REPORT 2

SUSTAINABLE CONSTRUCTION IN FINLAND IN 2010

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NATIONAL REPORT

CONTENTS

1. INTRODUCTION

This is the Finnish national report of the CIBW82 project: Sustainable Development and the Future of Construction. The report is based on brainstorming discussions within an informal scenario group (see Annex 1.) that was temporarily called for that purpose. Remarkable contribution has also been received from other sources, such as relevant ongoing research and development projects [1], the cluster-based working groups [2] of the Ministry of Trade and Industry and the sustainable construction committee [3] by the Association of Finnish Civil Engineers RIL.

1.1 Construction and Environment

Building sector presents 44 % of the total energy consumption in Finland: 34 % for heating of buildings and electricity used in households and 10 % for building production (out of which 70 % comes from manufacturing of products and 30 % from transportation and building sites). In addition, 3 % of the total energy is consumed by production of building materials and products for exportation (see Figures 1 and 2).

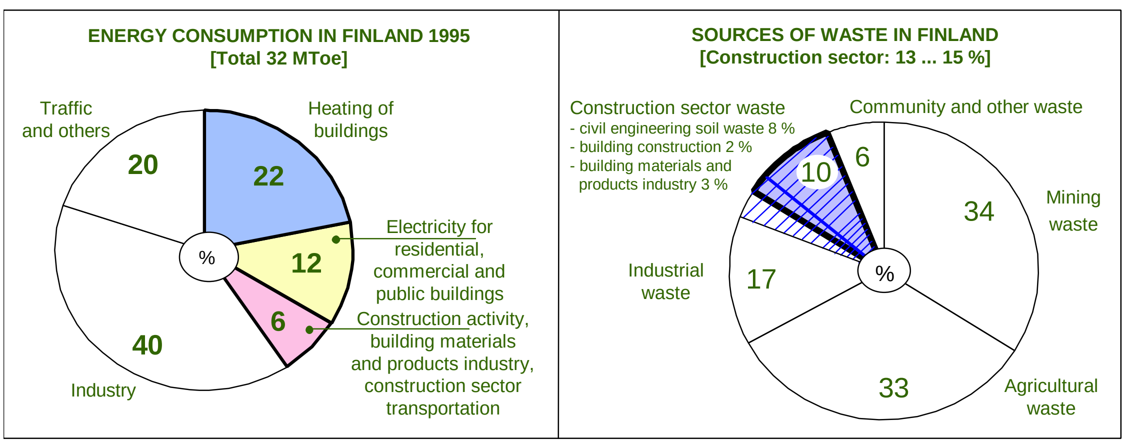

Figure 1. Energy consumption and sources of waste.

About 13 % of the total waste is estimated to come from building sector: 8 % from civil works (soil construction), 2 % from construction of buildings and 3 % from manufacturing of building products. 15-30 % of the building waste is estimated to be now recycled. [4]

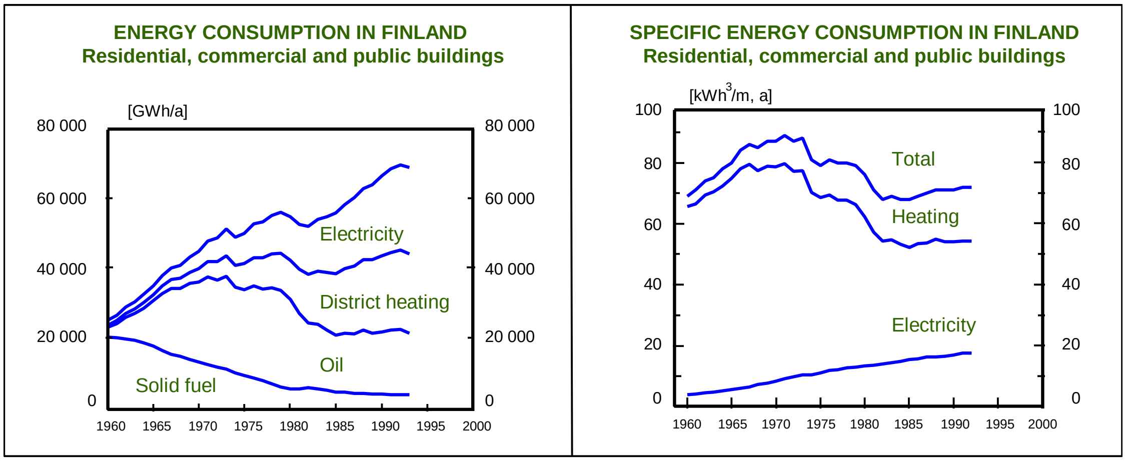

Figure 2. Energy consumption in buildings.

The most important ongoing environment-related research and development effort in our country is the technology program: Environmental Technology in Construction (1995-99) [5], that is coordinated by the Technology Development Centre. It has an estimated budget of 20 million USD to be covered by about 50 % by the participating companies. It aims at developing of methods and technics for environmentally sound construction to be implemented in enterprises. It covers the fields of ecobalance and life cycle, design guides and procedures, environmental geotechnics, products and production technologies, and demonstration projects.

1.2 Environmental Concerns

The main environmental concerns of our society are environmental burdens of the industry, energy economy and emissions in the use of buildings, and environmental impacts of traffic. The important issues related to the building sector are, besides energy and emissions, the service life of building systems and products, and maintenance and refurbishment of the existing building stock. One hot topic of today in Finland is management of indoor air quality, including the mould issues.

The Council of State of Finland has in December 1995 made a policy decision concerning the realization of energy saving. According to it, the energy consumption in 2010 should be 10-15 per cent lower compared to the development without a change in the energy policy (estimates based on energy economy and prices). The saving policy is economically based on taxes, elimination of subventions which may prevent savings, building refurbishment, research and development for energy saving technology, and a new third party financial system. The influence of the European Union policy has been taken into account. According to the decision, all measures should be initiated during years 1996-97.

The preparation of Agenda 21 programmes is based on the UN Rio Conference on Environment and Development which was held in 1992. One chapter of the work programme Agenda 21 recommends the preparation of Local Agenda 21 programmes. In Finland, around 50 municipalities (or cities) are now involved in Local Agenda 21 projects. In spite of the fact that they are around one tenth of Finland's municipalities, they cover more than 40 per cent of the Finnish population. The Agenda process is going on in practically all bigger cities but there are also minor municipalities like Kumlinge in Åland. A regional perspective is still rare. The few exceptions are Mikkeli, Oulu, and the capital areas. Each municipality makes its own local programme for sustainable development. The programme is made in cooperation between the municipality, organizations of citizens, industry and commerce, and residential organizations. The municipal administration acts as a coordinator. Central issues have been land use, traffic, energy, environmental attitudes and education, nature conservation. Social issues include i.e. employment and local democracy. Less attention has been paid to consumer habits and the problems of rural development. The Ministry of Environment has been subsidizing the most prominent Local Agenda projects.

One of our major challenges for the future will be setting of growth objectives to qualitative level instead of quantitative. Sustainable growth may be interpreted as increase in efficiency of production and increase of consumption of services instead of consumption of goods.

1.3 Objectives of the Study

Long term objective is to improve the quality of our life (see Figure 3) by promoting environmentally sound construction – or, to ensure its present level for future generations.

