet the rules, all rectangles should end above the minimum line. However, Kleemann and Hansen (2005) reported that **the required standards are missed by 31% on the average** (see red dashed line). More specifically, for a large sample of building vintages 1995 to 1999 it was found that 30% of the new housing (green) were significantly better than the code, 20% were within a tolerance band of +-15% (orange) and **50% was far beyond the minimum** (red rectangles) [103]. Though these results were obtained for housing built according to the "Wärmeschutzverordnung WSchV95", Kleemann and Hansen suggest that similar results are to be expected for the "Energieeinsparverordnung EnEV ".

The deviations can be attributed to bad construction, as well as to occupant behaviour. Evaluations of well controlled building projects, however, show that occupant behaviour does not have a significant influence on the statistical average of larger occupant samples (cf. e.g. Ebel et al. 2001) so that the main part of the deviations has to be attributed to **short comings in building practice and lack of compliance.** Thus, besides striving for higher legal standards, it is necessary to **improve average building practice** and safeguard **standard compliance.** Note that the former "only" accounts for a 30% deviation, while another 80% or **factor 5 deviation in the domain of new buildings is due to weak standards.**

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[103] Kleemann only gives numbers for the average deviation and the market shares, from which the distribution shown in Fig. 33 has been derived in an approximate way.

Expanding Niche Markets:

As the energy quality of new houses and the availability of statistical data is strongly influenced by the German Energy Code **EnEV and KfW** loan programmes, we shall take the respective code prescriptions and loan requirement as a basis for the definition of corresponding quality groups and market segments. More specifically, **the primary energy intensity "PE" for heating and hot water** is used to define three idealized segments [104]

HighQ: PE ~ 40 kWh/M^{2}a ("KfW40-level" including "passive houses"),

Mid Q: PE ~ 60 kWh/M^{2}a ("KfW60-level"),

Low Q: PE ~ 100 kWh/M^{2}a (EnEV minimum standards … 70 to 150 kWh/M^{2}a).

Fig. 34 shows the resulting **eco-map** for the year 2006 (coloured rectangles) with results for the year 2005 superimposed (white/grey rectangles). Estimates for the high (green) [105] and middle (blue) market shares have been derived from corresponding KfW loan commitments for 2006 (2005) (cf. KfW 2007c) yielding the figures with the low (red) segment as the remainder. Possible development paths for the segments and the overall market are indicated by arrows according to Wüstenhagen's classifications (cf. Fig. 32 above).

Note that the high and middle market segments only reflect KfW-funded projects.

Thus, the real market shares of theses segments may be higher[106].

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[104] In theory, the buildings should stay below the given numbers. In practice, however, most planners only try to just reach the rules ("edge optimization"). The final implementation may even seriously miss the rules (see above). Thus, real values will scatter around these idealized figures. This holds especially for the first and the third segment. The first segment also includes zero energy and passive houses, which may be well below the given limit. The third segment contains the large number of buildings built according to EnEV, which defines the PE-limit as a function of surface to volume ratio and which for the given purpose has been averaged.

[105] As the funding benefits for KfW-40 and passive-houses are similar, but the technical requirements for passive houses are more stringent, many claimants may only have applied for KfW-40, though conforming to the passive-house standard.

[106] Due to the attractiveness of KfW loans for new buildings, however, the difference should be a small one.

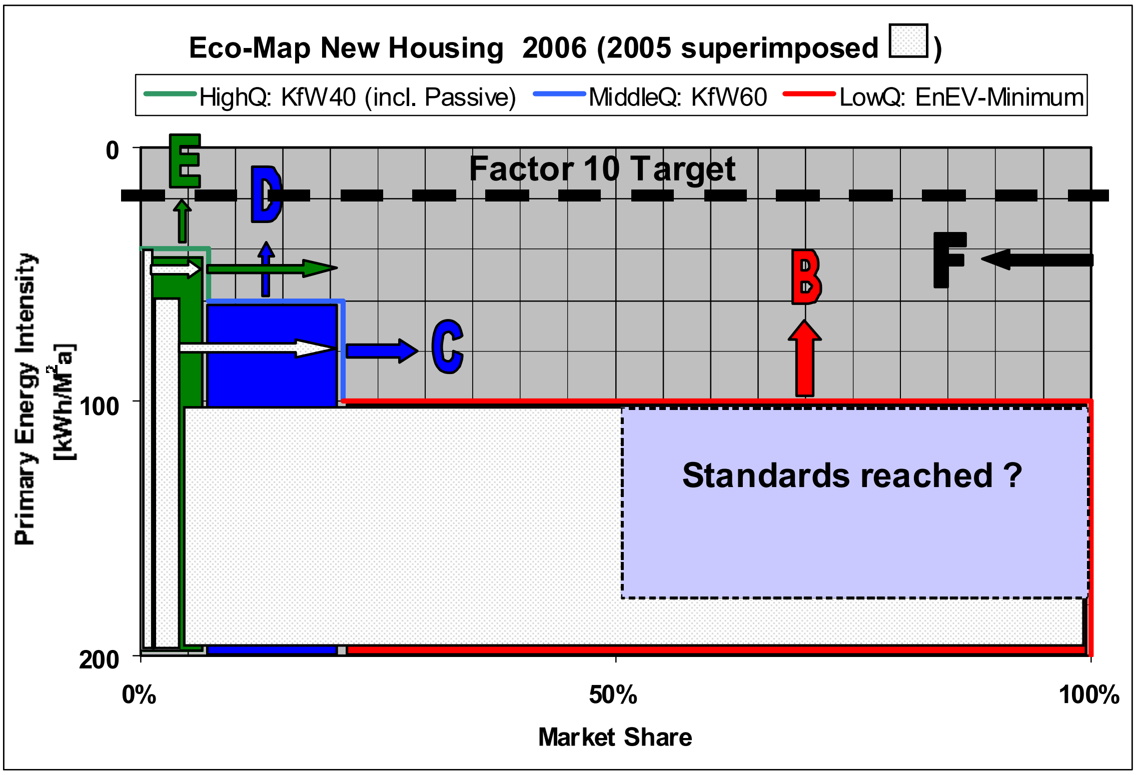

Figure 34: Market Eco-Map for Energy Efficient New Housing in 2006 (2005)

The map shows that **the lowest quality segment dominates the new housing market by about 80% (95%) in 2006 (2005)** missing the sustainability limit by a factor of 5. In fact, according to Kleemann and Hansen (see above, Fig. 33) it can be suspected that half of these buildings even fall seriously short of the EnEV requirements so that the shortcomings may be even more serious (see shaded area on the right). The **dominance of the low segment is an alarming fact.** It shows that large economic efficiency potentials are not touched yet. Thereby, the resulting sustainability gap will remain effective for several decades until the first major renovation cycle is due. Thus, **upgrading (path B) is urgently needed.**

On the other hand, the **high and the middle segments have grown by a factor of 4 to 5 within one year** from about 1,5 and 3% to 7 and 14 % respectively. The growth of these segments demonstrates that **attractive funding conditions can vigorously stimulate "eco-growth" (path A) and "enlarging the middle" (path C)** raising the joint market share above 20%.

Nevertheless, the share of 20% still is far away from the whole market. Moreover, it appears paradoxical that the tax payer should fund building improvements, which to a large extent are economic anyway. Thus, driving path B - e.g. by upgrading regulations - is of central importance and corresponding deliberations (cf. section 5.3.2) should be vigorously promoted. Thereby, the **passive house standard should be a near rather than a long term goal**, as all the technology is available. **Freed funds should then be used to stimulate an "eco-plus" path (E) towards a 20kW/M^{2}a-level**.

Finally - though net new housing rates have dropped to about 200 000 units p.a. - the net increase has not stopped yet. Thus, **path F "sustainable shrinking" should be continued in parallel** until a sustainable balance between the abolition of old houses and the erection of new houses has been achieved. Actually, in 2007 a further reduction can be expected due to the cancellation of the "Eigenheimzulage" (cf. Statistisches Bundesamt 2007b).

5.4.3 Old Housing

As indicated in section 5.4.1, the net present value of current annual energy consumption in the building stock amounts to about 1,5 trillion or 450 /m^2, which signals an enormous potential and chance for expanding corresponding retrofit niches towards mass-markets. A factor of 10 energy reduction accordingly corresponds to a net value of the order of 400 /m^2 - which increases, if non-energetic or external cost benefits are added (cf. also Jochem 2005).

Basics:

A **comparison of the real retrofit market to the theoretical market minimum** implied by regulative requirements can be drawn in a similar fashion as for the new housing market (see Fig. 35). Thereby, a market share of 100% is defined by the average number of housing units ready for a major retrofit, which - on the basis of 40 million housing units and an average renovation cycle of 40 years[107] (or 2.5% p.a.) - amounts to about 1 million housing units p.a. The average regulative minimum according to the Energy Saving Ordinance EnEV is about 40% less demanding than for new buildings and corresponds to an average primary energy intensity PE ~ 140 kWh/M^{2}a (see dashed line).

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[107] Kleeman and Hansen have derived such a rate for the German housing stock, pointing out that this cycle might extend towards 50 years in the future.

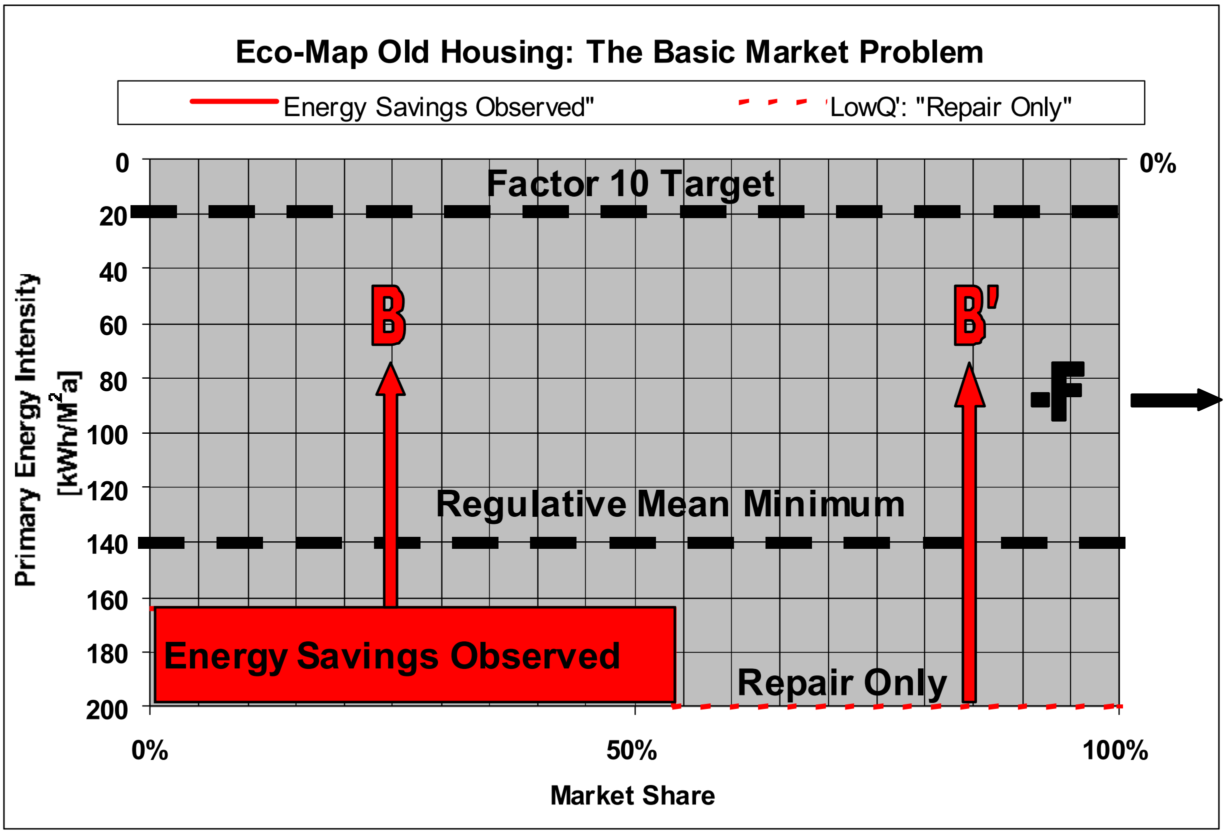

Figure 35: Old Housing Measures Miss Rules and Sustainability Targets

Kleemann and Hansen (2005) found (see in Fig. 35) that the **real retrofit market** (red rectangle) **misses the theoretical minimum** (grey rectangle below regulative minimum line) **by almost 70%** (68%), as almost half (44%) of the buildings ready for major renovation were “repaired only” (see red dashed line), whereas energetically renovated ones only realized 59% savings required by the rules. Moreover, considering that - due to long-lasting neglect of renovation measures - the real annual market could and should be much larger and that economically achievable target values currently range between the new housing (100 kWh/M^{2}a) and KfW40 (40 kWh/M^{2}a) level, it **can be concluded that the market failure amounts to more than 90%,** whereby sub-optimum measures block eco-efficient repairs for decades. This means that we have to drastically push average energy measures above the current regulative minimum **(path B),** similarly convert “repairs only” into effective “repair and sustainable energy saving measures” **(path B’)** and finally expand the current retrofit market in order to dissolve the current renovation backlog **(path –F, sustainable growth).**

Expanding Niche Markets:

As outlined in section 5.3.2, the German government significantly expanded the federal housing programme in 2006. The corresponding loan and allowance allocations to the KfW refurbishment programme rose by a factor of 3. The author estimates that the equivalent market penetration of the corresponding KfW high and middle quality measures has risen from about 5 to roughly 15%[108]. In 2007, a major restructuring of the old housing refurbishment programme took place. The following discussion reflects the new situation, giving a first sketch of the arising market segments and trends.

