



IEA Future Buildings Forum Think Tank Workshop
Future Sustainable Buildings and Communities
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Vision and Research Roadmap for Future Sustainable Buildings and Communities



FOREWORD

This document describes the research roadmap established by the IEA Future Buildings Forum Think Tank Workshop on "Future Sustainable Buildings and Communities", 21.-22.3.2007 in Espoo, Finland.

Contributions from the participants of the workshop are acknowledged. It was inspiring to see how eager all the participants were to give their contribution in the workshop.

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EXECUTIVE SUMMARY

The FBF workshop on “Future Sustainable Buildings and Communities” was organized to increase and strengthen the co-operation of various experts in the scope of sustainable buildings and communities and related technologies within IEA.

The aim of the workshop was to identify R&D needs and new business opportunities in the scope of sustainable buildings and communities. The expected outcome of the workshop was a vision and a roadmap towards the vision concerning the energy system and the most important components of this system. The timeframe for the outlook is up till 2030.

The building and construction sector is one of the key sectors for sustainable development. The construction, use and demolition of buildings generate substantial social and economic benefits to society, causing at the same time serious environmental impacts. To achieve a sustainable community, these impacts have to be minimised. Any sustainable solution needs to fulfil the demands of ecological, economical as well as social sustainability.

The common view of the FBF Workshop participants was that, to reach this goal, the emphasis has to shift from technology development **to market development**. New thinking is required to move from the current way of making first-cost-based-business towards life-cycle-performance-based business. This will benefit both the consumer and the environment as well as the industry. There is still room for technological development, too.

The FBF Workshop concluded in the following Vision statement:

By year 2030, powerful and enlightened consumer surrounded by culture of energy and environmental awareness can select appropriate spaces provided by one business partner offering life-cycle performance based services in a low-energy-consuming built environment that produces carbon free energy according to demand.

There are currently several things working for the introduction of more sustainable buildings and communities, but still many barriers obstruct the way and must be tackled before a real breakthrough. Taking into consideration these drivers and barriers, roadmaps towards the target (research priorities) were presented for four important areas of attention:

- **end-users:** this area describes the sustainability from social point of view
- **energy and environment:** this area describes the sustainability from ecological point of view, the focus in the roadmap is on energy issues
- **market and business:** this area describes the sustainability from economical point of view
- **solutions:** different products and solutions are placed differently according to their ability to fulfil the three criteria. The final goal is a solution that fulfils all three criteria in a balanced way.

Many enabling technologies already exist to realise an economic solution for an energy efficient community that operates according to owners’ expectations and users’ needs. To move towards an energy efficient and environmentally sustainable building and community, some technologies still need to be developed, especially for compact, building-integrated storage of heat, cold and electricity. The developed solutions should be intuitive and robust.

To improve the social acceptability of the sustainable buildings and communities, information mechanisms have to be improved, and methods and tools developed in order to create powerful, environmentally aware end-users and to create basis for attractive environment of new business models. The applicability of the solutions to the circumstances in developing countries should also be investigated to achieve a global market and global sustainability.

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1. INTRODUCTION

1.1 Future Buildings Forum

As a major industrial sector, the real estate and construction sector must contribute to reduce the consumption of natural resources, especially energy, water and materials. Although not visible, energy supports vital services and societal comfort. Energy consumption has major impacts on the environment and the economy.

Energy consumption of communities and of buildings must be dramatically reduced. There is a need to develop a new generation of “highly efficient buildings” with reduced energy demand and “highly efficient production and supply structures” in an integrated and optimised way.

What is needed is to increase and strengthen the co-operation of various experts in the scope of sustainable buildings and communities and related technologies within IEA. Therefore, the FBF workshop on “Future Sustainable Buildings and Communities” was organized.

1.2 Purpose and target audience

The aim of the workshop was to identify R&D needs and new business opportunities in the scope of sustainable buildings and communities. The expected outcome of the workshop was a vision and a roadmap towards the vision (draft of strategy) concerning the energy system and the most important components of this system. The emphasis was on processes and co-operation models which are exceeding traditional “limits and borders”, and on integral technology solutions as well. The timeframe for the outlook is up till 2030.

Any sustainable solution needs to fulfil the demands of ecological, economical as well as social sustainability. This is illustrated by *Figure 1* below. The document presents research priorities in four important areas of attention:

- **end-users:** this area describes the sustainability from social point of view
- **energy and environment:** this area describes the sustainability from ecological point of view, the focus in this roadmap is on energy issues
- **market and business:** this area describes the sustainability from economical point of view
- **solutions:** different products and solutions are placed differently according to their ability to fulfil the three criteria. The final goal is a solution that fulfils all three criteria in a balanced way.

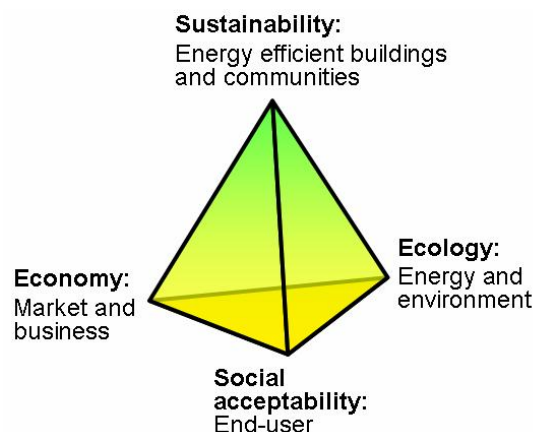


Figure 1. Three aspects of sustainability.