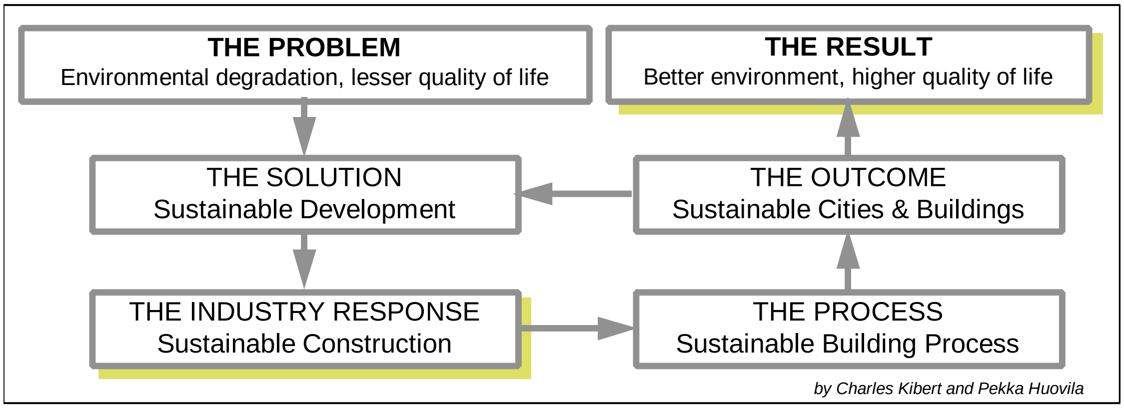

Figure 3. Improving the quality of life by sustainable construction.

The research objective is to study which will be the consequences of sustainable development to construction by the year 2010 [6]. National research results are planned to serve for managing the construction industry and its research and development to consider the identified main consequences of sustainable development to the building and operating process. The planned time schedule of the international study is presented in Figure 4.

Figure 4. The planned time schedule of the international study.

2. METHODOLOGY

The methodological structure (Figure 5) consists of the following steps [7]:

- definition of what is meant by sustainable construction
- description of national constraints, special issues and future scenarios for 2010
- answers to defined questions concerning the building sector
- analysis of the main consequences of expected sustainable development to the building and operating process (Figure 6)
- presentation of selected success stories to serve as examples for companies, organizations and countries to encourage them towards implementation of environmentally sound procedures and products
- an international synthesis, based on national reports, will be produced following a common methodology and format
- recommendations to the building sector based on the discussed main changes.

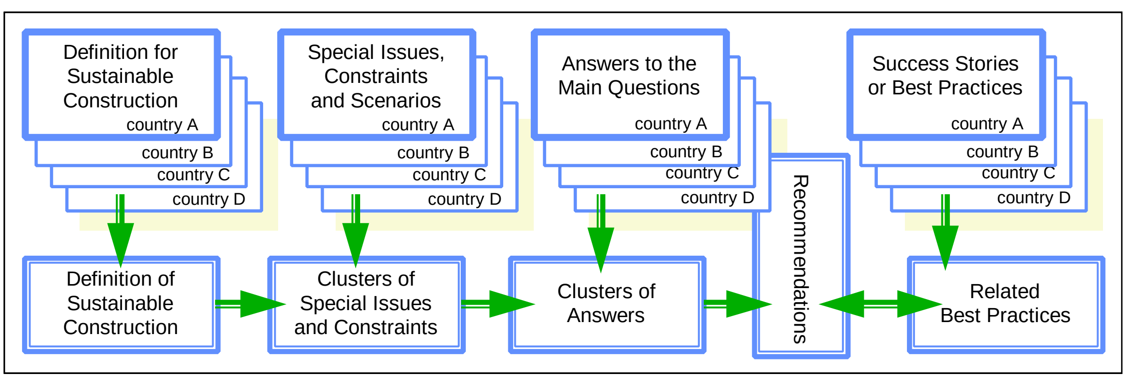

Figure 5. Different steps of the project.

Process \ Resources	LAND	ENERGY	WATER	MATERIALS
Urban planning				
Product development & Design				
Manufacturing & Construction				
Operation				
Deconstruction				

Figure 6. Structure of the consequences to the building and operating process.

2.1 Definition of Sustainable Construction

Sustainable development has been defined by the World Commission on Environment and Development in 1987 as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable construction was defined in the First International Conference on Sustainable Construction in 1994 as: "The creation and responsible maintenance of a healthy built environment, based on ecological principles, and by means of an efficient use of resources."

In Finland, sustainable development is often treated in three areas: ecological and economical, social, and cultural. In this context, the sustainable construction discussion is emphasized at ecologically sustainable construction, which means essentially management of biodiversity, tolerance of the nature, and saving use of resources. Achievement of ecologically and economically sustainable construction enables socially and culturally sustainable construction.

According to our current definition [8], sustainable construction: "In its own processes and products during their service life, aims at minimizing the use of energy and emissions that are harmful for environment and health, and produces relevant information to customers for their decision making." To building construction this means:

- intensified energy-efficiency and extensive utilization of renewable energy sources
- prolonged service life as a target
- saving of the natural resources and promotion of the use of by-products
- reducing of waste and emissions
- recycling of building materials
- supporting of the use of local resources
- implementation of quality assurance and environmental management systems.

The desired state prevails environmentally responsible industry and building owners together with environmentally conscious consumers.

2.2 National Constraints, Special Issues and Future Scenarios

In Finland, the availability of free space, and air and water of good quality, is not seen as a problem to be solved. That reality is not striving us for environment-saving solutions (like it maybe has in some other countries). The climatic conditions in the North of Europe are cold, leading us to energy saving thinking and acting as a self-evident matter. Large share of our population lives in scattered areas and we are depending on imported energy. In general, the education standard is high, and means for co-operation and large-scale responsibility exist. All that gives us a good starting point for developing and implementing sustainable construction both within our borders, and abroad.

Although construction is mainly a home market activity, the market requirements in Central Europe act as a driving force to a larger extent than just to our manufacturing industry, that is already actively exporting their building products. Our risen interest towards environment-conscious thinking risks to stagnate if no clear signs of its practical implementation is seen in the European market. The driving force for sustainable development in our building sector may be based on competitive factors (quality and environmental control), and image considerations to amplify the picture of the pure nature in the North. These success factors are, and certainly will be, associated with competition circumstances in Finland and in Europe.

Definition of our sustainable development scenarios was started by looking at applicable existing scenario works. Three recent ones (Figure 7) were selected: four Dutch [9] national sustainable development scenarios for 2030, four French [10] national future scenarios for 2030, and five Finnish [11] global future scenarios for 2005 and on.

Our scenario discussion commenced with treatment of the Dutch scenarios Strong Together and Strong Alone combined with the Finnish scenario Master Plan. The chosen working procedure, that was judged most profitable for this occasion, was first to set sustainable future objectives, then start to accomplish them. Therefore our efforts were focused on describing one desired and realistic future, instead of comparing different alternative scenarios. The mission of the group was understood as not to discuss unsustainable futures.

The methodical idea of the Dutch framework Duurzame Ontwikkelingscenario is interesting. The method is based on the idea of four kinds of capital which are environmental, manufactured, human, and social capital. Different weights are given to them in the four scenarios. In the background there are assumptions about how far the environmental capital can be substituted by other kinds of capital. In the first two scenarios (Strong Together, Strong Alone) there is no substitution available. The third scenario (Considered Sustainment) allows limited and the fourth one (Weak Sustainment) practically unlimited substitution. Other differences between the scenarios concern i.e. the international role of the Netherlands, international development of environmental policies, some social considerations, and the role of technology in the society.