Accordingly, the following idealized funding segments can be distinguished:

HighQ: PE ~ 70 kWh/M^{2}a (KfW: EnEV new housing level – 30%),[109]

MidQ: PE ~ 100 kWh/M^{2}a (KfW: EnEV new housing level),

MidQ': PE ~ 140 kWh/M^{2}a (KfW: component bundles ➔ ca. new housing + 40%).[110]

In addition (see above, Fig. 35) there will be the market segments:

LowQ: PE ~ 170 kWh/M^{2}a (low level energy savings),

LowQ': PE ~ 200 kWh/M^{2}a (no energy savings, repairs only).

Fig. 36 shows the corresponding eco-map including the market potential, which can be gained, when extending the annual renovation rate from 2,5 to 4%. Annual market shares have been derived from semiannual KfW-figures by linear extrapolation. Thus, the picture only is a rough one with similar caveats as for the new housing maps[104].

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[108] Estimates have been derived from data provided by KfW (KfW 2007a, b). Here and in the following component bundles have been counted as one measure, cf. [110].

[109] In addition "EnEV PE-Level new housing – 50%" was introduced by April 1st as a special programme. The segment, however, is new and still negligibly small.

[110] The bundles require the selection of 3 to 4 out of 5 to 6 measures. In lack of precise data the author estimates that they fall short of a full scale modernization to the EnEV new housing level by about 40%, which is equivalent to reaching the EnEV PE-level for major old housing retrofits.

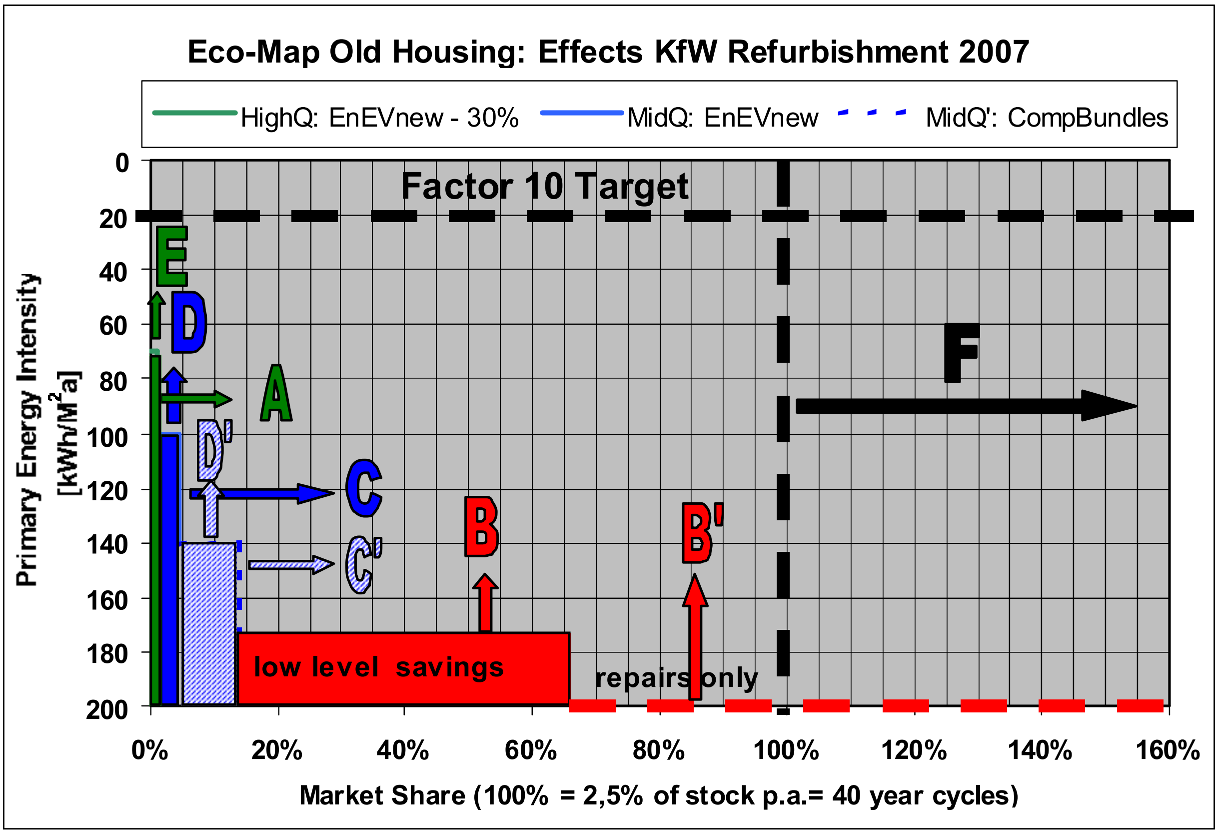

Figure 36: Market Eco-Map for Energy Efficient Old Housing

As Fig. 36 indicates, even with the new funding programme, the **low quality segments dominate the market by more than 80 % to 90%** depending on the assumptions with respect to the overall market size. Even for moderate market assumptions **middle and high quality retrofits only reach a share of about 15%.** More specifically:

1. Less than 1% reach the EnEV new housing level - 30% (High Q),
2. Less than 5% reach the new housing level (MidQ),
3. Less than 10% reach the new housing level - 40% (MidQ').

The role of high quality retrofits (1%) is still marginal – though the level considered here is still a factor of 3 off the ultimate sustainability target.

In order to prioritize possible strategies (paths A to F in Fig. 36), it is helpful to develop an **idealized annual target map** and a guiding vision (see Fig. 37), which would lead to a factor 10 reduction by 2050.

The key thoughts behind the target map are:

- There are about 40 years left, thus a modernization rate of 2.5% p.a. is required on average at least, whereby a target level of 20 kWh/M^{2}a has to be reached. This means that each year a map area equivalent to (200kWh/M^{2}a – 20kWh/M^{2}a)*100% has to be filled on average.

- In practice full, partial and component renovations have to be considered, as well as different modernization rates implied by different life-times of basic components such as walls, windows and heating devices. This implies reduced energy savings per modernization. Hence, if the sustainability target is to be reached by 2050, the overall annual modernization rate and "market" has to be increased.

The target map in Fig. 37 reflects these thoughts as follows:

- The overall market is extended to 200% or 2 million houses p.a. – which means that each house is touched every 20 years. This appears realistic and feasible, especially if major modernizations of individual components (e.g. heating systems!) are explicitly included.
- It is assumed that about a quarter are fully modernized in one step to the sustainability target, a half gets "semi-renovated" (i.e. needing 2 steps for a full renovation), while another quarter is only "component-renovated", i.e. only a critical component (e.g. the heating system) is modernized.

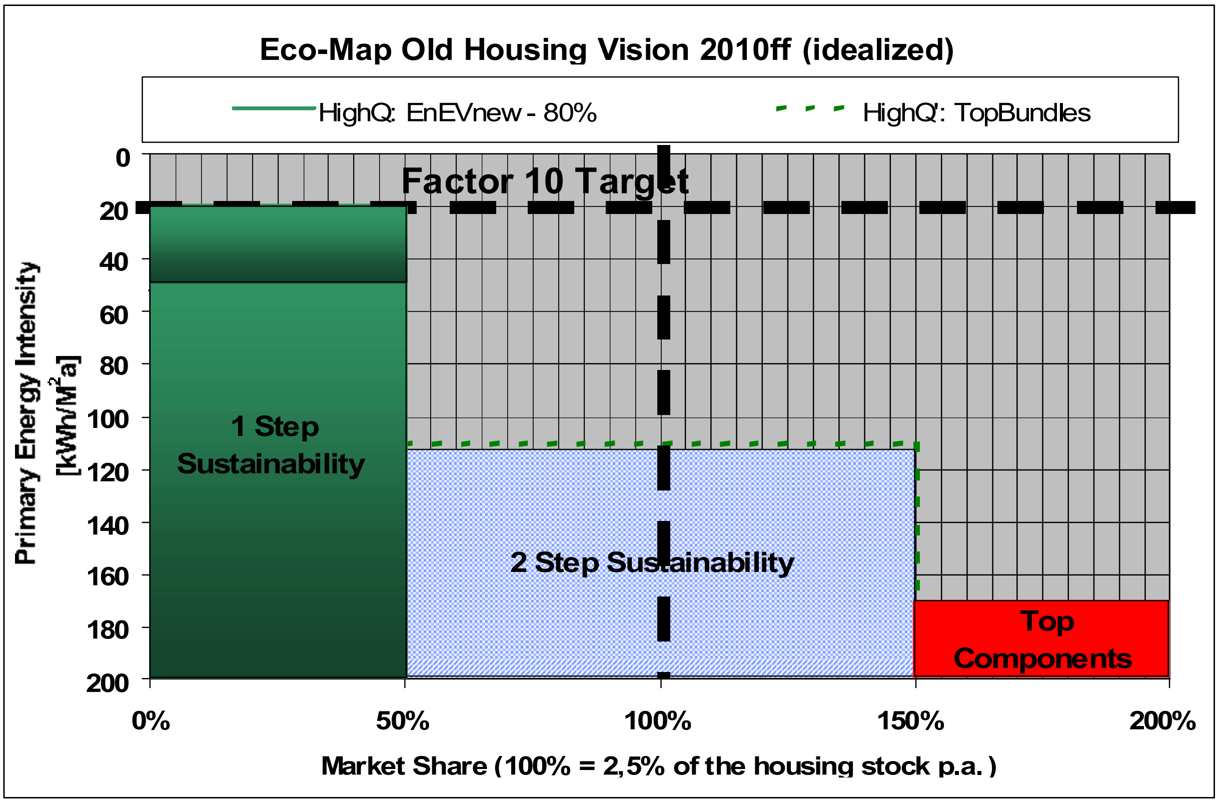

Figure 37: Target Map Old Housing (Vision, Simplified, Idealized)

Apparently, theses measures save a little more than required (red area of top components). In practice, however, full scale modernizations may fall short of the 20 kWh/M^{2}a target in the beginning (e.g. by starting with a more conventional heating system – indicated by shading intersecting the green rectangle). Thus, the "red reserve" makes up for this potential "green shortcoming.“

With this target map in mind, we arrive at the following **idealized strategies** (cf. Fig. 36)

a. **Towards sustainable 1-step modernization**: **Path E (eco-plus)** has to be pushed in order to achieve the 20 kWh/M^{2}a-level demanded by the factor 10 requirement, whereby target levels of 40 kWh/M^{2}a are proven by pilot projects, while higher levels need further R&D and piloting. **Path A (eco-growth)** is needed for a dramatic increase of market share towards 50% or 500 000 units p.a. or 1.25% of the building stock.

b. **Towards sustainable 2- (or multi-) step modernization (component bundles): Path D’** has to improve current quality levels of major partial renovations in such a way that overall sustainability target can be reached, whereby 2 major steps should be sufficient in most cases. This usually implies that a component should reach the final sustainability level, if touched. Considering market expansion, **Path C’** has to secure a market share which to a first order approximation is twice as large as the gap left by the 1-step modernizations, i.e. 1 million units p.a. or 2.5% of the building stock.

c. **Towards top components: Paths B and B’** have to be followed on a component basis. This holds especially for **short-lived components as heating devices,** but also for components, with major innovation/cost reduction potential. Examples of the latter include combined ventilation/heat supply units and windows. Still, careful planning is necessary, as it may be cheaper to integrate a more expensive component now, than expensively integrate a cheaper component later.