Under each area, detailed research topics have been sorted out according to time span to wide adoption in construction:

- **state-of the art (current situation):** technologies that are already commonly used in the industry and form the baseline for further development,
- **short term (...2010):** technologies that are available and are ready for being used in construction;
- **medium term (...2020):** technologies that offer beneficial opportunities for construction but need to be adopted or further developed for construction.
- **long term (...2030):** emerging new technologies that are deemed to offer benefits to construction in long term in applications that still need to be identified.

1.3 Background, present situation and challenges

The building and construction sector is one of the key sectors for sustainable development. The construction, use and demolition of buildings generate substantial social and economic benefits to society, causing at the same time serious environmental impacts created by the use of energy, water and other natural resources, by land use and by waste generation. To achieve a sustainable community, these impacts have to be minimised.

The common view of the FBF Workshop participants was that, to reach this goal, the emphasis has to shift from technology development to **market development**. “Many technologies are ready for the market, but the market is not ready for the new technologies!” New thinking is required to move from the current way of making first-cost-based-business towards life-cycle-performance-based business. This will benefit both the consumer and the environment as well as the industry. There is still room for technological development, too.

Table 1 . Current vs. target state

	Current state	Challenges
1. End-users	<ul style="list-style-type: none"> • Consumers often choose the cheapest alternative, not giving many thoughts on the life-cycle costs or let alone performance. People are not aware of the environmental impacts of the buildings. 	<ul style="list-style-type: none"> • Disseminating the information in an understandable and easy-to-adopt way and to get people to act according their knowledge will be challenging, especially in the developing countries, where some people may have difficulties even in finding their every-day nutrition.
2. Energy and environment	<ul style="list-style-type: none"> • Buildings account for 40 % of the energy use today. Most of the energy is produced by fossil fuels. 	<ul style="list-style-type: none"> • Changing the energy use pattern and energy efficiency of buildings is relatively slow, since the renewal rate of the building stock is only 2 % yearly.
3. Market and business	<ul style="list-style-type: none"> • Building and construction business is mostly driven by price and the product is usually the building and its systems. Some attempts towards life-cycle delivery have been made. 	<ul style="list-style-type: none"> • Construction industry is one of the most conservative branches. Changing the attitudes will demand a lot of work. Business is running well also as it is now, so there is no business-driven need to change.
4. Solutions	<ul style="list-style-type: none"> • Solutions delivered today are mostly separate building parts or systems, not “buildings as a system” or “space solutions”. 	<ul style="list-style-type: none"> • Someone needs to take the responsibility to act as the integrator of different systems, building parts and services into a solution that fulfils the end-user’s needs.

2. VISION

The FBF Workshop concluded in the following Vision statement:

By year 2030, powerful and enlightened consumer surrounded by culture of energy and environmental awareness can select appropriate spaces provided by one business partner offering life-cycle performance based services in a low-energy-consuming built environment that produces carbon free energy according to demand.

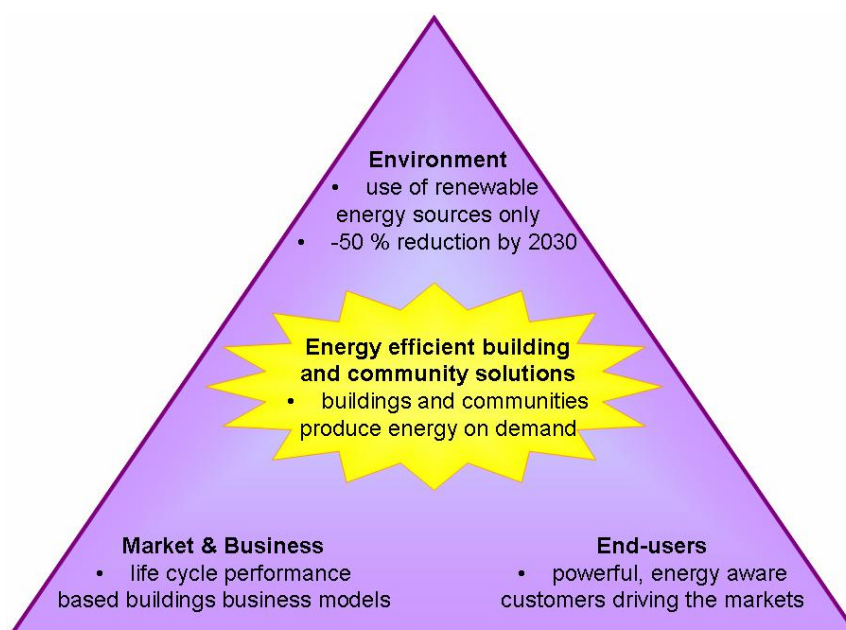


Figure 2. Vision for energy efficient buildings and communities

Market & business:

User driven market offers life-cycle optimised spaces, the price of which is connected to the performance, rather than to technical details of the components.