Duurzame Ontwikkeling-scenario (The NL 1996) *Span*: 2030 *Scope*: "Extended economy" forms of capital and their interchangeability	**Bâtiment 2030 / Club Bâtiville** (France 1992) *Span*: 2030 *Scope*: National & European socio-economic variables	**Finland an the possible worlds / SITRA** (Finland 1995) *Span*: 2005 – ? *Scope*: Global development "macro level phenomena"
A1 **Strong Together** Global dominance of environmental values	B1 **Laisser-faire** Strong liberalism + economy in crisis	C1 **Master Plan** Multinational cooperation + political stability + sustainable development
A2 **Strong Alone** National dominance of environmental values	B2 **Croissance duale** "Intermediate scenario": liberalism + fordism + modest economic development	C2 **Mercyless Business** Dominance of the market and free capital + economic and political instability
A3 **Considered Sustainment** "Intermediate scenario": modest regulation + technological optimism	B3 **Productivisme** Dominance of the EU level + modest regulation + technological optimism + strong economy	C3 **Conflicting Cultures** Cultural blocs + national separatism + economy-driven conflicts
A4 **Weak Sustainment** Market dominance, liberalism + technological optimism + strong economy	B4 **Développement durable** Dominating environmental values on the global and the EU level	C4 **Beyond the End** A fast and severe crisis invoked by competition and economic growth + global disorder + new localism and regionalism
		C5 **Competing Power Blocs** International spheres of influence + hegemony of power blocs + power politics

Figure 7. Future scenarios.

The French Bâtiment 2030 stays on the national level but runs a respectable apparatus of structural components (14) and variables (27 in total). The components are: population, economic growth, housing policy, role of Europe, urban policy and land use, environment, lifestyles and dwelling, energy, traffic, economic market and cost level, building design and functionality, quality of building, building research and technical development, and greenhouse effect. The resulting four scenarios describe different causal patterns of development of these elements. The international level is included as external conditions in the framework. The overall approach seems quite consistent and logical. A relatively strong emphasis is given to (positive) impacts of technological progress and independent (not industry-driven) research in building and construction.

Finland and the possible worlds is interested in general global development and the respectively invoked national issues. The scale is larger and less accurate than in other frameworks. Each of the five scenarios is based on a dominating single factor. These are: international politics and supranational institutions, the power of the free capital market, cultural issues, ecological problems, and international spheres of power. The strength of this approach is its ability to delineate (national) risks and opportunities. However, the work is a somewhat problematic combination of realistic conclusions and creative causal imagination. The latter is needed to cope with multivariable uncertainty of global development without a strict method. However, this is the only approach which tries to derive the consequences of both political, economic, and cultural development outside the European Union.

The frameworks are not directly comparable because of crucial differences in their objectives and orientation. Duurzame Ontwikkelingscenario is the most environmentally oriented on a general level. However, building and construction do not have any special role in it.

On the contrary, Bâtiment 2030 is, as also its name indicates, specially aimed at the preconditions of favourable development of building and construction (including their social and ecologic aspects). This goal naturally reflects the national role of CSTB, the producer of the scenarios.

In Finland and the possible worlds the environment is only one theme and nothing is said of building. There is a clear emphasis of international politics and national decision-making.

2.3 Answers to the Main Questions

The following five questions were to be answered:

① What kind of buildings will be built in 2010, and how will we adapt existing buildings?

② How will we design and construct them?

③ What kind of materials, services and components will be used there?

④ What kind of skills and standards will be required?

⑤ What kind of cities and settlements will we have then?

The applied methodology [12] was to analyze data that was collected from simple questionnaires, which were filled by experts. The objective was to get a range of expectations of possible sustainable futures. A short questionnaire consisted of a definition for sustainable construction and the five main questions with the following assumptions and instructions:

- the fulfillment of a sustainable development (whatever it means)
- the future to be rather favorable than probable
- profound reasons for the answers are not needed, short answers are adequate
- the differences between today and year 2010 are especially interesting
- questions that don’t make sense to be ignored.

27 people were chosen as experts among those who work on the field and/or who should (based on their position) have a vision of the future of sustainable construction. The final sample consisted of 22 people with various backgrounds. Among varying answers at least the following themes could be identified:

① BUILDINGS (Figure 8):
- flexibility, multiple use, functionality of buildings
- small energy consumption, energy conservation, autonomous energy production, energy-economic construction, new energy sources, energy storage
- small amount of new buildings, utilization, economic renovation, and modification of existent buildings
- high and good quality, no quality defects
- long/short service life, life cycle costs.
- the speed and amount of the development was a minor question.

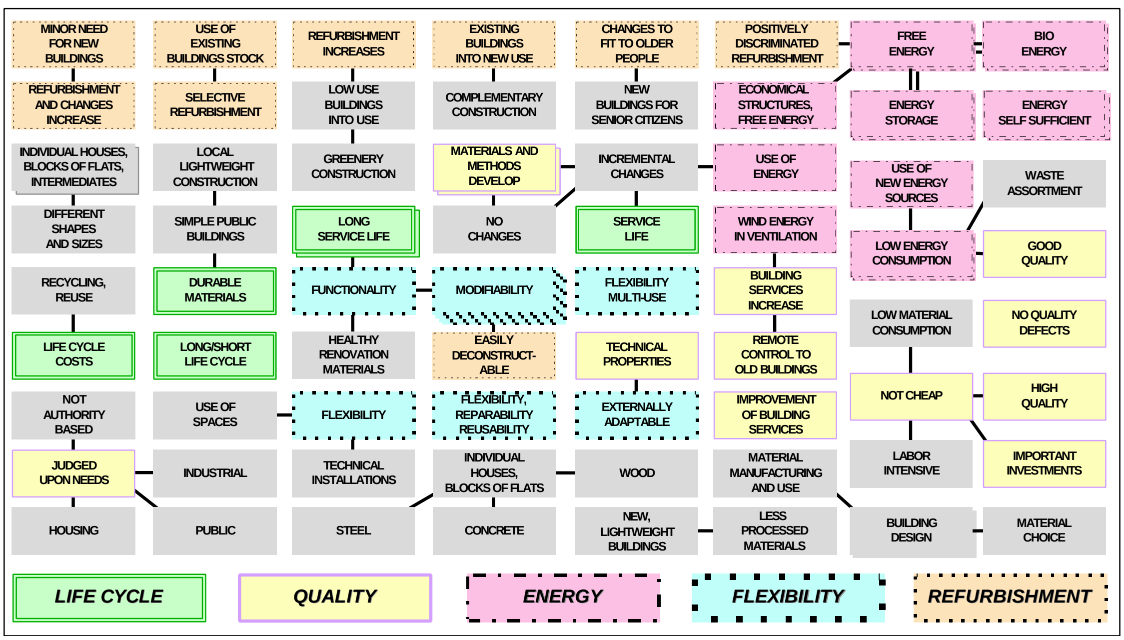

Figure 8. A map of answers regarding to sustainable buildings of the future.

② DESIGN AND CONSTRUCTION (Figure 9):
- the needs of the user, the participation of the client/user
- the increasing amount of design work, more demands for design, more investments to design work
- the importance of ecological knowledge, life-cycle analysis, environmental and ecology databases or other information systems, ecological profile data
- the increase of construction on-site, specialized on-site constructors
- the importance of local (natural) conditions and environment.