It should be considered that the inclusion of different complex modernization types in one eco-map necessitates a **stretching of the eco-map concept and change of its interpretation**. Here

Top-quality levels are expected/striven for in all segments.

- Market shares of different offerings are accumulated on one x-Axis.
- The y-axis indicates quality levels reached, when applying a set of measures of the respective segment to an average building of the building stock.

Note also that the **middle quality full-scale modernization** segment has been discarded as it **appears neither sustainable nor economic**. Besides raising the entry levels for funding it can therefore be recommended to make the **funding mechanism open-ended so that all savings above minimum threshold are rewarded.** This is currently not the case, stimulating “edge optimization”, where an investors just goes so far as to get the funding neglecting any further reaching efficiency potentials.

5.5 Summary and Implications

Regarding the **market sphere** the findings can be summerized as follows:

The German housing market has been dominated by small and medium sized market players and conservative forces. Thus, **the promotion of energy efficient sustainable housing was triggered by industrial research and pioneers outside the traditional building market,** whereby pioneering "Davids" opened a market niche for highly energy efficient passive houses in the nineties.

Big players or "Goliaths" are rare. Their business interests are diverse. Promotion of energy efficient sustainable housing is limited.

Strong forces can be observed at the customers interface, where large cities and their associated building companies - infected by the Davids - have adopted the passive house standard **creating a force-full market pull** and a strong signal to the public sphere.

In the **public sphere**,

the role of the mass media in the transformation of ecological pressure into ecological claims for energy efficient sustainable housing **is a rather ambiguous one.** With a focus on dissence and emotions, a **distorted picture of action necessities has been furthered** for a long time.

- Energy efficiency has been mainly promoted by **engaged pioneers and scientists** with NPOs and associated information networks working as a multiplier. The privately driven **passive house conference** has evolved as one of the key information providers with growing influence upon the market and the political sphere far beyond Germany.

As far as **politics** is concerned,

- Political support has been essential for the promotion of energy efficient sustainable housing since the first oil crisis. However, **perceived as a low-interest subject** and **scattered** over several governmental bodies and sub-national levels, **the subject did not get the attention it deserved** so that the deployment of political instruments remained highly deficient.
- **Only recently**, embedded into a new wave of global concern and negotiation, **major political steps have been initiated in Germany**. Financial funds for energy efficient housing and building have been quadrupled, while efficiency campaigns have been pushed via the relatively new German Energy Agency DENA. Regulative instruments are under revision and **a new energy and climate programme has been announced.**

Though positive effects promoting energy efficient sustainable housing can be expected, closer inspection shows that **current trends still seriously miss sustainable development.**

- **In new housing market** 2005/2006 the high and the middle efficiency segments have grown by a factor of 4 to 5 within one year to about 7% and 14 % respectively. This demonstrates that attractive funding conditions can substantially stimulate "eco-growth" and "enlarging the middle". However, **the annual market share of the high efficiency segment is still below 10% , while the quality level is still a factor of 2 below the sustainability target.**

- The **old housing market** – though more complex – shows a similar picture on a reduced quality scale. Higher and middle quality modernization are estimated to reach about 15% in 2006/2007. Yet, **the role of high quality retrofits (1%) is still marginal – though the top quality level considered here is still a factor of 3 away from the ultimate sustainability target.**

Thus,

- there is **not only an order of magnitude difference** between the current efficiency **status and final targets**,
- but also between the **current and required rate of change.**

Considering that **the net present value of energy consumption** adds up to **a quarter of the market value of the German housing stock** of about 6 trillion , this **signals an extraordinary economic potential,** which should be exploited with a triple win for environment, economy and society**. Hence, further drastic improvements are necessary:**

- **In the new housing market** – in spite of some positive funding effects - it appears irrational that the tax payer should fund building improvements, which to a considerable extent are economic anyway. Thus, an ambitious, determined **tightening of regulations should get top priority**, whereby a merged passive house/KfW 40- Standard should be realized as a short time goal. **Freed funds should then be used to stimulate an "eco-plus" path towards a 20kW/M^{2}a-level.**

In the old housing market, full-scale, partial and component modernizations have to be promoted in parallel, whereby sustainability could be reached as follows:

- 1-step modernizations 500 000 units p.a. or 1.25% of the building stock,
- 2-step modernizations 1 Millionen units p.a. or 2.5% of the building stock,
- component modernizations 500 000 measures p.a.

Thereby, target **quality** levels should be largely **consistent with the passive house standard,** whereby primary energy use should be further lowered by intensified use of renewables. On the other hand, "hopeless" buildings have to be taken from the market (Eichner 2007).

According to the more complex situation in the old housing segment, energy-efficient sustainable retrofit requires a particularly fine-tuned instrument-mix.

While **regulative measures** and compliance control should be tightened as well,

flanking by effective market and public sphere measures is of special importance.

In particular - following the example of Frankfurt - political actors should **create strong market pull** as orderer, rule and trend-setter directly or indirectly as partial owner of building companies.

Consistent political behaviour and good examples should then be used as a basis **for trustworthy, convincing information & marketing campaigns** stimulating the public and private housing market and creating a positive market climate for innovators and new business.

Financial incentives should focus on **sustainable efficiency levels** far beyond current minimum standards and buffer temporary social conflicts or potential capital shortage.

Finally, in parallel to tightening regulations**, regulations should be streamlined and freed from obstacles** impeding energy efficiency.

6 PROMOTION IN EUROPE

Europe comprises 46 countries with about 700 million inhabitants, whereby 500 million or 70% of the people live in the European Union "EU-27." In the following we shall focus on the EU and the promotion of highly energy efficient passive housing in particular[111].

6.1 Political Boundary Conditions & Strategies – The EU-27

The EU **institutions** include the European Commission (EC – formally the Commission of the European Communities CEC), the Council of the European Union (CEU) and the European Parliament (EP). Here the EC acts as an executive body, whereas CEU and EP jointly share into legislative power. The heads of the 27 governments meet 4 times a year in the so-called European Council in order to coordinate political vision and action. Energy specific issues are handled by corresponding sub bodies, namely directorate TREN of the EC and the Committee on Industry Research & Energy of the CEU[112].

The EU supplies a political framework to be filled in by national and cooperative actions, whereby **energy policy** is strongly determined by national interests. However, the growing dependency on external energy sources, as well as the awareness that challenges like global warming can only be solved together strengthened cooperation between the nations [113].

The **political cornerstones** are summarized in Box 8. **Green papers, road maps and action plans** outline visions, goals, paths and steps. Formalization occurs via so-called **directives,** which **define the legal framework** to be implemented nationally. Besides, the EU runs a number of **support and research programmes** stimulating community research, innovation and education. Though the financial volume is limited, they stimulate the promotion of advanced energy efficient housing concepts across Europe (see section 6.2 and 6.3). Note that renewables (EC 2007a) and efficiency often are "treated in one basket", whereby **efficiency** only recently increased its relative weight (cf. green paper on sustainable energy, EC 2006a).

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[111] For general trends of the building market cf. Heinze 2007, Rußig 2007

[112] The CEU (institutional meeting of ministers) should not be confused with the European Council (European summit meetings of the heads of state) and the older "Council of Europe", which has acted as much looser European body also enclosing the Non-EU countries since 1949. The CEU meets in different configurations, whereby energy affairs are handled in the formation "Transport, Telecommunications and Energy." Further details can be found a.o. under the internet portal of the EU http://europa.eu/.

[113] This was demonstrated at the G8-summit in Heiligendamm (see section 1.1.1), which was strongly driven by the joint vision and pressure of the EU-27.

EU Political Cornerstones Energy Efficiency and Renewables

- EU green papers outline goals and strategies:
  - Security energy supply 2000
  - Energy efficiency 2005
  - Sustainable energy 2006
- EU action plans and road maps refine green papers:
  - Action plan energy efficiency 2006 (reaching from 2007 to 2012)
  - Road map renewable energy 2007
- EU-directives define legal framework to be implemented nationally:
  - Energy performance of buildings 2002 (to be implemented 2006 – 2009) on calculation, performance, labelling standards; energy pass port
  - Energy using products on performance & labelling standards
  - End energy use 2006
  - Renewable electricity, fuels
  - Renewable heat (in preparation)
- EU- programmes stimulate research, innovation, education:
  - 1984 – 2006 five framework and Joule-Thermie programme
  - 2007 - 2013 7th Framework programme with > 1175 Million for renewables & end-use efficiency
  - Programme Intelligent Energy Europe (2007 – 20013) 700 mill.

Box 8: EU Political Cornerstomes Energy Efficiency and Renewables[114]

Based on the Green Paper on Energy Efficiency (EC 2005), the **Action Plan 2006 is the most recent and specific EU strategy paper on energy efficiency** (EC 2006b). The purpose is “to mobilise the general public, policy-makers and market actors, and **to transform the internal energy market in a way that provides EU citizens with the most energy-efficient infrastructure (including buildings),** products (including appliances and cars), and energy systems **in the world.”** More specifically, the objective of the action plan is “to control and reduce energy demand and to take targeted action on consumption and supply in order to save 20% of annual consumption of primary energy by 2020 (compared to the energy consumption forecasts for 2020).” This corresponds to achieving approximately a 1.5% saving per year up to 2020.

Though this is below what is required for factor 10 strategies[115], it is a step into the right direction. Most noteworthy, the action plan places a very **high priority on the very low energy buildings** making this issue the “priority action 2” of the top-ten-list (see Box 9, EC 2006b:12).

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[114] Sources: portals of the EU http://europa.eu/ of the EC http://ec.europa.eu/ with sub-portal http://ec.europa.eu/energy/, EU energy portal http://www.energy.eu/ (last access October 2007)

[115] Considering CO_2-emissions in 2050, the EU currently only targets at 60 to 80% reduction with respect to 1990. The 2020 target has recently been tightened from 20 to 30% under the provision that other developed countries and advanced developing countries join in with adequate comparable efforts (see CEU 2007)

“Priority Action 2
Building performance requirements and very low energy buildings ("passive houses")
The Commission will propose expanding the scope of the Energy Performance of Buildings Directive substantially in 2009, after its complete implementation. It will also propose EU minimum performance requirements for new and renovated buildings (kWh/m²). For new buildings, the Commission will also by the end of 2008 develop a strategy for very low energy or passive houses[116] in dialogue with Member States and key stakeholders towards more wide-spread deployment of these houses by 2015. The Commission will set a good example by leading the way, as far as its own buildings are concerned.”

Box 9: Action Plan Energy Efficiency – High Priority for Passive Houses

Note that **the action plan explicitly points to “passive houses”**, the necessity of updating corresponding EU-directives and minimum standards for new and old buildings in the EU.

6.2 Triggering Passive Houses in Europe

As for passive houses, already in 1998 first trans-national project called “CEPHEUS” was started under the umbrella of the European Joule-Thermie programme (cf. Fig. 38; Schnieders et al. 2001). CEPHEUS stands for **“Cost effective Passive Houses as European Standard”.** It features the erection and scientific evaluation of about 250 passive housing units in **5 European countries** creating the preconditions for further market penetration. As indicated in Fig. 38, a broad spectrum of building types and locations was involved. Central results were presented on the world Exposition EXPO 2000 in Hannover, where a whole settlement of highly energy and cost-efficient passive houses was erected[117] presenting a full primary-energy and climate- neutral approach by inclusion of renewable energies. This also showed how the passive house concept can be successfully extended to include zero-energy approaches under less favourable Mid-European climate conditions. In summary, the project laid the basis for a European passive house standard and triggered the promotion in Europe.

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[116] “Passive house are commonly defined as houses without traditional heating systems and without active cooling. This would involve very good insulation levels, and a mechanical ventilation system with highly efficient heat recovery. They can also be called: zero-energy houses, houses without heating.”

[117] by “David” Rasch & Partner, see also section 3.2.2;

CEPHEUS Cost Effective Passive Houses as European Standard
1998 - 2001

- First European Research & Development Project, sponsored by the EU-Joule-Thermie Program
- Erection and Scientific Evaluation of about 250 passive houses/living units
- Demonstrating cost-effective passive houses in 5 European countries
- Creating preconditions for market penetration
- Presenting full primary-energy and climate neutral approach combined with use of renewable at the World EXPO 2000

Figure 38: CEPHEUS: Cost Effective Passive Houses as a European Standard[118]

In the sequel of CEPHEUS further passive house projects and promotion activities were initiated (EC-IEEA 2006). Currently three projects PEP (cf. section 6.3), PASSIVE-ON (cf. section 6.4) and E-Retrofit-Kit are carried out under the umbrella of the Programme “Intelligent Energy Europe”[119]. Further projects are under negotiation (EC-IEEA n. d.). E-Retrofit-Kit aims at the development of tools for passive house retrofitting in support of social housing companies, architects and others interested parties. PEP and PASSIVE-ON target at the promotion of passive houses in different European regions as discussed in the subsequent sections and respectively.