- Life cycle performance based business models are common practice (e.g. one entity responsible; designers involved in operation).
- Focus is on user's activities in spaces.
- Performance demand and supply are balanced.
- Demanding regulations are performance based.
- Closed innovation cycle is practiced as standard.
- Market demand is created by consumer knowledge of energy and environment.
- Long term predictability, openness, modularity and flexibility for future changes are offered as standard solutions.

End-users:

Powerful and active consumer is surrounded by CULTURE OF ENERGY AWARENESS.

- Active consumers executing consumer power are common practice.

- More information about energy consumption is available in an easily understandable form:
 - Consumers know how much energy is consumed by their activities.
 - Consumers know the effects of their activities on environment.
- Society supports environmentally conscious and energy effective behaviour.
- Society supports effective decision making (and has clear structures for this).
- Solutions used in buildings are easy to use, robust and invisible.

Energy & environment:

Buildings and communities in 2030 use half of the amount of energy than today and only use renewable sources for the energy they produce according to demand.

- Buildings cause minimum negative impact on environment.
- Carbon neutral energy production and consumption is applied worldwide.
- Maximum energy separation / energy cascading systems are used, facilitating efficient use of resources (with minimal losses).
- Passive (heat & cold) society is realised.
- All non-EE buildings are demolished or upgraded.

Solutions:

Instead of components or single buildings, in 2030, market offers integrated and performance-based solutions for energy efficient and environmentally friendly buildings and communities that support sustainability and produce carbon-free energy according to demand.

- Solutions consist of services that apply performance based integrated systems (health, productivity, comfort, ...).
- Solutions consist of prefabricated, industrially produced systems and buildings.
- Solutions offer flexibility for future changes.
- Buildings are responsive (user behaviour, external environment).
- Buildings are G.O.L.D. (Globally Optimised Locally Designed).
- Buildings and their system performances are designed, operated and maintained optimally to meet owner expectations and user needs (= life-cycle commissioning).
- Self contained buildings or communities that produce energy on demand, connected via energy hubs are common practice.
- Virtualised built environments help with operating the energy hubs.
- Interconnected, decentralised energy production is applied including “virtual” production plants with dynamic grids.

3. SCENARIO

Many enabling technologies already exist to realise an economic solution for an energy efficient community that operates according to owners' expectations and users' needs. It is estimated that some technologies could even be applied with net negative costs¹. Some technologies still need to be developed, but the emphasis needs to be shifted towards the market development. The building and construction industry still operates mainly on basis of minimising the first-cost. Also, many consumers are only interested in the price. In some rare occasions life-cycle services are offered or required. Especially in the residential sector life-cycle thinking is virtually non-existent. People are usually not directly aware of the impacts of buildings in the environment. Local renewable and waste energy sources are rarely used optimally to supply the energy needs of the community. Partial optimisation is the normal standard in both construction and energy design.

The current situation is represented with the bottom level of the tetrahedron of *Figure 3*, and the development has to move towards the top of the tetrahedron in all the three aspects. The solutions are represented by points inside the tetrahedron. Currently, most of them are more technology-oriented, and near the "Ecology" corner, while some are placed more evenly between the three corners, taking into account also some user-needs and business aspects. There is a need to harvest the full potential of the designed concepts by taking advantage of all the sides: business process, building and services process and the end-user's behaviour.

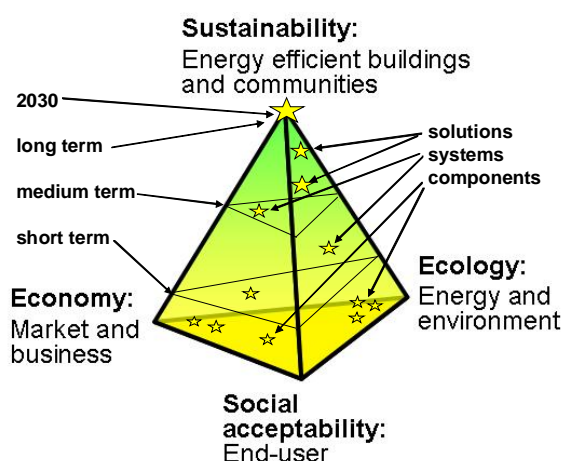


Figure 3. The development of the three aspects of sustainability towards the vision.

To move towards an energy efficient and environmentally sustainable building and community, some technologies still need to be developed, especially for compact, building-integrated storage of heat, cold and electricity. In design of energy efficient communities, three actions are imperative, and should be used in the following order (see also *Figure 4*):

1. Reduce the heating, cooling and lighting loads to a minimum
2. Use the exergy of renewable and waste energy sources as effectively as possible.
3. Make fossil fuel use as effective and clean as possible.

The solutions resulting from the above mentioned design procedure should also be intuitive and robust, so that people would automatically be able to use the technology right, and not be able to cause fatal defects to the system, even if they fail to use it like it was designed to be

¹ IPCC Fourth Assessment Report, 2007. "Options with net negative costs (no regrets opportunities) are defined as those options whose benefits such as reduced energy costs and reduced emissions of local/regional pollutants equal or exceed their costs to society, excluding the benefits of avoided climate change."

used. The final goal should be integrated and performance-based solutions for energy efficient and environmentally friendly buildings and communities that support sustainability and produce carbon-free energy according to demand.