③ MATERIALS, SERVICES, COMPONENTS (Figure 10):

- recycling and re-use of materials, products, and equipment;
- recyclableness of materials, the ease of demolition
- easy repairs and service of equipment, little need of repairs, durability, long service life
- economic use of resources, renewable natural resources (like wood), small energy content of materials
- healthy, non-poisonous and non-allergenic materials, low emissions of hazardous substances
- new and 'high-tech' materials, glass products.

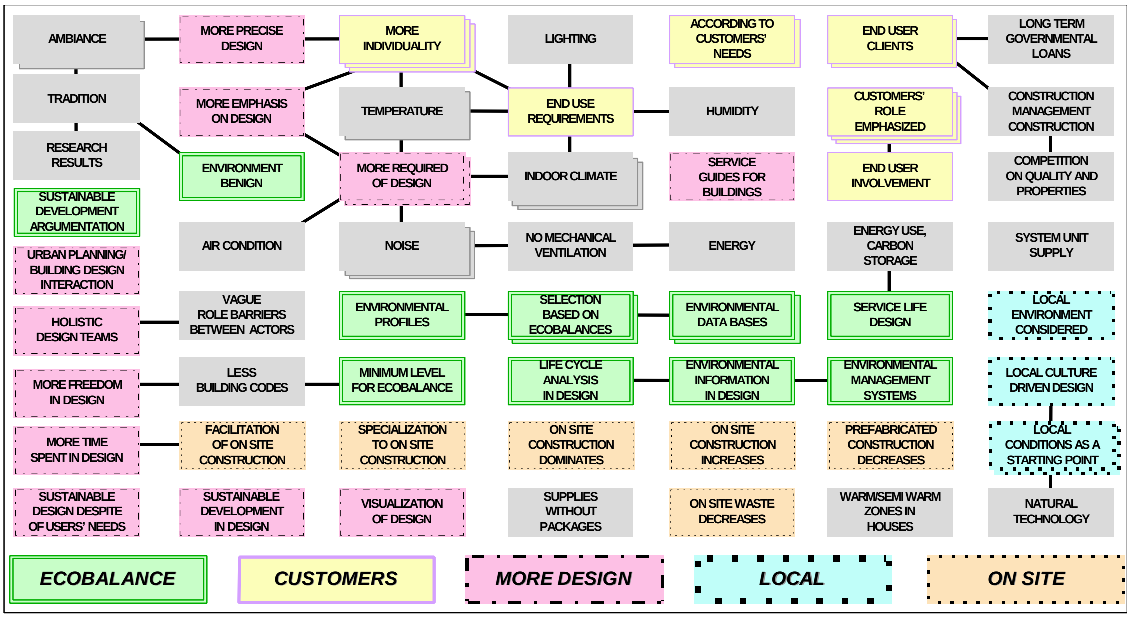

Figure 9. Design and construction.

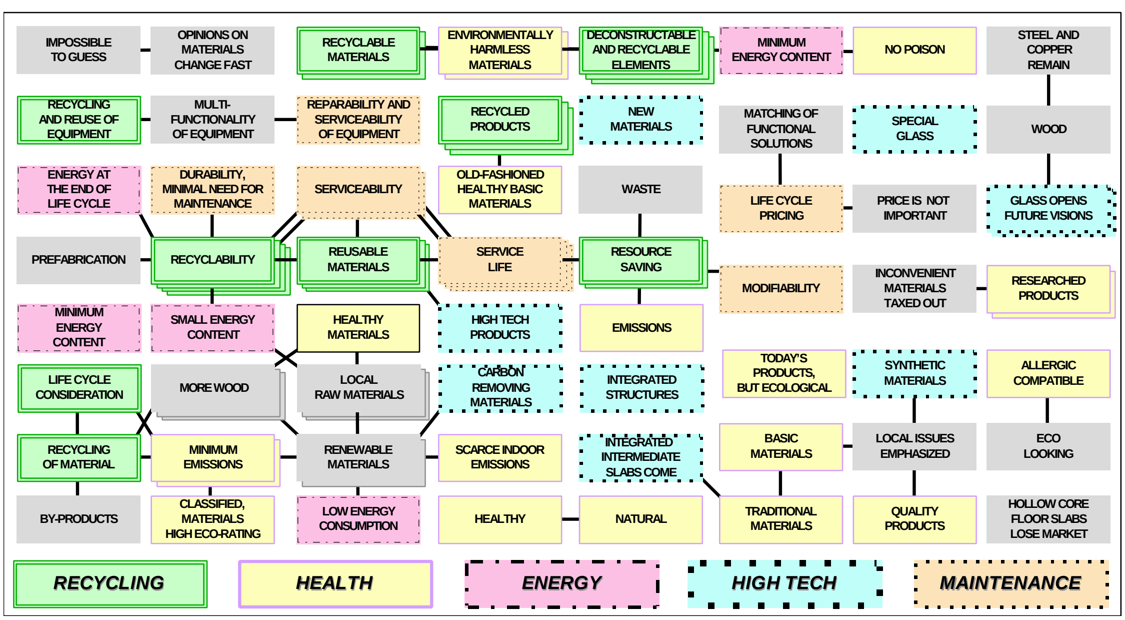

Figure 10. Materials, services and components.

④ SKILLS AND STANDARDS (Figure 11):

- skills, qualified labour, expertise;
- autonomy and responsibility of labour, quality production
- (on the contrary?) general skills, non-specialization, less important professional limits
- the ability to handle both new and old materials
- flexibility of regulations, non-descriptive regulations
- the importance of the life-cycle and overall performance, mutual coordination of the regulations.

No clear opinion existed about the importance of regulations.

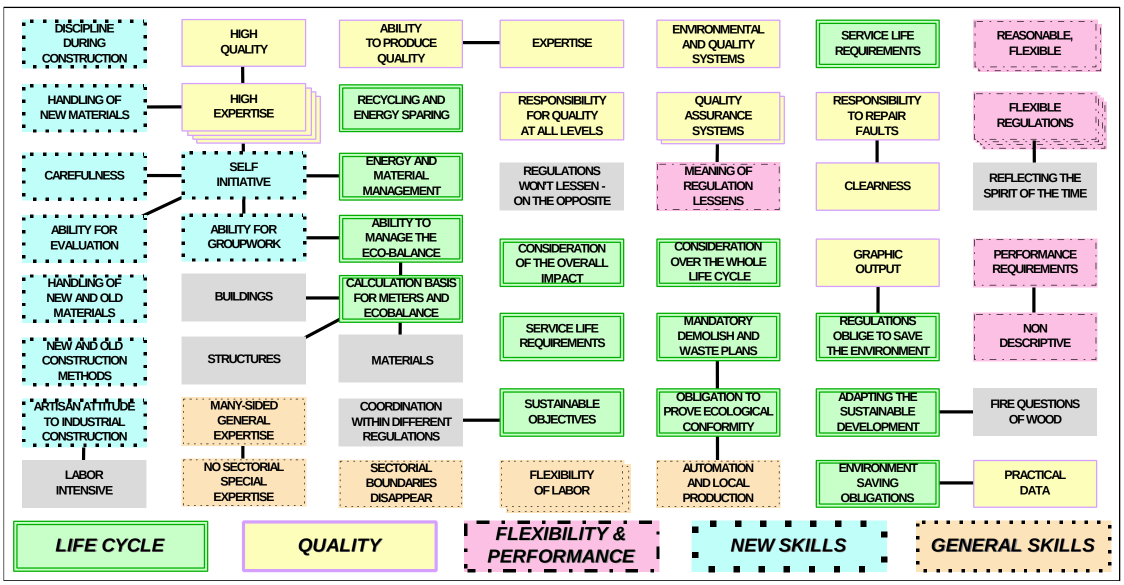

Figure 11. Skills and standards.