6.3 Promotion of Passive Houses in North and Central Europe

The general objective of **PEP (Promotion of European Passive Houses)** is the “Promotion of the Passivhaus concept and dissemination of experiences with the CEPHEUS project” (EC-IEEA 2006:37) with a **focus on north and central Europe**. The project showed that – in spite of different energy supply structures, construction preferences and climates – primary energy use for space heating can be drastically cut down in all 9 participating countries (Fig. 39, Kaan et al. 2006:303, Joosten et al. 2006:12).

The most frequent hindrances in the participating countries were found to be (Kaan et al. 2006):

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[118] picture Energieinstitut Vorarlberg (n. d.) and http://www.cepheus.de/Kurzberichte/Kurzbericht-PI22.html

[119] Respective home pages: www.europeanpassivehouses.org, www.passive-on.org, www.e-retrofit-kit.eu, http://ec.europa.eu/energy/intelligent/index_en.html.

a. Limited availability of advanced windows
b. Limited know-how
c. Limited knowledge among builders
d. Limited acceptance of passive houses in the market

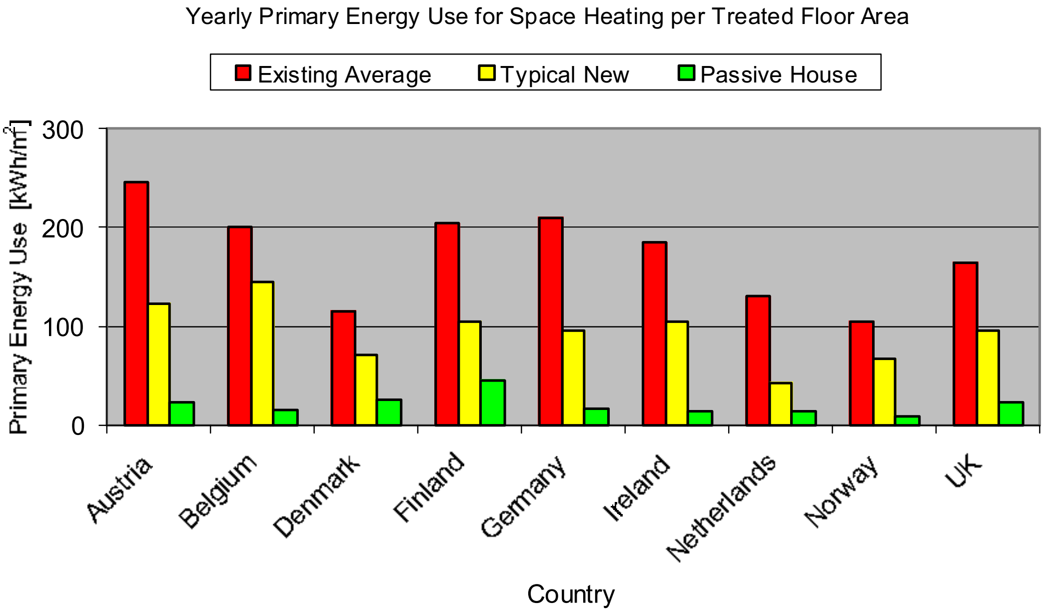

Figure 39: Passive House Performance in North and Central Europe (Kaan et al. 2006)

PEP mainly targets at alleviating b, c and d by the development of information packages and design tools for passive houses, the set up of an international passive house website and the organization of workshops, symposia and conferences. Corresponding general and national information packages for the nine countries are already available on the project home page (cf. www.europeanpassivehouses.org). The end of the project is scheduled for Dec. 2007.

Looking at **northern European** countries**, the interest in passive houses has particularly increased in Norway** (i.e. a non-EU member), where the first passive house was built in 2005 (Andresen et al. 2007). While Scandinavian know-how and building practice influenced R&D in Germany in the seventies and eighties (see section 3.1 and 3.2), corresponding knowledge and highly energy efficient techniques are now being “re-imported.“ According to Andresen (ibid:147), more than 15 projects with more than 1000 passive house dwelling units are currently in the planning phase. Extra investment costs reach from 0 to 10%, whereby lack of high-efficient ventilation aggregates and standardized planning/construction techniques still inflict extra time and effort.

Looking **at central Europe, Austria has been excelling.** In fact, Austria currently is showing the **highest growth rates for passive houses worldwide** (Fig. 40).

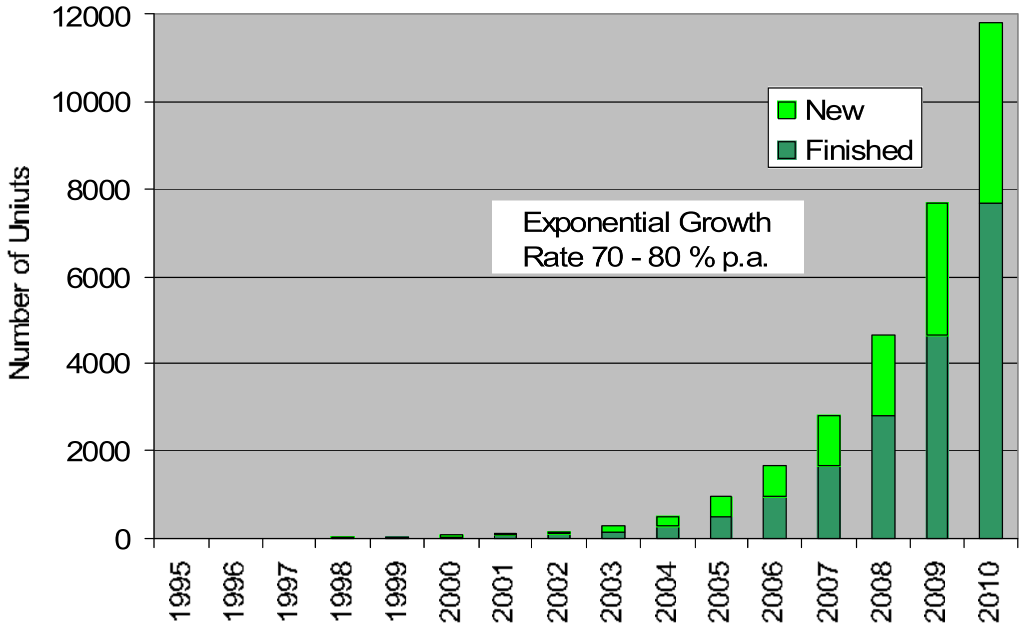

Figure 40: Exponential Growth of Passive Houses in Austria (Lang 2007)

Starting with a time lag of about 3 to 5 years, Austria has passed Germany not only with respect to speed, but also with respect to accumulated passive house density (Krapmeier 2007). Thereby, the **Energieinstitut Vorarlberg** - inspired by the work in Germany and stimulated by IWU and PHI - acted as one of the main drivers. After erection of the first Austrian passive house in Vorarlberg in 1996, the Energieinstitut Vorarberg coordinated and promoted the CEPHEUS in Austria. As a result, passive houses were introduced in 4 of the 9 Austrian states. After the end of CEPEHUS in 2001 **passive house interest groups** were founded in Vorarlberg and other Austria states, as well as on the national level **interconnecting interested public and market actors. Funding programmes for passive houses were initiated in 7 states**, which had a marked influence on the number of passive houses erected. Since the beginning of 2007, public utility housing enterprises (“gemeinnützige Wohnbauträger”) have been required to reach the passive house standard in order to get public funding. According to Lang 2007:420 this led to a real **passive house boom in Vorarlberg**.

Nevertheless, the market share of new passive houses in Austria still is below 5% in 2006/07, while the market share of advanced retrofits probably is even smaller. Relatively high transaction and information costs and lack of professional qualification still are considered to be major hindrances (Köppl 2007:38). The securing of favourable political boundary conditions and corresponding incentives are seen as a central requirement for the broad application of energy efficient sustainable passive housing technology (Köppl 2007:39). Government officials announced (see Pröll 2007:21) that **in Austria the passive house standard will become the general norm for new buildings.**

This way **Austria sets an example how innovation can be accelerated by collaboration between the public, market and political sphere**.

6.4 Promotion in Southern Europe

Considering its proximity to Austria, it is not astonishing that the first successful promotion of the **passive house concept south of the Alps occurred in Italy**, namely in South Tyrol (Troi & Sparber 2007). While the first passive house was erected in 1998, 30 passive houses – including multi-family, as well as office buildings – had been built in South Tyrol until 2006, reaching a regional annual market share of 12% (or nearly 20% for residential buildings). The **certification** programme KlimaHaus/CasaClima **combined with agenda setting, issue management**, **education, trained planners and companies** are considered to be key success factors (Franzelin 2007). Several passive house initiatives promote the "casa passiva".

The **goal of PASSIVE-ON** (EC-IEEA 2006:35) is to **promote the development of passive homes in southern Europe as a whole** by providing

- recommendation for passive house standards in Mediterranean countries
- strategies for political decision-makers and public institutions on the European, national and local level
- design guidelines for architects
- software design tools in particular for Italy, Spain, Portugal and France.

Thereby the positive experiences from existing passive homes in central Europe shall be exploited and adapted to the specific conditions in southern Europe. Although the project has not been completed, the following **preliminary conclusions** can be drawn (cf. EC-IEEA 2006:36 and www.passive-on.org):

- The **passive house concept can provide conformable low energy homes in large parts of southern Europe, whereby the milder climate allows simpler and less expensive solutions.** Thereby, precautions with respect to summer heat gains are essential (e.g. window shading, night time ventilation).
- Relatively **simple guidelines and calculation procedures** can direct the choice of solutions at the crucial early design stage, **especially for heating. Low energy cooling design often requires more complex dynamic calculations.**

These issues are specifically addressed in the new planning package PHPP (Feist 2007c).

6.5 Main Implications

The main findings of this chapter can be summerized as follows:

Highly energy efficient buildings as exemplified by passive houses appear feasible in all parts of Europe offering a high level of comfort and important benefits along all three sustainability dimensions.

CEPHEUS and follow-up projects have effectively triggered the spread of the passive house concept in Europe demonstrating the **importance of collaboration and political support on the European level.**

- The high growth rates in Vorarlberg and Austria show **how multi-level collaboration of actors in the public, market and political sphere can stimulate the expansion of niche markets,** whereby Vorarlberg acted as a key “domino” triggering actions all over Austria. Here political support with a fine-tuned set of instruments appeared essential on a regional and national level as well.

In spite of high growth rates in some regions, highly energy efficient sustainable buildings still form a niche in Europe. The Commission of the European Union has recognized the chances and taken steps to promote energy efficient sustainable buildings. In particular, the **EC has declared the wide-spread deployment of passive houses by 2015 as a top priority strategic goal. Now a constructive answer of the member states is needed to realize the target cooperatively.**

7 NORTH AMERICA AND THE US

7.1 General Background

North America comprises up to 40 countries with about 500 million inhabitants[120]. 60% live in the US (300 million), 20% in Mexico (100 million) and 6% Canada (30 million). Thereby the US is responsible for about 85% energy related carbon dioxide emissions (about 6 000 million tons p.a. or 20 tons p.c. and p.a.), followed by Canada (about 600 million tons p.a.or 20 tons p.c. p.a.) and Mexico (about 400 million tons p.a. or 4 tons p.c. p.a.)[121]. In the following we shall **focus on Northern America and the US** in particular.

As indicated in section 1.3, about **40% of the primary energy consumption and carbon dioxide emissions in the US are caused by buildings,** whereby residential buildings and heating are the main sources (cf. Hendron 2004, US DOE 2006). Though the heating requirement shows a strong dependency on climate, total energy consumption per household and capita is almost climate independent (Hendron 2004; EIA 1999). This phenomenen currently is only partially understood. One reason is given by anti-correlating cooling demand, which however, is a factor of 4 below heating demand on the average. In effect other energy usages – including miscellaneous household appliances – increase with mean ambient temperature and help to neutralize the effects of reduced heating demand (Hendron 2004).

Similar to Germany and Europe, the **first oil crisis in 1973 marked a decisive turning point in the US energy policy and created high public awareness.** Intensive research on alternative energy sources, as well as the efficient use of energy was started with strong public funding and support. Due to favourable insolation levels, in many locations so-called passive solar buildings received particular attention, but energy efficient super-insulated buildings were studied, as well (cf. Balcomb et al. 1977). In parallel, computer-based simulation models were developed and prepared as a basis for performance based national building codes (cf. references in Hörster et al. 1980).