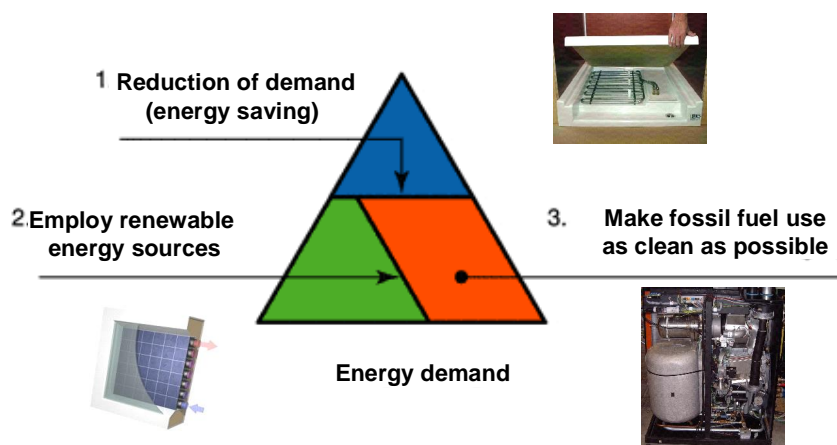


Figure 4. Energy impact of the applied methods can be described with the energy pyramid.²

To improve the social acceptability of the sustainable buildings and communities, information mechanisms have to be improved (e.g. energy issues should be integrated into all areas of education, and policy makers need to be provided with concise and accurate information). Energy terminology has to be harmonized internationally. Attractive financial credits for sustainable buildings should be introduced. Reporting buildings must be developed by virtualisation and visualisation of energy use and performance with ICT. Demonstration and lighthouse projects act as important information channels.

The progress from the current way of making partial-optimised-first-cost-based-business towards life-cycle-performance-based business models could happen through the changes described in Figure 5.

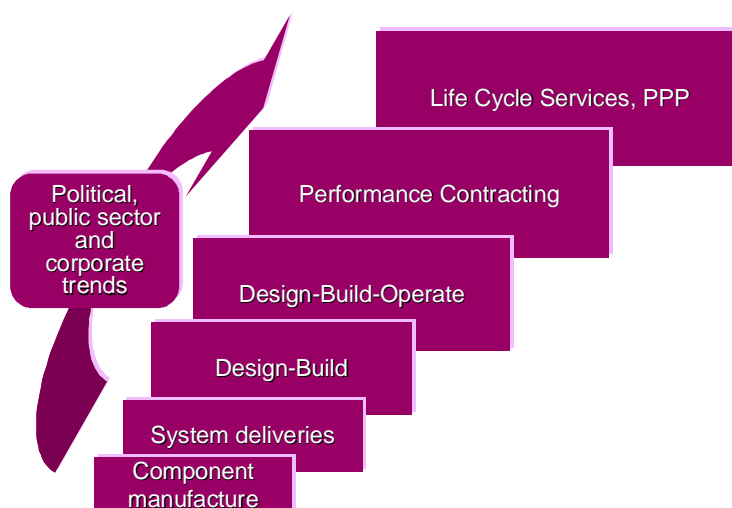


Figure 5. A vision about how added-value business-models could accelerate the change towards life-cycle optimised, service based business.³

² Adapted from Ivo Opstelten

³ Adapted from Ilari Aho

4. RESEARCH ROADMAP

Taking into consideration the drivers and barriers described below, roadmaps towards the target (research priorities) were created for four important areas of attention:

- **end-users:** this area describes the sustainability from social point of view
- **energy and environment:** this area describes the sustainability from ecological point of view, the focus in the roadmap is on energy issues
- **market and business:** this area describes the sustainability from economical point of view
- **solutions:** different products and solutions are placed differently according to their ability to fulfil the three criteria. The final goal is a solution that fulfils all three criteria in a balanced way.

The roadmaps are based on the outcome of the four working groups in the Future Buildings Forum. The working groups were commissioned with the questions: “Where should we go?” (Vision) and “What needs to be done?” (Roadmap) The key questions to answer were: What technologies and systems would be used in 2030? Which business practices that will make it happen? All other participants circulated in the four groups, only the Groupwork leaders stayed in the original group. The results were then discussed in a common session and a whole picture mapping was conducted jointly.

4.1 Barriers and drivers

There are currently several things working for the introduction of more sustainable buildings and communities, but still many barriers obstruct the way and must be tackled before a real breakthrough.

Increasing scarcity of natural resources on one hand and population growth on the other hand necessitate more effective use of energy and materials. In these circumstances, the endlessly available source of energy offered by the renewables is getting more and more attractive. Pollution and extreme weather phenomena have increased lately, resulting in e.g. Kyoto Protocol and increasing co-operation between international authorities. Also, awareness of environmental issues has grown dramatically over the past few years. Unfortunately studies have shown that environmental awareness not always results in environmentally friendly behaviour (Steg 1999).

The appearance of more legislation on environmental issues in building codes was seen as a driver for more sustainable buildings and communities. The increasing legislation on emissions and energy-use also creates demand for new ways of making business. On the other hand, lack of internationally harmonised terminology and lack of binding international agreements and targets were seen as barriers.