⑤ CITIES AND SETTLEMENTS (Figure 12):

- denser cities, dense urban structure (high or low)
- lower suburban structure, less apartment houses (or smaller ones), smaller scale, village-like environment;
- demolition of inferior suburban housing, no new suburbs
- more greenery and greener urban areas, well-planned natural areas, careful planning of non-built land;
- rural milieu will be conserved and utilized for food production
- telework will be more common and the workers may live in less urban or in rural areas;
- autonomous (satellite) districts of cities, functionally more integrated and more heterogeneous cities
- increased use of light traffic and public traffic, the separation of light and car traffic, central pedestrian areas;

- greater importance of traffic systems and traffic planning;
- more efficient utilization of networks and technical infrastructure.

But also opinions that no great changes will occur were given, or that sparse structure is still possible in Finland, or that the nature will not be conserved in time.

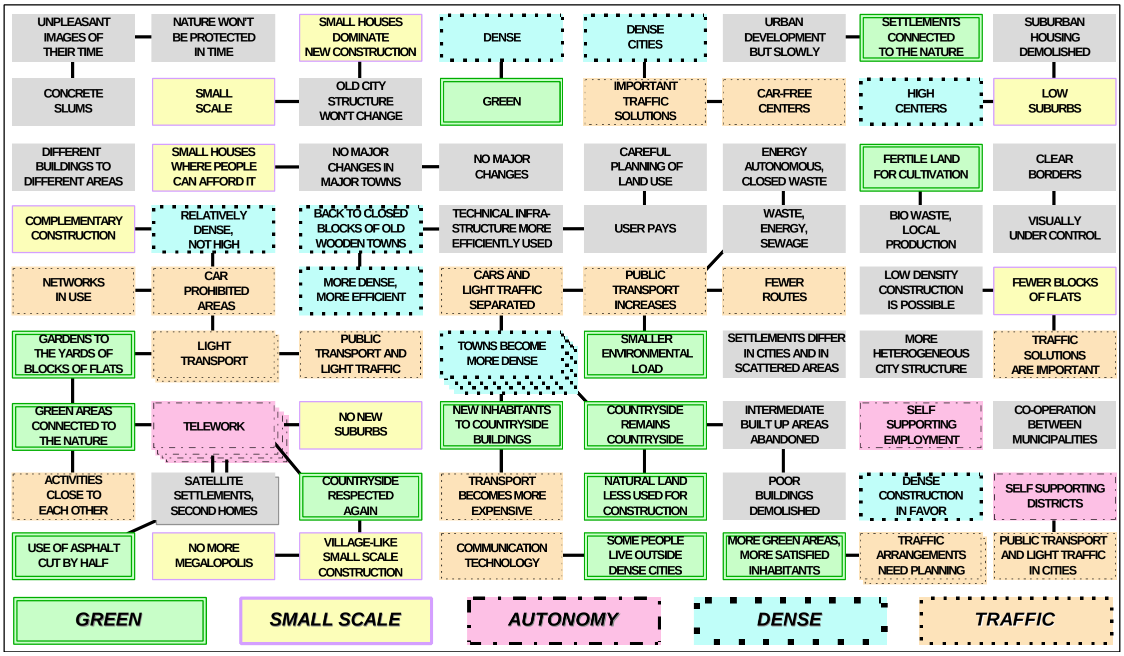

Figure 12. Cities and settlements.

3. CONSEQUENCES TO THE BUILDING AND OPERATING PROCESS

General consideration in Finland is, that our infrastructure (roads, schools etc.) could serve considerably greater population than the present. The national policy is to develop out networks further to support the industrial competitiveness and an overall logistics optimum. Electronic infrastructure is formed above the physical infrastructure.

Increasing share of aged (and disabled) people and the lifestyle in 2010 (values and consumption habits) will have a crucial influence in the housing requirements. A radical minority is expected to remain, regardless to the general trends, to act as our ecological conscience. Individual motivation towards environment-saving solutions may as well be ecological consciousness, optimization of life cycle costs or desire for high tech - gadgets.

The share of immigration in Finland is minor and the possibility of its remarkable increasing in the near future is occasionally discussed. (There are more people living around St. Petersburg, less than 500 km from our capital, Helsinki, than in Finland altogether.) That kind of future is not, however, considered to be likely.

In spite of the Nordic climatic conditions the level of our energy consumption (Figure 13) in buildings is in the same order than in the South of Europe. The share of low energy buildings will remain minor – most likely less than 1 % of the population will live in such dwellings in a fifteen-year time span, unless that will be supported through a conscious policy. In the 2010 horizon, 20 % of our buildings at the most, will be built after 1996.

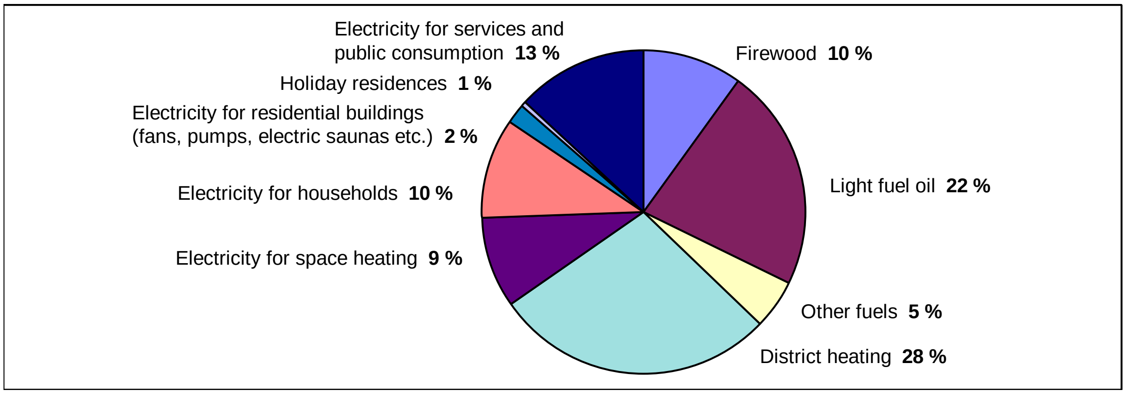

Figure 13. Energy consumption in residential, commercial and public buildings, total 7.1 Mtoe.

If 20 % of our buildings constructed after 1996 were, what is today concerned as low energy buildings (e.g. consuming half the energy that corresponding buildings do on the average), the total share of low energy buildings would reach 4 %, but even that can not be achieved without taking subsidizing measures. In fact, there isn't any common definition for low energy buildings. Such aspects as use of renewable energy sources, functionality, flexibility and service life should also be considered when judging the sustainability issues.

Refurbishment has also potential to affect considerably on energy saving. The share of our building stock constructed in the 1960's and 1970's is 30-40 % (Figures 14 and 15). If replacing of windows were done in 80 % of them the energy saving, together with other improvements, could be 15 % of the total energy consumption in each dwelling – summing up to 4-5 % decrease in total.