The election of **Ronald Reagon as president in 1981, however, introduced a serious change in national US energy policy, which has been targeted at minimum political intervention ever since** (see section 7.2). Research funds where radically reduced and plans for national building codes rigorously stopped[122]. Energy efficiency was largely left to the "free market", where, however, declining energy prices (cf. Appendix, Fig. 44) reduced the pressure for action. Supported by rising oil prices since 2000 and a growing international pressure with respect to global warming, however, **"green forces" gained strength again**

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[120] The notions "North America'" and "Northern America" are used with some variation. Here, North America includes the region north of the isthmus of Panama, whereas Northern America starts north of Mexico.

[121] US EIA 2005. Note: overall emissions, which include non-energetic parts and other green house gases usually are somewhat higher.

[122] Here LBL Lawrence Berkeley Laboratory (dpt. A. Rosenfeld) had a leading position and was severely hit - personal communications A. Rosenfeld & R. Sonderegger 1980/81, 2007

so that energy efficiency in general and energy efficient housing in particular received increasing attention in the last few years. Al Gore’s film “an inconvienient truth”[123] aroused the public. The climate summit 2007 signal a political change[124] .

7.2 Political Sphere

In the US **the president with his advisory body** is the key political force on the national level[125]. He directly controls the guidelines for national energy policy, which is characterized by a lack of regulative, informative and financial energy efficiency measures. This shows up in the **strategies and budgets of the governmental departments** for housing (HUD) and energy (DOE), which share the responsibility for energy efficient sustainable housing. The **HUD Strategic Plan** FY2006 – FY2011 (US HUD 2006) names 6 strategic goals and 27 subgoals without making any reference to the “energy” problem. In **the budget document** the word “energy” is totally absent.

Considering the **DOE Strategic Plan** (US DOE 2003), which “charts the course for the next 25 years” (ibid:secretary’s message), energy is only found to be one of four strategic goals, namely “to protect our national and economic security by promoting a diverse supply and delivery of reliable, affordable, and environmentally sound energy” (ibid:3)[126]. While the DOE budget 2008 adds up to about 24.000 million $, 2/3 are spent on Atomic Energy Defense Activities and only 1/3 on Energy Programs (US DOE 2007a). **1200 million $ or 5% of the budget are attributed to Energy Efficiency and Renewable Energies (“EERE”) and less than 300 million $ (or 1 $ p.a. p.c.) to energy in buildings.** Analyzing this share, it turns out that 220 million $ or 0.7 $ p.a. p.c., are allocated for “Weatherization and Intergovernmental Activities” including assistance and grants for low-income households, whereas **just 80 million $ or 0.3% of the DOE-budget (equivalent to 0.3 $ p.a. p.c) are spent for advanced energy efficient “Building Technologies BT”.**

The core **vision of the Building Technology Program is “the realization of marketable net-zero-energy buildings** through the development of conservation technologies and practices” (US DOE 2007b:1-6) with 60 to 70 percent energy reduction with respect to conventional practice as an “efficiency” target (ibid:1-8). This means (cf. 3.4) that individual **net-zero-energy buildings may still produce large amounts of carbon dioxide** - unless energy efficiency is driven beyond the target assumed in the programme. The programme focuses on precompetitive public-private partnerships with DOE assuming an integrating role facilitating the transfer of component research into best construction practices.

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[123] USA 2006, www.climatecrisis.net (official home page film, last access Nov. 10, 2007)

[124] Cf. Also section 5.3.1 and Kleine-Brockhoff 2007.

[125] The president is legally controlled by Congress, which acts as the top legislative body. Since the democrats gained the majority of seats in 2006, however, the president’s action space and power has been significantly reduced. Note that the individual government departments are less powerful than their German counterparts.

[126] … whereby the other goals deal with defense, science and the clean-up of nuclear waste and environmental legacies of cold war. Note that DOE was founded in the sequel of the first oil crisis with an initial emphasis on energy development including energy-efficient housing. With Reagon nuclear weapons gained priority.

While the horizon of the vision is the year 2025, earlier milestones are set for the demonstration of prototypes[127].

Regarding **financial incentives**, energy policy focusses on the supply side including the **promotion of renewable energies** (see e.g. US White House 2006). The federal energy policy act 2005 (US Congress 2005, Baden et al. 2006) also provides **tax breaks for conservation and energy efficiency in houses** amounting to about 1,3 billion US $ (i.e. 4$ p.c.).

The political key instrument of regulation is used in a very restricted way. The federal government has defensively bounded its role to "protecting consumers from products that consume uneconomical amounts of energy or bring about undue environmental degradation as a result of their use" whereby this task is further **limited to equipment** under the authority of the Energy Policy and Conservation Act of 1975 (US DOE 2007b:1-5).

The regulatory abstinence on the federal level is only partially compensated by regulatory measures on the sub-national level. The measures strongly differ statewise, which is also a problem for the building industry, which is confronted with a **fragmented regulatory landscape** (see Fig. 41). In some states (e.g. California) advanced codes are employed, while they are completely missing in other states (e.g. Wyoming).

As for **climate protection**, some strong initatives have evolved on the sub-national level. In 2005 **US Conference of Mayors' Climate Protection Agreement** was set up, which meanwhile has been signed by more than 500 Mayors (US Conference of Mayors 2007). In 2006 California issued a **Global Warming Solutions Act** with requirements reflecting the Kyoto protocol (US State of California 2006). Thus, in spite of long-time abstinence on the federal level, the green movement has received more and more political support on the levels below.

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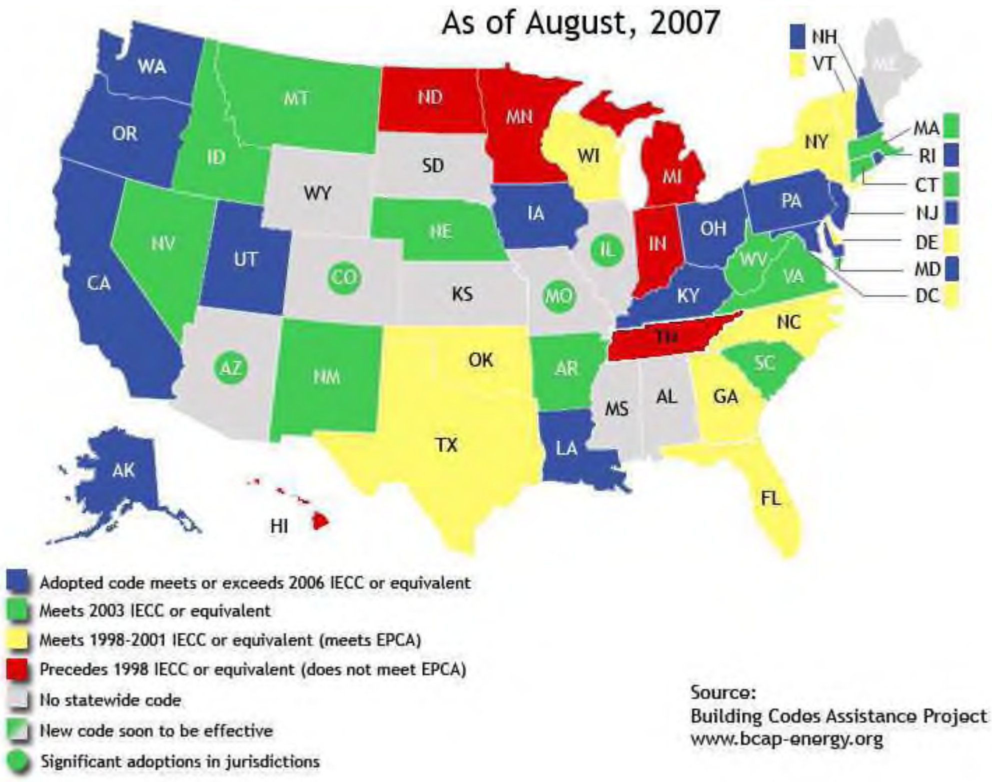
[127] … In parallel to R&D, DOE-BT works on equipment standards, technology validation and market introduction in collaboration with the environmental protection agency EPA. Different from the German environmental agengy UBA, EPA acts under direct control of the president. EPA promotes the "ENERGY STAR" for buildings. However, this label only aims at energy reductions of about 15 - 30% with respect to current standards and practice.



Source:
Building Codes Assistance Project
www.bcap-energy.org

Figure 41: Landscape of Residential State Energy Codes in the US (BCAP-energy.org)

7.3 Market and Public Sphere

The American housing market with about 125 million homes in the US is **dominated by the single-family dwellings** with a share of about 75%. Multi-family homes only account for about 20% of the market, while mobile homes make up the rest of about 5%. Most of the single-family homes (90%) are self-occupied, only a small fraction rented (Eggers & Thackery 2007, Hendron 2004).

The **housing stock has grown by about 1% p.a**. with 2% new buildings added and 1% of the existing buildings retired each year. Thus, more than 50% of the present building stock will be in operation in 2050 as well, which means that the existing **building stock is the most significant determinant** for residential energy consumption over the next decades.

According to Hendron 2004 the average energy use in the building stock for heating amounts to about 100 kWh/m^{2}a, whereby the use has dropped from about 130 kWh/m^{2}a for homes built in the 1940s to about 65 kWh/m^{2}a for homes built in the late 1990s. Thus, the average specific heating requirement is more than 1/3 lower than in Germany, which partially can be attributed to milder average climate conditions. On the other hand the floor area per capita is about 50% higher than in Germany so that the **heating consumption p.c. is of the same order of magnitude as in Germany**. Looking at the building quality, a marked difference can be observed with respect to window quality: **almost 50% of the windows are single pane,** 90% clear glass without any heat-reflective coating. Besides, **lack of air tightness** of the building envelope, as well as of the duct systems appears to be a major problem. According to Hendron the average energy expenditure per household in the different states varied between 1000 and 2000$ p.a., which – for an assumed time factor of about 30 (see section 2.2.4) - indicates a net present energy value of the order of 30 000 to 60 000$ per household or about 1 to 2 trillion $ for the US. This indicates that there is a **an enormous potential for investments into energy conservation measures**. On the other hand about 300 million $ p.a. corresponding to 3000 $ p.a. and household or 1000 $ .p. a. and p.c. are spent for various of home improvements and major repairs (ibid:17) indicating that considerable building activities are already under way, which could be used for hooking in advanced energy efficiency measures.

The advancement of energy efficiency, however, appears to be confronted with **structural market problems** similar to those in Germany. According to US DOE 2007b:1-3 the building industry is **extremely fragmented** with a large number of different types of firms required to build and operate a building (e.g., manufacturers, designers, builders, subcontractors, suppliers). With the exception of some appliances and materials, firms are typically very small and represent a small portion of their overall market (for example, the top 5 homebuilders account for only 15 percent of the market) ….". Hence, the **small size of building firms** makes it difficult to undertake substantial research, to absorb the costs and risks of verifying the efficiency, safety, and health characteristics of new building designs and technologies and to realize the resulting benefits themselves. "Even larger private sector organizations, such as the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI), have reduced R&D investments significantly in the face of increasing competition in these energy markets." Thereby "building efficiency improvements entail unique market risks because they are relatively invisible and difficult to measure, making them difficult to market, especially without independent verification of savings levels." (ibid:1-3).

"Another barrier is the **compartmentalization of the building professions**, in which architects and designers, developers, construction companies, engineering firms, and energy services providers do not typically apply integrated strategies for siting, construction, operations, and maintenance" (ibid:1-4).

Similar as in Germany, **house buyers lack knowledge and awareness** with respect to energy efficiency issues (cf. also Mentzer 2006:14, 16). The author himself visited various construction sites during his stays in the US finding inefficient uncoated double pane windows built into luxury new homes. When asking the craftsmen on the site about this misfit they answered that they knew that they were building "sh…". But as long as the house owner did not know or care and the building company wanted to save cost, they had to implement it.

Competence gaps can also be found on the suppliers side (Mentzer 2006). According to Klingenberg (2007a:342) there is "a **fundamental lack of knowledge on how to design a well performing building envelope** amongst designers, engineers and contractors." Especially in milder climates – where current constructions still display a sizable heating demand – the fundamentals of a well-insulated building envelope are not commonly taken into account. Thus, buildings turn out to be poorly insulated and drafty.

This lack of knowledge is in contrast to the **academic know-how available** at research labs, such as Lawrence Berkeley National Laboratory LBL (www.lbl.gov), various universities and government sponsored research organisatitons such as the National Renewable Energy Laboratory NREL (www.nrel.gov) and NPOs as the American Council for an Energy Efficient Economy ACEEE (www.aceee.org), which a.o. carries out the well known biannual ACEEE Conference “Summer Studies on Energy Efficiency in Buildings” (cf. ACEEE 2006).