A driver to performance based solutions is the increasing interest in human health and wellbeing aspects (like sick building syndrome, productivity, etc). It is also expected that the increasing environmental problems affect negatively to human health. The performance of the spaces has to fulfil the individual requirements of the users

The rapid and continuous urbanisation gives challenges for the design of communities, but it also gives opportunities, like possibilities to increased use of district heating and cooling systems and development of compact energy efficient cities. Aging of people and buildings in industrialised countries creates need to adapt buildings to life-cycles of population and increases need of renovation. Labour shortage in industrialised countries necessitates product development towards more prefabricated and industrially produced buildings and systems. This in turn requires changes in education.

Rise of living standards in developing countries offers on one hand increasing business opportunities, but on the other hand new challenges to solve the scarcity of natural resources. The 80 % of world's population now living in developing countries will soon require the same quality of life as the people of the industrialised countries. The urgent need to solve this equation in a sustainable way calls for close international co-operation. Although many solutions are universal, some specific solutions are needed in the very different circumstances of the developing countries. In developing countries, fast-paced new development both in the formal and informal building sectors, coupled with a more limited ability to pay for high-tech or expensive technologies, means that solutions must be low-cost and be readily available to wide range of people, governments and businesses.

Lack of knowledge was seen as one of the major barriers for more energy efficient buildings and communities. It is overlapping many groups, like policy makers, designers, consumers, and many areas, like energy usage, carbon emissions, terminology, new technology, energy efficiency. The information has to be easy to find and understand, preferably in peoples own language. Financial barriers consist mainly of two factors: 1) Perceived high investment cost of energy efficient technology, 2) Perceived low price of non-renewable energy. Some political barriers were also recognised, including powerful lobbies (i.e., oil companies, electric companies, airline companies). Financial incentives (subsidies and tax credits) are often critical to overcome barriers.

The rapid development of ICT solutions offers new possibilities for improvement of environmental awareness as well as the persistence of performance through continuous commissioning with the help of building service systems.

4.2 Market & business

4.2.1 Roadmap

Main topics:

- User driven market
- From components through systems to solutions
- Integrated processes, performance-based business

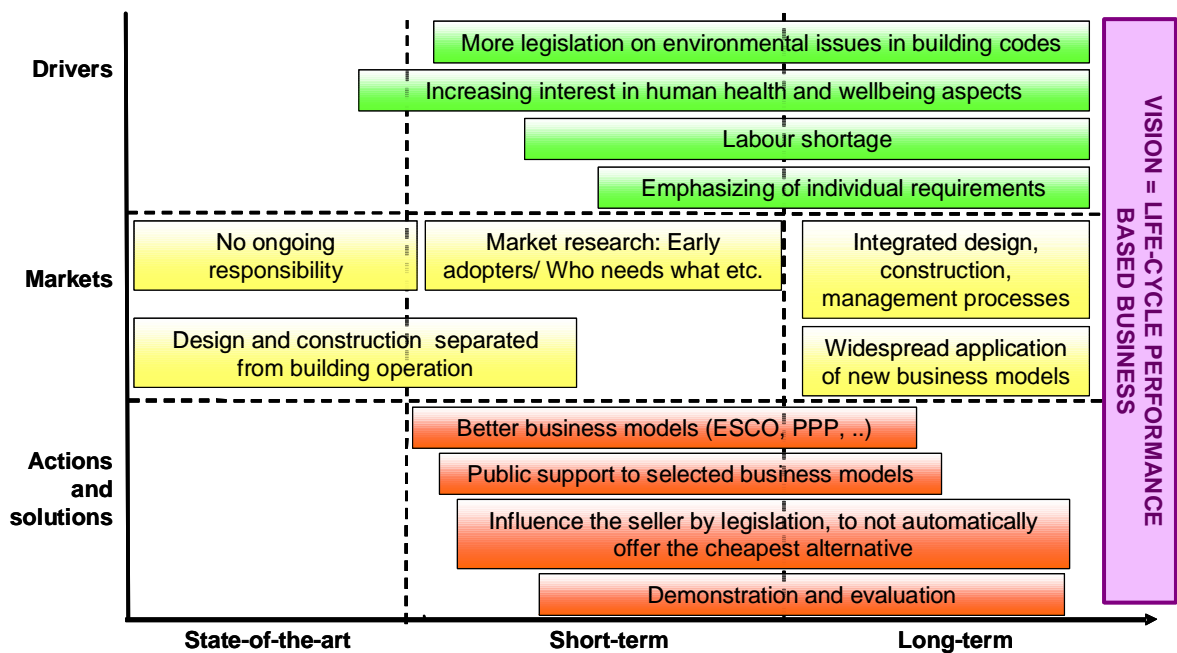


Figure 6. Roadmap - Value-driven business processes.

Table 2. Current vs. target state

Current state	Envisaged target state
<ul style="list-style-type: none"> • The design and construction process is separate from building operation • Once the building is handed over, there is no ongoing responsibility • This results in poor feedback to designers and builders and little incentive to respond to any that there is. 	<ul style="list-style-type: none"> • Buildings that meet users' needs • Customers have confidence in long-term performance • Integrated design, construct, management processes • Successful and profitable businesses.

4.2.2 Short term actions and R&D

- Identify better business models, ESCO could be one example or public-private partnerships (Different models for different circumstances.) Some models may need public support. Models must include
 - effective feedback mechanism from operation and users
 - financial rewards for good performance
 - appropriate risk apportionment

- ongoing designer responsibility
- Identify likely early adopters for demonstration. These could include
 - Owner-occupiers
 - Municipalities
 - Builders
 - Companies
- Could we influence the seller by legislation, so that he would not automatically offer the cheapest alternative? Incentives to constructors and sellers to learn about energy-efficient technology?