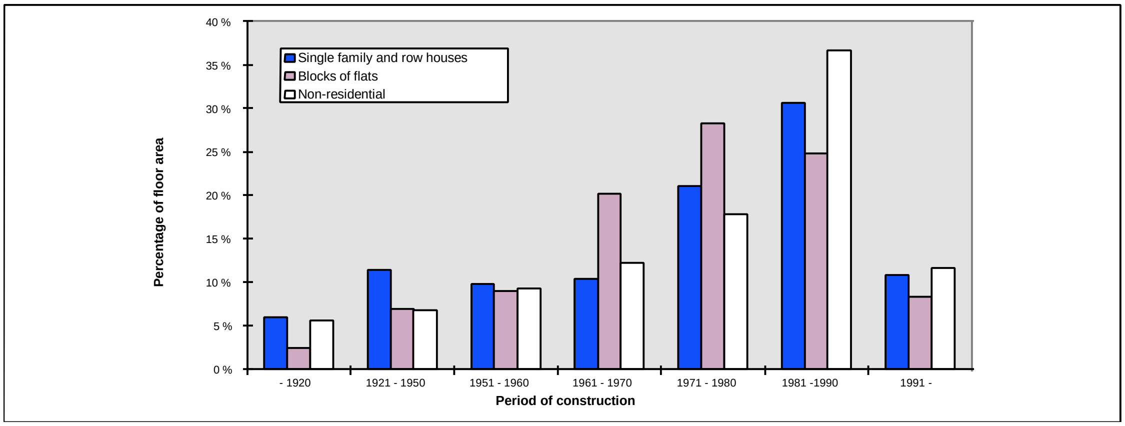

Figure 14. Age profile of the Finnish building stock as a percentage of the total stock floor area.

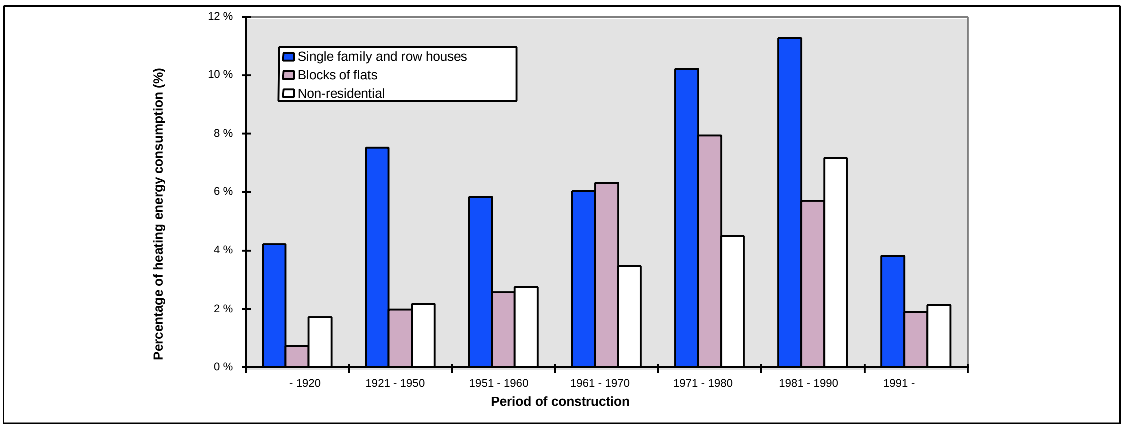

Figure 15. Calculated estimate of heating energy consumption related to the period of construction (influence of refurbishment is not counted).

The situation where the price that environment pays, can be changed to money, will affect all phases of the building and operating process.

3.1 Urban Planning

The growth of environmental-responsible thinking and possible public subsidies in energy saving affect on refurbishment. Increasing knowledge about greener solutions is expected to create new demand. A minor share of population will go teleworking as a result of improved electronic highways, but that doesn't necessarily affect on the development of the infrastructure. Ecological indicators are hard to define, density of habitation being one of the possible ones. That can, however, not be taken as the only measure, especially if it conflicts with the living comfort requirements of the individuals. A certain "minimum" level of sparse space must be maintained, although it would be in contradiction with environmental objectives. The know-how in the future will be harnessed to improve the quality of the neighboring environment.

LAND

The former industrial land use released for other purposes rises construction needs and speeds implementation of soil cleaning technologies. That development is expected to be accomplished by 2010, which means, that the market for that technology has then to be then found outside our borders.

ENERGY

Energy questions in communities will be answered from the point of view of technical solutions in the urban infrastructure, traffic arrangements, placing of buildings on site etc. District heating will remain the solution for big communities. In the countryside, flexible, wood-based – or other renewable – solutions, have potential. Combined heat and power production is still, and natural gas as a new alternative in the future, appreciated in large scale solutions.

WATER

Ground water protection will be our main challenge. Other possible issues will be local use of storm water, double drainage systems etc. Overestimated water consumption in our water supply network has created new problems. Low consumption and slow flow in ducts results in lessening quality of drinking water. We don't have water shortage and water saving is not our primary objective.

MATERIALS AND PRODUCTS

Local use of materials and products is prioritized because it reduces energy consumption in transport influences also positively in waste management opportunities. The overall impact of transport remains, however, small.

3.2 Product Development and Design

Most important issue is expected to be the indirect influence of producing of ecobalance by architects and engineers. Once the methodology exists and the tools are available (developed through research), it leads "automatically" to optimization process. (Analogically to the development of cost optimization with cost calculation tools.) Even normal loads for environment can be obtained as normal prices that are used in cost comparison. More design will be done early in the process. Penetration of energy-conscious thinking in architectural design will show. Design for service life is undertaken. Life cycle costs play a key role in trade-offs. Use of passive solar energy and daylighting, development of diagnostics and regulation systems increase energy efficiency.

LAND

The environmental footprint will be considered in design. That concept has a wider content (production, emissions, waste management etc.) than just the constructed land around building foundations.

ENERGY

Energy applications will be developed upstream early in the design process. The judgment develops from U-value to building entities. In the energy use, fuel switching may become important. That means choice opportunities in the energy sources in the real estates. Heat transfer systems that are not tied on one energy source will be favored. The objective is to use renewable energy sources. The cost level of new technologies is expected to change remarkably in the near future.

WATER

The essential objective is reducing of sewage water. Improved measurement for individual water consumption and waste water consumption is also needed. (Today, waste water is charged according to consumption of drinking water – even if not lead to drainage.) Water saving water and sanitary fittings are promoted.

MATERIALS AND PRODUCTS

In the proper use of materials it is important that the characteristics of waste materials are known and adopted in design. Selection of materials will be done according to users' needs and material properties, and individual service lives. Recycling becomes a reality. Products and systems of a shorter service life have tighter recycling requirements! It is also discussed whether some parts, like the envelope of building or heating and ventilation systems, should be designed for a shorter service life, when new products with new technology will be launched in the near future. (Sometimes it is better for the environment to replace old solutions with new ones.) Despite of the objective of minimizing of transport, for some components even a very long transport can be feasible. It is hard to predict how things, like modularity or easy replacement, should be considered in the ecobalance calculations.

3.3 Manufacturing and Construction

In the supervision, public approval of designs and follow-up of construction will be emphasized towards assurance of conformity to the plans, and technical supervision may be bought as a private service in the future. Developed technology enables flexible solutions. On-site emission of waste, noise and dust will decrease. Environmental management systems affect to the development, they are seen as means to increase the productivity and profit. The influence of a certain image is also important. Emissions of our own industry are important, because it has an effects on environment still after the year 2010. Environmental taxation is one of the possible means to influence in the future development.