There is also a **“green building” movement** driven by the US Green Building Council (www.usgbc.org) advocating the LEED approach for sustainability rating which, however, as far as energy is concerned falls short of meeting long-term sustainability requirements. A few organizations as Green Homes America (www.greenhomesamerica.com) have started to develop integral one-stop modernization approaches for old buildings.

Furthermore, there are very **active NPO organisations,** such as the **American Institute of Architects AIA** (www.aia.org), which has formulated **the 2030 challenge,** a vision and action programme defining step-wise energy reductions targets so that zero energy homes can be reached by 2030 (see Architecture 2030, n. d.). Recently the **Affordable Comfort Incorporated ACI** (www.affordablecomfort.com) has started an ambitious initative for old buildings, which will be detailed in section 7.5 below.

7.4 Promotion of Passive Houses in the US

As already indicated in chapter 6 and apparent from the last international passive house conferences (www.passivhaustagung.de), the passive house movement has started to expand far beyond Germany to almost all continents worldwide.

The first American passive house was built in 2003 by Katrin Klingenberg, founder of “e-co lab” (Fig. 42), www.e-colab.org), an NPO committed to designing energy-efficient, environment-ally healthy, “delightful” buildings to especially serve low- to middle-income families (ibid). Thus, e-co lab follows a **low-cost strategy incorporating non-energy benefits** into its promotion. As German experience indicates (cf. sections 3.3.3 and 5.1.1) and eco-marketing strategies (section 4.5.2) suggest, this should accelerate niche expansion in the market. Currently, e-co lab finishes the **first passive house retrofit project** in Berkeley, California (Klingenberg 2007a). Here it shows that **under favourable climate conditions “passive houses” can already be achieved with simpler “low-energy” constructions** at reduced extra cost. Ironically, the Californian building code makes a separate heating system mandatory, while requirements with respect to air tightness are missing. This shows that even **relatively advanced US building codes** currently are far from optimum, moreover, they **even prohibit optimum designs**.

Figure 42: First US Passive House – A Low-Cost Solution (cf. Klingenberg, e-colab)

In 2006 the first certified passive house “BioHaus Waldsee” was built in one of the coldest US climate zones, where automobile manufactures from around the world perform testing under severe winter conditions (see Fig. 43, http://waldseebiohaus.typepad.com, Tanner et al. 2007). The building outperforms the Minnesota energy code by 85% and confirms that the **passive house concept also works under very cold climate conditions**. It comprises a school for “learning by immersion” including sleeping, eating and learning spaces and is seen as a “model for Germany’s best environmental planning and ‘green’ sustainable environmental building concepts” (ibid: 141). Due to its unique location, mix of functions and educational mission, the building can serve as a strong promoter for passive houses in the US. However, as opposed to the Urbana house, it presents a high-cost solution.

Figure 43: US Passive House in Cold Climate

In October 2006 the 1st North American Passive House Conference was held at Biohaus Waldsee. In July 2007 Klingenberg founded the first American Passive House Institute "PHIUS" (www.passivehouse.us), which in November 2007 houses the 2nd Passive House Conference. Thus, the two **pioneers** have started working **as nuclei with a strong multiplicative function**. According to Klingenberg (2007b), a **high demand for passive houses** can be sensed in the US-market. Several new projects are under way. in different US states. Promotion has also started under the compelling name "1-Watt-House" (cf. section3.2.1).

7.5 Recent Trends & Future Chances for Old Buildings

As pointed out above, the housing stock decisively determines the future development of energy use in buildings in Europe, as well as in the US. The **Amercian NPO ACI** as one of the key driving forces in the North American retrofit market has started an ambitious initiative for "deep" energy conservation on the annual North American ACI conference in April 2007 (ACI 2007a), where the author had been invited to deliver a corresponding key note speech (Steinmüller 2007a) accompanied by side-events (cf. ACI 2007a, Steinmüller 2007b and c)[128]. Encouraged by the positive resonance, a special **ACI-summit on** "**Moving Existing Homes Toward Carbon Neutrality**" was called in for San Francisco in July 2007 (ACI 2007b) with about 100 invited experts from the US and Canada and the author as European member.

The goal of the summit was to "**create and clarify the vision of deep energy savings (70 – 90% reduction in total energy use) in existing single family and multifamily dwellings** through a combination of technical interventions and behavioural choices" (ACI 2007b). Thereby the question of green energy supply was purposefully omitted in order to **focus on energy efficiency and conservation as top priorities.**

Being aware of the huge opportunities and challenges, case studies were performed in parallel working groups, which indicated that **factor of 10 energy savings are possible in all climates**. Groups using a net present value life-time costing approach suggested that this was also possible **in an economic fashion**. At the same time, it became apparent that "piece meal approaches" ran danger to implement measures, which would not only be sub-optimum from an overall standpoint, but also block the later achievement of an optimum. A central learning challenge was – as Amory Lovins expressed it in his greeting address – to **tunnel through the conventional barriers of thinking and costing**, which usually hinder the discovery of new sustainability optima – in a similar way as the passive house creates a new optimum beyond conventional cost barriers (cf. Lovins 2007 and section 3.2.1, Fig. 17). Consequently one result of the meeting was that the "Total Return Cost TRC " and "Saving

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[128] A driving force behind the scene was John Krigger, who - after having access the 10th Passivhauskonferenz 2006 in Germany - enthusiastically reported to ACI's programme manager Linda Wigington. The 2006 ACEEE Conference "Summer Studies on Energy Efficiency in Buildings" worked as an additional amplifier (personal communications at ACI San Francisco Summit).

Investment Ratio SIR" models, which are customarily used to judge energy conservation measures, are inadequate and counterproductive. Moreover, these traditional costing models do not consider the "non energy benefits" like "comfort", "health", "passive survivability", "status" etc., which may even double the value of the energy saved (cf. also Knight et al. 2006). Thus, the **traditional cost models tend to drastically underestimate the real benefit of deep energy conservation measures.**

The results and conclusions of the summit shall be published as a white paper, which currently exists as a review draft version (ACI 2007c). In line with the draft version, the following preliminary conclusions can be drawn:

- **Deep energy reductions are possible now**: The technology for these ambitious energy cuts largely exists, but the knowledge is fragmented.
- **Realignment of political, economic and institutional framework essential:** The realignment of current residential energy initiatives, programs and policies is a bigger issue than remaining technical challenges. Significant improvements in codes, code enforcement, commissioning and incentives are needed.
- **The new paradigm requires new thinking:** To achieve deep energy reductions we need to look at a building and household from a new perspective. Short-term incremental approaches ("widget paradigm") have to be supplemented and replaced by long-term systems approaches ("holistic home performance paradigm").
- **New thinking tunnels cost barriers, creates overall gains:** Holistic, integrative design coordinated with retrofits being done anyway optimizes cost in relation to overall long-term energy and non-energy benefits **so that deep energy reductions become economically attractive for individual stakeholders and society.**

Specific recommendations were derived with respect to the advancement of technical components and market promotion. These can be summerized by the following key words:

- Harmonize organizational systems, initiatives, policies with deep reduction paradigm.
- Establish adeaquate performance metrics, monitoring, monetarization and knowledge system on national scale with regional customization.
- Show feasibility and multiply knowledge with 1000 houses demonstration project.

8 CONCLUSIONS

The world of the 21st century is confronted with an unprecedented **sustainability challenge**, whereby limited energy resources and global warming belong to the most prominent problem areas. The Western industrialized countries are the main problem causers. Their energy induced carbon dioxide emissions transgress the global sustainability limit of about 1 ton per capita and annum by a factor of 10 to 20. Consequently, at least **factor of 10 reductions are needed** in the Western world. Renewable energies on their own cannot solve the problem, thus energy efficiency has to be exploited in a much more rigorous way than in the past. The building & housing sector typically causes 40% of the energy demand, hence, the **promotion of energy efficient sustainable housing is a top priority**. Thereby the size of the problem and the running out of time call for parallel, multi-level solution approaches and determined action.

Looking at the building lifecycle, **energy consumption in the "use" stage dominates** consumption in all other stages by almost an order of magnitude. Thus, it is necessary to focus on this stage. Thereby it is essential to gain an understanding of the relevant system and efficiency concepts, promising energy efficient sustainable housing strategies and the driving and retarding forces in the economic, political and public spheres.

As far as **top level system models** are concerned, Wüstenhagen's transformation model of eco-niches toward mass-markets is taken as a promising starting point. However, the suggested uni-directional transformation process determined by public, political and economic "control systems" appears too idealistic and not fully consistent with a rather "chaotic" reality. Moreover, the three systems are defined in behavioural rather than organizational terms, which renders problems and potential inconsistencies in practical applications. Hence, the **concept of "control systems" partially has to be replaced and merged with the more general concept of "influence spheres**", while the unidirectional linear transformation process has to be replaced by **cyclic multi-connected structures**.

On the lower level, **eco-marketing provides powerful concepts,** which have to be tuned to energy efficient sustainable housing, while the concepts of ecological domino chains, greening Goliaths, multiplying Davids and ecological market maps supply heuristic guidance.

Regarding **eco-efficiency**, the use of straight forward, popular indicators like the "price of the energy unit saved" is not without pitfalls. The highest eco-efficiency (here lowest price) does not necessarily indicate the best solution. As to the latter, it is necessary, to correctly include relevant opportunity, as well as applicable capital cost and optimize the net present value, which – especially in the case of housing - involves long-term assumptions about future scenarios. Thereby, it is essential to include all relevant parameters in a transparent way. Corresponding **simplified models are introduced and used in this study**.

Looking at **promising energy efficient housing strategies,** factor of 10 approaches have already been proposed about 30 years ago. Though economically attractive, neither the market, nor the public and political system were sufficiently open and prepared to realize the chances and exploit the potentials. As described in this study, initially the further development of efficiency strategies mainly rested on the shoulders of a few engaged individuals in Germany and Scandinavia, where major energy efficient housing R&D had been continued. State funding finally enabled the proposal and realization of the "**passive house**" concept, which reaches a new optimum of eco-efficiency and comfort, and thus can serve as a **core template for energy efficient sustainable housing**. Its specific heating requirement is a factor of 10 below that of of average German houses. As shown in this study, the template can also be successfully applied to old buildings. Though it is difficult to reach the level of new passive houses, **factor of 10 savings and considerable overall improvements are possible,** too. Other approaches as "zero" or "plus energy" houses may deliver even higher energy savings, whereby, however, economy is at stake. Under typical boundary conditions, the passive house seems to be a necessary prerequisite for long-term economy and sustainability. Thus, passive house technologies form the basis of"factor 10 visions" for the whole building stock, whose feasibility can be extrapolated from former housing scenarios, whereby factor of 5 reductions can be expected from efficiency, while factor of 2 contributions are needed from regenerative energy supply.

Analysing **general market structures,** it turns out that the housing market is determined by a typology of goods and suppliers, which towards the end customer interface are characterized by a compound of product and service elements so that the business involved tends to be a **solution or project business** rather than a simple product one. **End customers** are confronted with a mixture of products and services offered along a **complex supply "chain"** by various parallel interconnected strands with multiple interfaces at various depths. Instead of a simple "domino chain" able to propagate innovation impulses in a linear predictable way, an **inert mesh of sticky quite different dominos** is found, **needing "resonance analysis" and targeted simultaneous stimulation** for innovation to succeed.

Examining **end customer behaviour**, three basic customer groups have to be distinguished: **self-using owners (or self-occupiers), private lessors (or landlords) and professional lessors**. Thereby, the latter may also turn up as actors within the supply chain and are expected to show a more "rational" behaviour than the former. Though housing is associated with emotions especially for self-occupiers, **habitual and limited demand behaviour dominate** in decisions concerning energy efficiency, whereby sub-decisions are confronted with a **lack of information and knowledge** on the demand, as well as on the supply side.

Empirical studies confirm that key behavioural patterns and barriers are not limited to end customers, but **apply to suppliers, too**, whereby the former demonstrate limited openness with respect to external advice so that **misjudgements tend to get stabilized and markets blocked**. In the lessor market the **user-investor dilemma** adds to these blockages. However, it can be shown that the dilemma partially is a virtual one.

A **rational supplier** can tackle these problems and barriers by adapting eco-marketing strategies. Here, **mega-marketing appears as a particularly powerful tool**, which extends the core concept of "promotion" to the public and political sphere. Promotion in the original sense of customer communication is the basic element of the mix. While communication of **key information** helps to combat limited behaviour, **strong incentives** are needed for unfreezing and refreezing habitual behaviour. Here the simplicity of the passive house concept with its compelling hard and soft benefits offers excellent promotion anchors, which can be enriched by positive **emotional buying "arguments."** In view of blocked markets, the **embedding and extension of promotion activities into the public and political sphere becomes essential**. Thereby small and medium sized companies have to embark on **cooperative approaches** in order to obtain the critical mass for corresponding overarching campaigns.