4.2.3 Medium term actions and R&D

- Demonstrate and evaluate early examples of new business models

4.2.4 Long term actions and R&D

- Move to widespread application

4.3 Energy & environment

4.3.1 Roadmap

Main topics:

- Energy efficient buildings and communities
- Waste and waste water treatment
- Optimal use of energy and resources

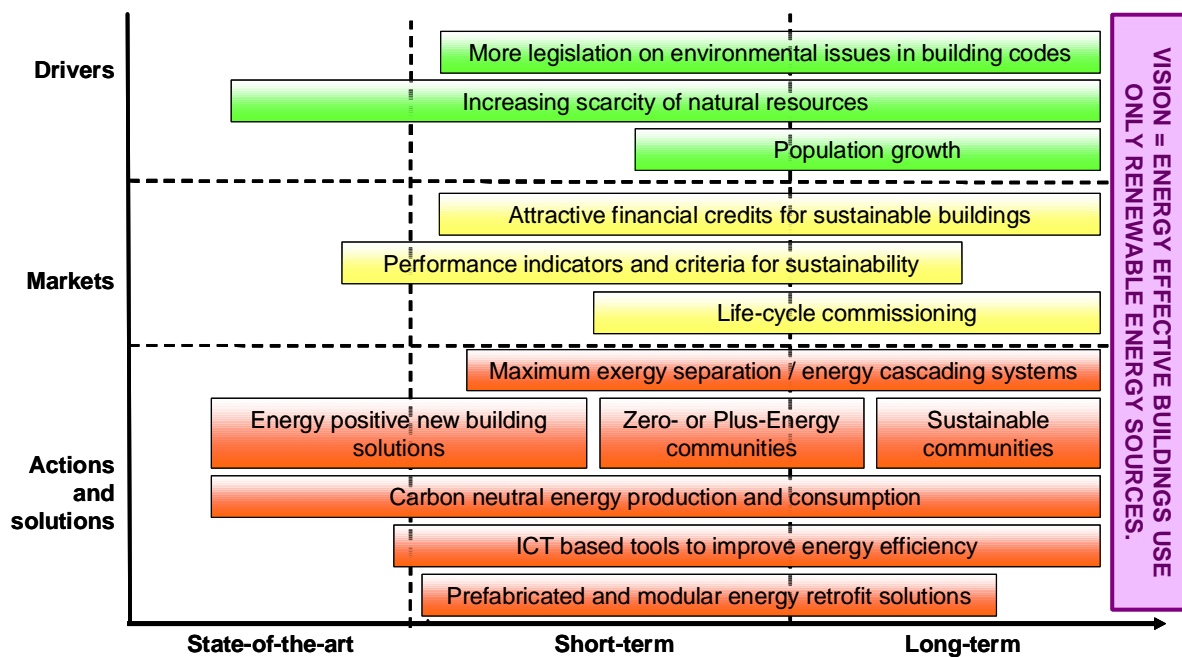


Figure 7. Roadmap – Energy efficient buildings and communities.

Table 3. Current vs. target state

Current state	Envisaged target state
<ul style="list-style-type: none"> • Buildings use 40 % of energy, and generate serious impacts on environment through the use of water and other natural resources, land use and waste generation. 	<ul style="list-style-type: none"> • Buildings and communities in 2030 use half of the amount of energy than today and only use renewable sources for the energy they produce on demand. • Full energy separation / total energy cascading systems. • Virtual H&P with dynamic grids / Interconnected decentralised energy production.

4.3.2 Short term actions and R&D

- Design and demonstrate energy positive new building solutions:
 - RE-driven μCHCP
 - smart & small AHU
 - passive energy storing construction materials
 - advanced (active, compact, loss-less?) energy storing construction material
 - HP-driven (dish)washing

- LED-lighting
- smart glazing
- E&C effective daylight capture through ceiling
- Design and demonstrate prefabricated and modular energy retrofit solutions, like:
 - multifunctional building envelope solutions
 - low temperature heating and cooling solutions (LowEx)
 - hybrid ventilation solutions
 - advanced lighting solutions
 - building and community systems
- Develop performance indicators and criteria for sustainability, environmental impacts and GHG reductions in buildings (low energy class, energy stars, etc.)
- Develop advanced control systems, sensor networks, user-interfaces and information management technology to improve energy efficiency and reduce negative environmental impacts in buildings and communities.
 - wireless sensor / actuator network
 - smart meters
 - dynamic heat and power grids

4.3.3 Medium term actions and R&D

- Design and demonstrate more solutions for energy positive buildings (new and retrofit):
 - vacuum frame
 - cabrio-facades
 - lego (retrofitting) building elements & interior refurbishing
 - compact seasonal heat/cold storages
- Demonstrate Zero- or Plus-Energy communities
 - intuitive, educational, self-learning E&Cms
 - HRU-bank for HHA (and waste water)