LAND

In the future, the building site needs not to be blown up first, and leveled flat next. Instead, environmental sensible construction methods will be developed. Access roads that are needed during construction, can be used afterwards without reconstructing them. Construction waste management will be developed together with secure and neat sites.

ENERGY

Minimizing of transportation cuts down energy consumption. Increase of the price of energy will directly lead to energy-saving refurbishment.

WATER

Closed water circuits will be implemented in the manufacturing industry.

MATERIALS AND PRODUCTS

Improved and completely new processes will be introduced. Open building systems are be implemented with modularity and mecano clips in building services systems. Use of local materials is prioritized. Recycling technologies and renewable materials will be developed in the manufacturing industry. The producers' environmental (life cycle) responsibility covers also production processes. Product information includes also description of the conditions for the proper use. Reliable quality, durability and service life information of building products are required to be produced by their manufacturers.

3.4 Operation

Professionalism in facilities management spreads. Service guides of buildings will be common. Cost management together with indoor air quality and energy management will be important. Efficient use of resources hasn't been until now really been carefully planned.

ENERGY

Management of operation costs, energy and water consumption, and the indoor air quality are, by 2010, developed in thinking, tools and technical systems. Complementary energy systems are needed side by side with electric heating (there is half a million dwellings equipped with only direct electric heating). That, together with extended use of daylighting, economizes the use of electricity.

3.5 Deconstruction

Buildings constructed after 1996 will not be demolished by 2010. Deconstruction methods will still be traditional then, but new buildings are already designed to be reused and recycled. The key issues will be

- assorted demolition
- reuse of building parts
- stone-based waste directed to soil construction
- waste utilization for energy production (everything that burns should be burned)
- quality requirements for waste
- raw material base may need to be reconsidered also for image reasons.

Management of hazardous waste in demolition of old buildings is under control. Demolition permits and demolition plans are required. New business opportunities rise in recycling of building materials, such as service leasing. Our suburbs need environmental impact analysis for their life cycle; are all of them good enough to be refurbished – or should some of them be demolished?

MATERIALS AND PRODUCTS

Maximal share of serviceable components will be collected unbroken to be reused when its economically feasible. Demolished parts, such as doors, windows, roof tiles, blocks, logs, floor planks etc. must be assorted to enable their reasonable reuse.

4. BEST PRACTICES FOR SUSTAINABLE CONSTRUCTION

4.1 Ecological Single-Family House (Marjala)

The aim was to develop and build a house which during its life cycle disturbs the processes of nature as little as possible, e.g. exists in harmony with nature. The house should be a simple and cheap basic house for everyone, still having good architectural quality and providing occupants good quality and flexible living spaces.

The Marjala house [13] is built largely of wood and wood products. Other keywords are local products, simple technical solutions, repetition of same details and components, thus decreasing the number of different components. The inner surfaces are coated with so called ecological materials from nature, such as wall paper, paintings and waxes. The outer paints are cooked on site or made of skimmed milk as a base material.

It gets its energy for heating and hot water from firewood and sun. There's one stove in the house and 10 m^2 solar heating panels on the roof. Heat from firewood and sun is collected and stored in a 1.500 liter hot water tank. Standby heating is provided by a 6 kW electric heater at the bottom of the tank.

The heating energy of the Marjala house is 42-50 % of that of eight reference houses. It is supplied with an owner’s manual and service instructions for the next 50 years.

4.2 CFC-Free Low-Energy Office Building (METOP)

The building module prototype METOP for a low-energy office building was built for testing the performance of new structural, electrotechnical and HVAC solutions developed in different development projects of different companies. The main objective was to put into practice good indoor air quality, thermal comfort and low energy consumption simultaneously and economically.

Its heating energy consumption was measured 13 kWh/m^3 (55 kWh/m^2), which is 60 % lower than the average consumption in Finnish office buildings. The consumption of electricity was 16 kWh/m^3 (72 kWh/m^2), which is equal to average consumption. According to the measurements, there was no problems with the indoor air quality. Concentration of odors, radon, particles, microbes, volatile organic (VOC) and other chemical compounds were low. Thermal indoor climate was pleasant in winter and in summer. The satisfaction index was over 90 %.

The ground slabs were heat insulated with 120 mm thick polyurethane without CFC. The roof was insulated with a 350 mm thick layer of loose-fill insulation. Quality of construction was good and the air tightness of the building envelope was 0,8 air change per hour. The calculated U-value of the windows was 0,5 W/m^2K.

Contrary to the public opinion, this project showed that it is possible to improve the indoor air quality and energy economy and at the same time to improve the quality of the construction process and to reduce costs. METOP office building is heated with the energy produced by its own operations, almost throughout the year. In the hot summer periods, the building can be cooled with outdoor air and with the aid of a heat recovery device without refrigerators operating on CFC-refrigerants.

4.3 Energy-Conscious Dwelling (Soidintie)

The purpose was to find out the actual influence of structural and technical systems on construction costs and comfortable dwelling when ecological alternatives are favored. The goal was a 30 per cent reduction of annual heating energy without significantly increasing construction costs. First, performance and costs of various exterior walls and windows were calculated. A trade-off comparison between a better thermal insulation of exterior walls and windows and, on the other hand, building costs and dwelling comfort was performed. The results indicated the fact that a better insulation gives an opportunity of using floor and air heating based on low temperature technique.

An experimental apartment was constructed, based on the results obtained. This was Kiinteistö Oy Malmin Soidintie 10, a block of flats containing 15 apartments in Malmi, Helsinki. Eleven of the apartments were equipped with air heating and four with floor heating. All of them had individual ventilation and a heat recovery unit. In humid rooms there was an additional floor heating facility (integrated in the heating system).

Room temperatures and dwelling comfort were studied in two air heated and two floor heated apartments. Energy consumption was measured from November 1995 to October 1996. The results were reassuring: The energy consumption of the heating system was 59,1 % lower than in the reference building and 30,4 % lower than the original goal. The energy consumption (hot water included) of the experimental building was 49,7 % lower than in the reference building. The annual temperature efficiency of the heat recovery systems was 42,7 % in air heated apartments and 40,8 % in floor heated apartments.

Due to the good indoor climate the apartments are suitable for allergic persons. Some additional research on air conditioning and water systems would still be needed.

4.4 Ecological elevator concept (Kone MonoSpace)

The Kone MonoSpace elevator concept with the EcoDisc hoisting machine is innovative in many respect. Compared to present hoisting machine technologies, it:

- increases the efficiency of the space use, because no machine room is needed due to the integrated slim design
- saves energy 40-60 % in operation due to elimination of power losses
- cuts down material consumption derived from slim shape of the elevator and elimination of the machine room
- eliminates waste oil production from elevator service and related spillage hazards, because it includes no oil
- has a longer expected service life, because there is only one moving part, and the rotation speed is only 95 rpm compared to 1500 rpm of traditional technologies
- facilitates elevator construction to existing buildings.

The hoisting machine applies permanent magnet technology in the axial synchronous motor. The variable frequency and voltage converter drive together with the new electric motor enable the elimination of a reduction gear and minimize related energy losses. The traction sheave and the motor form one single part that is the only moving part in the machine.

The integrated structure with the axial magnetic flux enables so flat design that it fits between the wall of the hoistway and the guiderail and no separate machine room is needed. The machine is fixed to the guiderail and all forces are lead to the pit instead of hoistway structures.