Looking at specific markets as **Germany**, the original **pioneers** and **ambitious small and medium sized market players** have formed collaborative efforts, which finally have set the market in motion so that approximately 30 years after the Philips Experimental House Project and 15 years after the first passive house project, about 10 000 passive house units will be reached in 2007. Here, the entrance of **cities and their housing companies** at the customer interface has recently **mobilized critical mass and initiated a promising market pull**. On the other hand, short term financial profit driven investment Goliaths present a latent danger. On the whole, **Goliaths or "Giants**" are rare in the housing market and **are mainly found at the beginning or in the periphery of the fragmented supply chain.** With a natural interest in mega-marketing they also turn up as sponsors of efficiency projects. However, highly energy efficicient sustainable housing does not necessarily fall in line with their core business interests. Hence, **their role on the national level has been an ambigious one**.

As for the **public sphere**, energy efficiency has been promoted by engaged pioneers, scientists, as well as a few NPOs for more than three decades. Yet, the **mass media rarely acted as an effective amplifier**. On the contrary: for a long time the media have evoked a picture of uncertainty about global warming and the need for action. Zooming into solar energy, most media created a strongly distorted picture of real priorities and guided public opinion and politics into the wrong direction so that energy conservation became a "non-issue." Thus, different from the canonical model, to a considerable degree **the transformation of ecological pressure into ecological claims occurred despite the media.** Hence, besides strengthening knowledge networks between scientists, practitioners and NPOs, **it remains a challenge to gain the public media for conveying key information, vision and messages** about energy efficient sustainable housing to the broad public **in a consistent, convincing fashion**.

Concerning politics, political support was essential from the very beginning. Unfortunately, the broad portfolio of instruments has not been effectively used in the past. While the potential power of market oriented instruments has been indicated by recent KfW-programmes, regulative instruments - forming the backbone of sovereign control - show serious shortcomings in quantitative, as well as qualitative aspects. Knowledge oriented instruments stimulating information, education, technology and market research remain underdeveloped As far as public buildings are concerned, the state largely failed to set **positive examples**. Hence, until present, German politics has not managed to effectively combat market failure. Recently, however, energy efficient sustainable housing has received growing political attention so that there is **new hope for corrective measures** in the right direction – though it still is questionable, whether sufficiently rigorous steps will be taken.

In Europe analogous observations can be made as in Germany, whereby the specific developments may vary considerably between individual nations. The analysis presented in this study focuses on the European Union and its promotion of passive houses. It turns out that **in spite of relatively limited financial funds** and traditional bias towards regenerative energy supply, the **passive house movement has received effective support**. With EU-funded projects, the applicability of the passive house concept to a broad range of climate and building conditions could be verified. At the same time - and with additional support from corresponding national and sub-national institutions - vigorous **exponential growth** has been **stimulated in several European regions**. Most noteworthy, the recent **European action plan** for energy efficiency, explicitly makes **very low energy buildings ("passive houses") a top priority** targeting at a wide-spread deployment of these houses by 2015.

The situation in **North America** is strongly determined by the US. While technical and political foundations for energy efficient sustainable housing were laid in the seventies, cheap oil prices and a severe **neglect of national political support** since the Reagon era led to a severe decline and backlog of American building practice and standards. Similar to Germany and Europe, the **market is characterized by high fragmentation**, small size building firms, compartmentalization of building professions and a lack of knowledge or awareness among house buyers, as well as professionals. Nevertheless, **public awareness with respect to energy, as well as global warming issues currently is steeply rising.** While the American Architects Association AIA formulated the **2030 challenge, which targets at zero energy homes by 2030**, first zero energy, as well as first passive houses have already been built. Moreover, the **North American ACI caught on the passive house idea and its relevance for the building stock.** In July 2007 a special summit event was called in to evaluate visions for deep energy reductions in existing American buildings and to formulate progressive private-public strategies for 70 to 90% savings in old buildings. drive

Thus, **factor 10 energy reduction strategies** for energy efficient sustainable housing have finally **gained ground in the Western world**. However, as indicated in this study**,** neither market, nor public and political forces on their own are sufficient to induce the drastic changes needed for sustainable energy strategies. Rather, **collaborative approaches are required**, where engaged actors in the public, political and market sphere act as promoters **within and between the spheres**. Thereby, a broad set of strategies and instruments has to be applied. While public and private research have an eye-opening function, **politics has to supply and secure the basic framework so that market actors can transform niches into widely accepted mass market solutions**.

Clearly, for safeguarding sustainable development on a global scale, energy efficient sustainable strategies have to be applied to **other regions in the world** as well. Here - besides India and Russia - China deserves particular attention, whereby the application of highly energy efficient passive housing techniques in the booming new housing development appears as a top priority. However, a successful export of these techniques will only take place, if they are applied in the exporting countries themselves (cf. Deutschmann 2005, Sudnig, Wolff 2006, Shi & Tao, Kraus, Marschall 2007a).

While the sector of buildings and housing is the largest global energy consumer and key emitter of energy-related CO_2-emissions, **traffic and industry** almost reach a similar share, whereas agriculture is the main emitter of non-energy related emissions. Thus**, equivalent efforts are needed in these sectors, too.**

Though a **global political action framework is urgently required** to initiate global standards and coordinate actions, anticipatory **local intiatives have to be pressed ahead**, if the race against time is to be won.

All sectors are **driven by the demand of individual human beings**, who in the end make up the public, market and political action spheres. For sustainability to be successful on a global scale, it is therefore essential to start changing ourselves, our habits and our local environment. Thus:

Sustainability starts at home – do join in and tell your neighbours!

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Klingenberg, K. (2007b): on the development of the American passive house market (personal view as market actor)

Rosenfeld, A. (2007): on US policies and energy research (views as a former head of LBL energy research and current advisor of governor A. Schwarzenegger).

Sonderegger, R. (2007): energy policy in the US in the eighties and at present (views as former scientist at LBL, researcher and entrepreneur in the energy & buildings field)

10 APPENDIX

Sections 10.1 to 10.3 supply background information concerning historic energy prices and net present values, section 10.4 briefly reviews German energy performance certificates.

10.1 Historic Development of Oil Prices since 1960

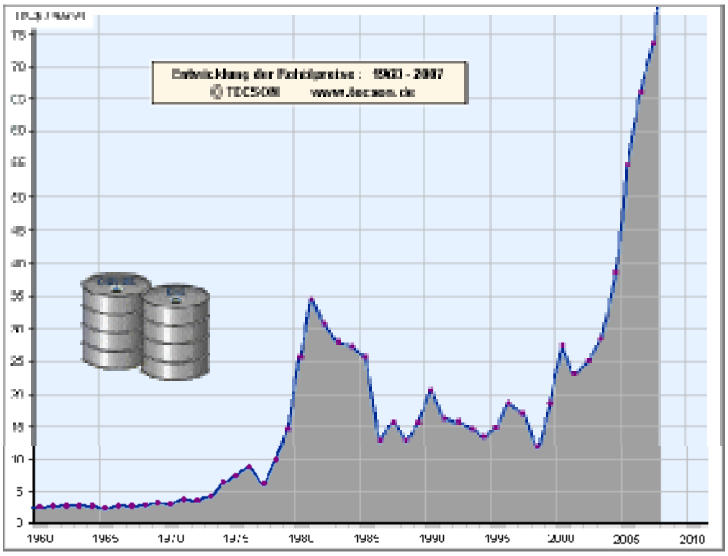

Figure 44: Development of Oil Prices 1960 –2007 (www.tecson.de/poelhist.htm)

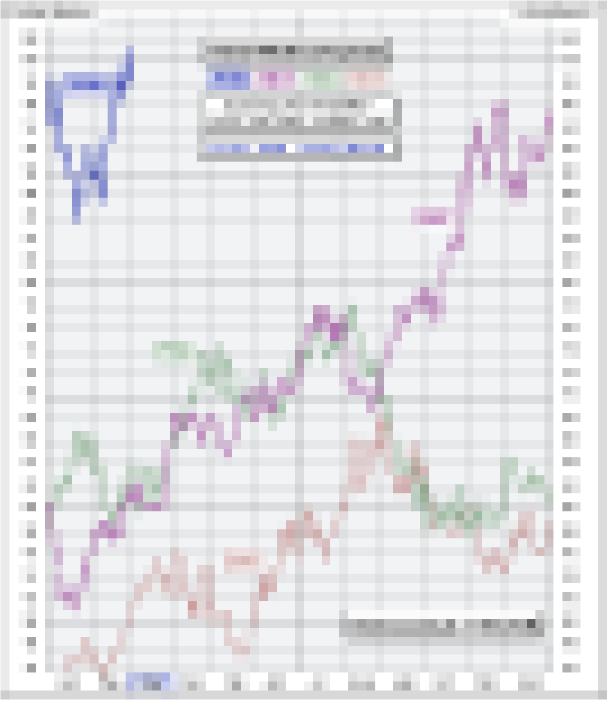

Figure 45: Oil Prices since Jan 2005 (www.tecson.de/prohoel.htm)

10.2 Historic Development of Energy Indices in Germany

Fig. 46 shows the development of energy price indices for German households over a 45 year period 1962 - 2006[129]. The data can be fitted by exponential curves yielding mean annual nominal inflation rates between **3.1 % for electricity and 4.7% for oil**. The consumer price index has risen by 3.1%, implying **real energy inflation rates of about 0 to 1.5%.** Historic values discounted with German discount or base interest rates can be approximated by an exponential curve with a **nominal 4.5 % interest rate**. This suggests **historic scenario parameters q_{ek}** := (1+energy inflation)/(1+ capital interest), **ranging roughly from about 98,5% (electricity) to 100% (oil).** Higher interest rates yield correspondingly lower historic scenario parameters. For example, 6% nominal interest – corresponding to a 3% real interest - would yield mean scenario parameters between 97 % and 98.5%. Note, however, that these values only give a rough indication of appropriate scenario parameters for future scenarios.

Figure 46: Development Price Indices in Private German Household since 1962

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[129] The data have been compiled from data series published by the "Statisches Bundesamt" (Fachserie 17, Reihe 7, cf. www.destatis.de and https://www-ec.destatis.de/csp/shop/sfg/bpfdfm.html.cms.cBroker.cls?cmspath=struktur,vollanzeige.csp&ID=1020929), whereby all data have been normalized to the year 2000. A "capital discount index" has been defined by discounting the value 100 for reference year 2000 using official German discount and base interest rates.

10.3 Historic Development of Net Present Value Factors in Germany

Regarding the high variations of energy prices, exponential fits introduce errors, whose effect is time-dependent. Thus, it is interesting to directly calculate **historic net present values or effective time factors** according to Box 1 with $N_{eff} = \sum q_{ek}^{t}$ and annually varying quotients q_{ek} := (1+energy inflation)/(1+ capital interest) for different instances in time. Taking the **public discount or base interest rate as a reference case,** the results for oil and gas are shown in Fig. 47 for five reference base years 1962, 1972, 1982, 1992 and 2002. Accordingly, relatively smooth curves are obtained, which can be compared to the coordinate system suggested in Fig. 11, i.e. to curves with constant $q_{ek.}$ The results for gas (cf. triangles in Fig. 47) show a reasonable fit with q_{ek} = 100%, 99%, 95% and 98% for the years 1962, 1972, 1982 and 1992 respectively, the results for oil (dots) fit for q_{ek} = 98%, 100%, 90% and 98%. The base year 2002 renders best fits for 108% and 115% respectively, which, however, should not be taken as characteristic due to the shortness of the series.