4.3.4 Long term actions and R&D

- Develop more solutions for energy positive new buildings and retrofit:
 - thermo-chemical material for heat storage
 - daylight storage
 - H₂ produced from the sun
 - vacuum envelope
- Develop solutions supporting energy positive communities:
 - energy HUB –economic driven buildings (industry) & transport
 - DC grids
 - PV&T wire & pipe free
 - wireless energy exchange
- Demonstrate Sustainable communities
 - economic efficiency by integrated system optimisation (optimal use of exergy)

4.4 End-users

4.4.1 Roadmap

Main topics:

- Demonstration of technologies and solutions
- Information mechanisms for all parts of society (from decision makers to end users)
- Reporting buildings

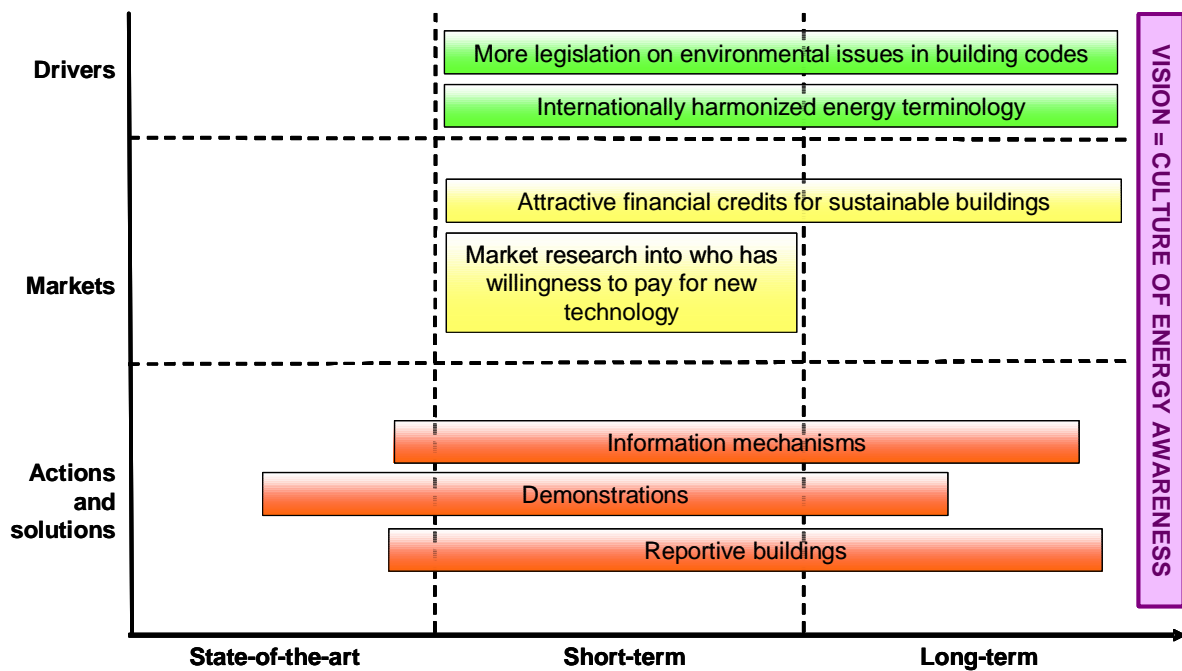


Figure 8. Roadmap – Energy aware customers.

Table 4. Current vs. target state

Current state	Envisaged target state
• Customers are only interested in price.	• Customers are interested in life-cycle performance.
• People are not aware of the impacts of buildings in the environment.	• Culture of environmental awareness.
• Lack of binding international agreements and common terminology for energy use and environmental impacts.	• Harmonized information leading to tight international agreements and their monitoring.

4.4.2 Short term actions and R&D

Following actions were proposed to improve the situation in short term:

- Information mechanisms have to be improved:
 - Energy should be part of young childrens' education
 - Policy makers should be provided with concise & accurate information
 - Changing peoples' attitudes is imperative
 - People have to know where they spend energy

- Information for building industry, manufacturing, installation, designers
 - Information has to be provided in peoples own language!
- Markets
 - Market research on who has willingness to pay for new technology and who needs more knowledge

4.4.3 Medium term actions and R&D

- Energy terminology has to be harmonized internationally.
- Demonstration is needed:
 - Demonstration of good practice
 - Demonstrate relation between knowledge & health
- Markets
 - Attractive financial credits for sustainable buildings

4.4.4 Long term actions and R&D

- People should be taxed on their energy consumption.
- Reportive buildings
 - Buildings report how much energy they consume in real time "Live Energy Benchmarks"
 - Consumers know, from their bill, how much energy they consume
 - Know embodied energy consumption for a particular system life-cycle analysis.
 - Virtualisation and visualisation of energy use and performance with ICT

4.5 Solutions

4.5.1 Roadmap

Main topics:

- Solutions instead of components
- Energy efficiency, self-contained
- Performance based
- New business models needed