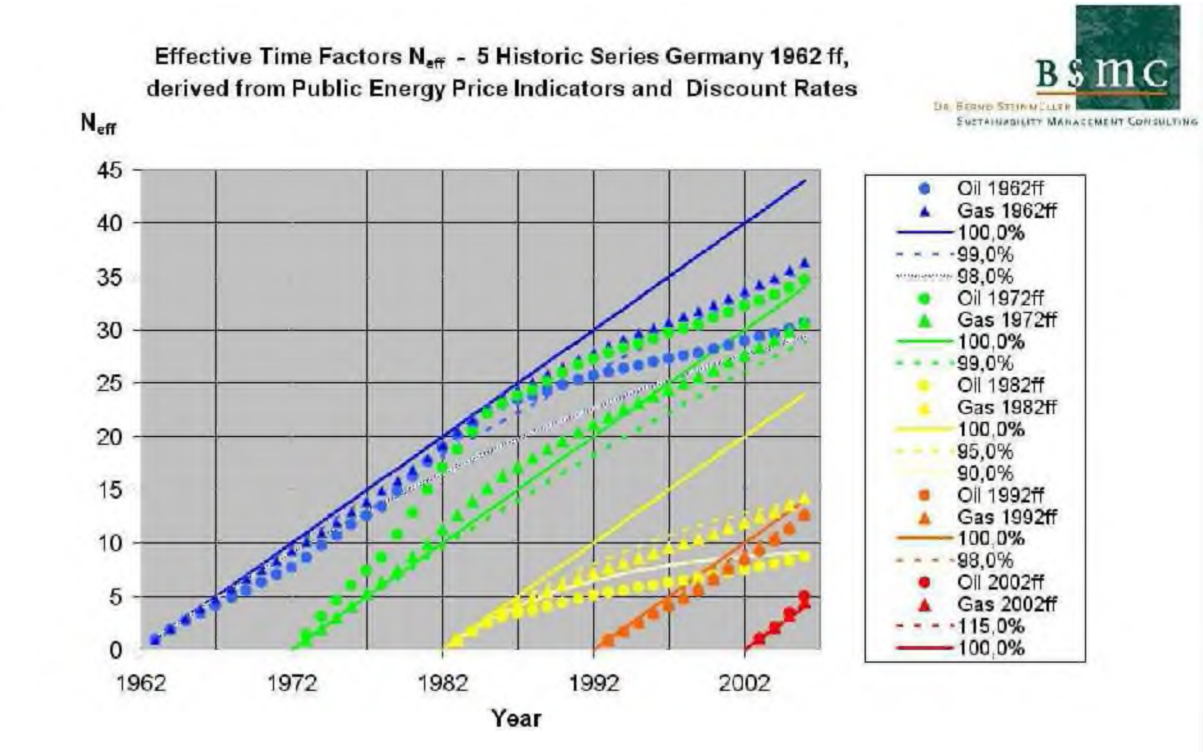


Figure 47: Net Present Value or “Effective Time Factors” Neff

Thus, with the exception of 1982 (after which oil prices collapsed, cf. Fig. 47), scenario parameters suggested in 10.2 can be confirmed. Note that the lower effective time factors for 1982 do not necessarily imply lower net present values, as the energy price was higher at that time. Thus, it is always necessary to consider the combination of both.

10.4 Energy Ordinance EnEV und Energy Performance Certificates

Together with the Energy Ordinance Act EnEV 2007, the energy performance certificate for buildings has been formally and legally introduced in Germany. Following the EU directive "Energy Performance of Buildings" (cf. section 6.1), the **objective** is

- to make the energetic status of buildings transparent and
- to stimulate sustainable energy saving measures.

Certification is **obligatory** for

1. new constructions
2. modernization of existing buildings
3. sale, rental and leasing events
4. public buildings with floor space beyond 1000 m^2

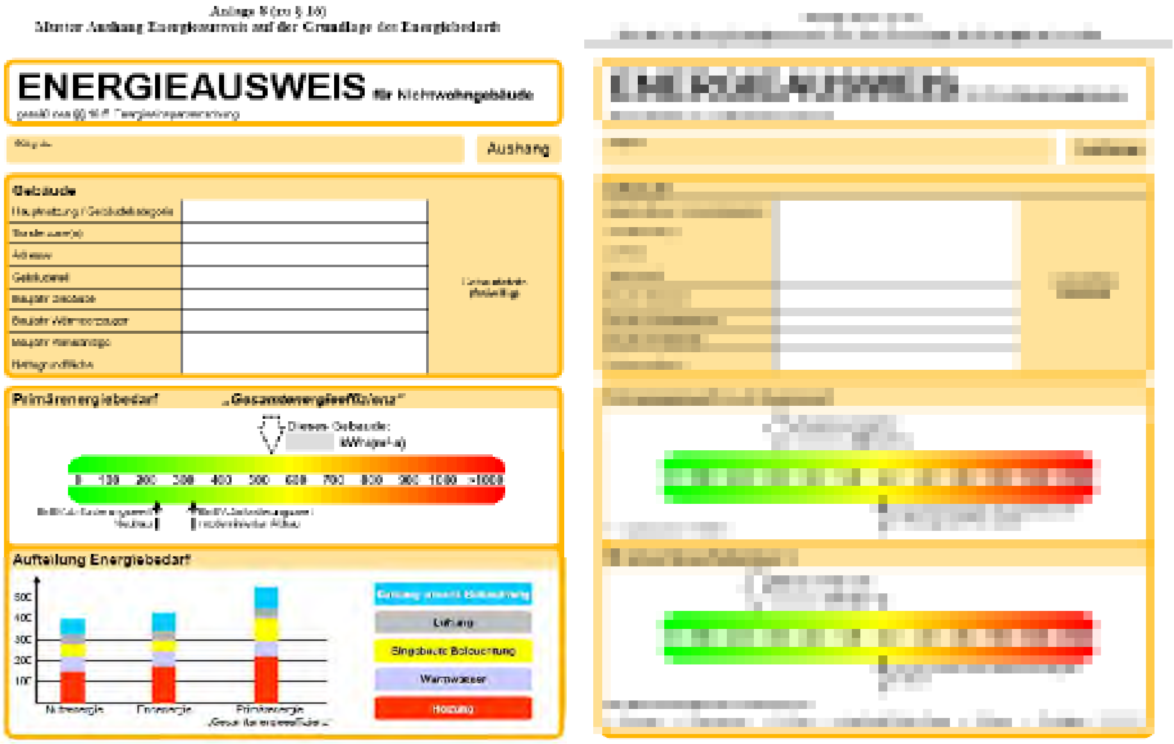
The certificate is issued in two standardized **basic forms**:

- demand-based
- consumption-based

in customized versions for residential and non-residential buildings.

As a rule, new and substantially modernized buildings will need a demand-based certificate. Moreover, large **public buildings have to display a simplified version** in a prominent place (Fig. 48, cf. EnEV 2007, app. 7 to 10).

The **demand-based certificate** (Fig. 48, left) compares the energy required with EnEV-minimum requirements on a coloured scale giving supplementary information with respect to cooling, ventilation, lighting, hot water and heating. In addition, the non-public version makes statements about CO_2-emissions, the energetic quality of the building envelope, the applicability of alternative energy supply, ventilation type and recommended modernization measures. The demand-based certificate is based on a theoretically founded, component-related energy balance of the building, which explicitly supports a detailed energy assessment and specification of improvement measures. The **consumption-based certificate** (Fig. 48, right) is issued on grounds of measured, climate adjusted consumption figures for heating and electricity showing the corresponding indices together with reference values issued by BMVBS und BMWi. The non-public version contains further information about energy sources and measuring periods as well as recommendations about "cost-effective modernization" measures. The latter, however, can only be given with great limitations, as a computational analysis and energy balances as well as adjustments with respect to user influence are missing. This is a one of its main chinks. On the other hand its issuing is simple and cheap. Thus, it may serve as cost-effective trigger and starting point for more detailed assessments.



Anlage 8 (zu § 16)

Muster Aushang Energieausweis auf der Grundlage des Energiebedarfs

ENERGIEAUSWEIS für Nichtwohngebäude

Aushang

Gebäude

Hauptnutzung / Gebäudekategorie

Adresse

Gebäudeteil

Baujahr Gebäude

Baujahr Wärmeerzeuger

Baujahr Klimaanlage

Nettogrundfläche

Primärenergiebedarf „Gesamtenergieeffizienz“

Dieses Gebäude: kWh/(m²·a)

0 100 200 300 400 500 600 700 800 900 1000 >1000

Aufteilung Energiebedarf

500 400 300 200 100

Nutzenergie Endenergie Primärenergie „Gesamtenergieeffizienz“

Kühlung einschl. Befeuchtung

Lüftung

Eingebaute Beleuchtung

Warmwasser

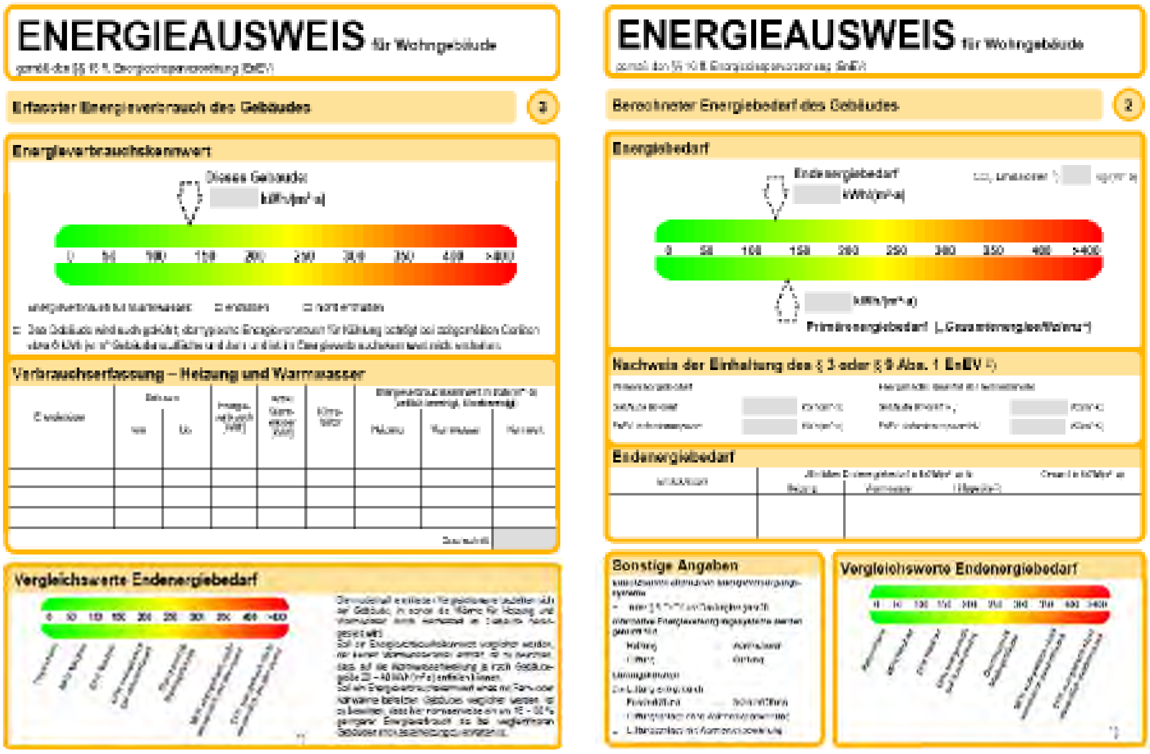
Heizung

Figure 48: Public Certificates Non-Residential Buildings. Demand-/Consumption.

Certificates for residential buildings are similar. However, they are not meant for public display and show demand and consumption on a reduced scale (Fig. 49, cf. EnEV 2007, app. 6).

A very **weak point of the named energy performance certificates** consists in the colouring of the scale, which **does not allow a simple, appropriate rating of buildings**. What is most alarming is the fact, that the **green range already starts at values, which are far away from sustainability so that the colouring raises totally misleading signals**. Regarding non-residential buildings the colour change to green already starts at about 500 kWh/m^{2}a (cf. Fig. 48), while for residential buildings (fig. 10-10), this happens at 200 kWh/m^{2}a, i.e. for values missing sustainability by factor of 10 and more! Even worse: the 200 kWh/m^{2}a mark is explicitly designated as “good modernization” (cf. Fig. 49: “EFH energetisch gut modernisiert”).

Hence - in its present form - the energy performance certificate sets wrong targets and runs danger to cement erroneous quality judgements, stimulate wrong recommendations and effect the opposite of what it is meant to do. Improvements are urgently needed.



ENERGIEAUSWEIS für Wohngebäude

Erfasster Energieverbrauch des Gebäudes

Energieverbrauchskennwert

Dieses Gebäude:

kWh/(m²·a)

0 50 100 150 200 250 300 350 400 >400

Verbrauchserfassung – Heizung und Warmwasser

Vergleichswerte Endenergiebedarf

ENERGIEAUSWEIS für Wohngebäude

Berechneter Energiebedarf des Gebäudes

Energiebedarf

Endenergiebedarf

kWh/(m²·a)

0 50 100 150 200 250 300 350 400 >400

kWh/(m²·a)

Primärenergiebedarf („Gesamtenergieeffizienz“)

Nachweis der Einhaltung des § 3 oder § 9 Abs. 1 EnEV

Endenergiebedarf

Sonstige Angaben

Vergleichswerte Endenergiebedarf

Figure 49: Certificates for Residential Buildings. Demand-/ Consumption-Based.

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