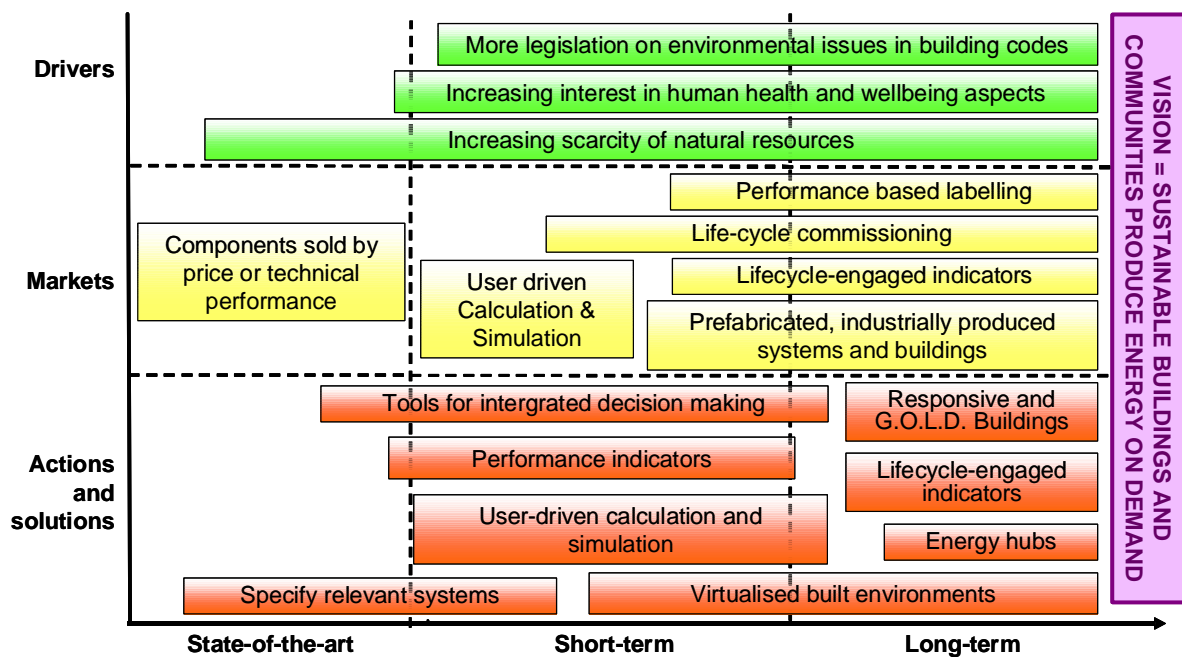


Figure 9. Roadmap – From components to solutions.

Table 5. Current vs. target state

Current state	Evisaged target state
<ul style="list-style-type: none"> • The information about the energy use, environmental impact or performance indicators is not easily available or even non-existent. 	<ul style="list-style-type: none"> • Communication (VR) box can be found in all homes and offices, offering real-time and easily understandable information about the performance, energy use and environmental impacts of the building and community.
<ul style="list-style-type: none"> • Buildings are partial-optimised. 	<ul style="list-style-type: none"> • Buildings are G.O.L.D. (Globally Optimised Locally Designed).
<ul style="list-style-type: none"> • Components are sold separately by price or technical performance. 	<ul style="list-style-type: none"> • Instead of components or buildings, in 2030, market offers integrated and performance-based solutions for energy efficient and environmentally friendly buildings and communities that support sustainability.

4.5.2 Short term actions and R&D

- Definition & specifications of performance

- User driven calculation & simulation
- Specify relevant systems
- Start by few performances & few systems
- Develop individual climate zones.

4.5.3 Medium term actions and R&D

- Demonstration & validation of performance indicators
- Robustness and validation of user-driven calculation and simulation
- RD&D⁴ of few performances and few systems

4.5.4 Long term actions and R&D

- Performance based labelling
- ICT-based tools for intergrated decision making (virtualisation and visualisation)
- Intergrated system based indicators
- Implement rating
- Lifecycle engaged indicators

⁴ RD&D=Research, Development and Demonstration

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6. ACRONYMS AND TERMS

- AHU: Air Handling Unit
- CHP: Combined Heat and Power
- DBO: Design-Build-Operate, The same entity is responsible for designing, building and operating the system, building or community
- DC: District Cooling
- Design-Build: The same entity is responsible for designing and building the system, building or community
- DH: District Heating
- DHC: District Heating and Cooling
- DSM: Demand Side Management
- ECBCS: Energy Conservation in Buildings and Community Systems, one of the x Implementing Agreements of IEA
- ECES: Energy Conservation through Energy Storage, one of the x Implementing Agreements of IEA
- Energy HUB: different energy flows (supply and demand) are interconnected in a central point from which the different energy demands can be fulfilled.
- ESCO: Energy Service Company
- Exergy: Quality energy. Usable form of energy. The Second Law of Thermodynamics tells us that the quality of a particular amount of energy i.e. the amount of work, or action, that it can do, diminishes for each time this energy is used. Unlike energy, exergy can be consumed and is constantly diminishing in the universe, while entropy is generated.
<http://www.holon.se/folke/kurs/Distans/Ekofys/fysbas/LOT/LOT.shtml>
http://www.holon.se/folke/kurs/Distans/Ekofys/fysbas/exergy/ENERGI_EXERGI2.jpg
- HP: Heat Pump
- HPC: Heat Pump Centre
- HHA:
- HRU: Heat Recovery Unit <?>
- LED: Light Emitting Diode
- PFI: Private Financing Initiative
- PPP: Public Private Partnership for Life Cycle Services,
- PV: PhotoVoltaics
- PVPS: Photovoltaic Power Systems
- RE: Renewable Energy
- RES: Renewable Energy Source
- SHC: Solar Heating and Cooling Programme
- μ CHCP: small-scale Combined Heat, Cool and Power

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