The environmentally-sound concept is applicable to both new developments and existing buildings. The machineroom-free solution gives more freedom to architects and savings in construction time for contractors.

4.5 Ecological criteria for experimental construction (Viikki)

The City of Helsinki and the Eco-Community Project organized a design competition for experimental building in a rural area including ecologically sensitive and valuable protected waterfronts at Viikki near the centre of Helsinki. The competition aimed to save nature and natural resources, to have a high quality with regards to their architecture and functionality of the dwellings, and to be feasible to construct. The competition also was a means for a search for solutions which follow the principles of sustainable development and which could be more generally applicable. A group of building consultants devised a tool for the ecological assessment of building plans.

Viikki's ecological criteria for ecological construction [14] is a method that defines minimum ecological levels for building and estimates the ecological degree of various development projects. Minimum ecological levels for building have been dimensioned to enable their implementation in residential construction to be carried out at a reasonable additional cost. The fulfilling of ecological criteria will also achieve cost savings during the use period. These criteria, whose purpose is to serve as a guide for design and implementation, shall be appended to regulations concerning building practices at city cites.

In Viikki, increasingly ecologically conscious building will progress as a four-step process: a minimum level of ecological criteria applied to all projects, supportive PIMWAG points for significant trial projects with a high expectation value, experimental image buildings representing radical ecological construction, and follow-up studies for mapping information about projects under construction. Examples of the required minimum levels are as follows (difference from reference building):

- CO_2 3.200 kg/grm^2, 50 years (- 20 %)
- waste water 125 l/resident/day (- 22 %)
- construction site waste from building 18 kg/grm^2 (- 10%)
- waste produced by residents 160 kg/residence/year (- 20 %).

4.6 Electric and District Heating Energy Plant (Vuosaari B)

The new energy plant, Vuosaari B, of Helsinki City is starting its operation in September 1997. The plant uses natural gas as its fuel and produces a nominal electric power of ca. 450 MW. The fuel is fossil but offers the advantage of practically no particle and sulfur emissions. The NO_x emissions are low: for NO_2 only 35 mg /MJ of fuel. In comparison, modern coal-fueled plants emit ca. 50 mg/MJ, and 10 years ago typical emissions for coal were above 200 mg/MJ. Also carbon dioxide emissions are low, only 56 g/MJ (more than 90 g/MJ for coal).

The power plant produces both electric energy and district heating energy. The electric energy is produced in two stages by gas and steam turbines. The remaining useful energy (about half of the yield) is then available for district heating. The amount of unused heat (e.g. outside the heating period) is cooled by seawater. When all available energy is used the total efficiency of the plant is about 90 per cent.

About 50 % of district heat is used in the densely built area of Helsinki. The heat from Vuosaari B is lead outside of this area, to North and East parts of the city, via a new 20 km long district heat tunnel (an investment of ca. 500 million FIM). About 90 % of the building volume in Helsinki is covered by district heating.

4.7 Business based on recycling of wastes (SKJ Companies)

Steel industry of the world produces approximately 700 million tonnes of steel annually. At the same time it produces approximately 400 million tonnes of by-products, solid residues and sludges.

In addition to the reduction of waste and emissions, the efforts towards a waste-free steel industry, has created business activities based on the useful application of by-products. Recycling in the steel industry means primarily either returning by-products into metallurgical processes or utilisation of the by-products elsewhere.

In Finland there are two steelworks based on blast furnace hot metal production in Raahe and in Koverhar. In addition there are two steelworks with electric arc furnace technology in Tornio and Imatra. The integrated steelworks in Raahe and Koverhar produced a total of 2.6 million tonnes of steel, and 0.8 million tonnes of blast furnace and steel slags. Besides this, approximately 0.15 million tonnes of dust and mill scale were formed as process by-products. In Tornio approximately 0.3 million tonnes of ferro chromium slag and 0.16 million tonnes of electric arc furnace slag were formed.

SKJ Companies, a subsidiary of the Finnish steel group, Rautaruukki Oy, is responsible for utilising the by-products of steel industry. Activities cover the whole range of the by-product business from by-product treatment to product development, marketing and export. SKJ has developed into products and is marketing approximately 90% of the above mentioned by-products of Finnish steel industry totalling about 1.4 million tonnes. Slags are the largest product group by volume, and they are marketed to road construction, agriculture and the building materials industry.

SKJ companies have activities in the fields of by-product treatment, product development and technology know-how. With regard to the technology know-how SKJ also has activities within export. The primary export countries have been Russia and East European countries.

5. CONCLUSIONS

The following recommendations to the buildings sector are given:

BUILDING OWNERS

to set concrete environmental demands to the parties involved in the design process, as well as to the final product, during the initial design phase

- to set concrete goals regarding building maintenance that are based on environmentally friendly methods and include these goals in, for example, the building maintenance agreements
- assure of the productivity of one’s own business by emphasizing environmental issues, quality and preservation of property values.

BUILDING USERS

- to act as a demanding customer when selecting spaces and considering the environmental qualities of the building over it’s life span as one selection criteria
- to see the environmental issues as one aspect of comfort and consequently as one factor that affects the productivity of the use of the spaces
- to develop one’s own activities to be more environmentally friendly in the occupied building.

CLIENTS

- to inform and analyze the owner’s environmental demands regarding the construction project, as well as make sure they are adhered to
- to select the parties involved in the building project based on their expertise on environmental issues
- make sure that environmental goals are part of the owner’s demands and implementation plans and, if needed, set them together with the owner.

DESIGNERS

- to consider the environmental qualities of construction materials as a starting point of the design and to develop design solutions from the point of view of environmental goals of the final product
- (one can also set goals, even if the owner is not yet doing it)
- to develop the design process together with other professionals in order to achieve the optimal situation
- to develop methods and tools which will enable the designers to control not just the statistics and cost but many other variables, such as life span and maintenance intervals, pollutants and health factors, heating and moisture technology etc.

MANUFACTURERS OF BUILDING PRODUCTS

- to see the life cycle considerations (environmental impact, life span) as the basis of product development

- to explain in the product information the environmental qualities based on life cycle analysis, together with information regarding use and conditions of use, recycling and and stick to this
- to minimize actively the environmental harms of one's own production processes.

CONTRACTORS

- to see environmental consciousness as a factor of competitiveness and to develop one's own services to be environmentally sound
- to reduce the environmental impact of one's own business processes regarding, for example site operations, logistics and material selections
- to require readiness from the other parties (sub-contractors, material and product suppliers) to work in cooperation towards environmentally sound goals.

BUILDING MAINTENANCE ORGANIZATIONS

- to see environmental consciousness as a factor of competitiveness and to develop one's own services to be environmentally sound
- to correct one's own processes so that they are based on sound environmental thinking, show initiative and give feedback to the building owners regarding environmental issues
- to expect cooperation from suppliers and partners regarding environmental issues.

OFFICIALS

- to confirm the creation and existence of mechanisms that lead to life cycle thinking
- to consider environmentally sound construction as one criteria in all building
- to use appropriate guidance (regulations, supervision and sanctions) in order to achieve environmental goals.

RESEARCHERS

- to produce, together with other parties in the construction business, environmental qualities for entire buildings and building parts as well as methods and means to calculate them, to be used by owners, builders, designers and contractors
- to aim in one's own activities to introduce life cycle thinking as the guiding principle of design and construction process and actively implement research results in, for example, experimental construction projects
- to produce research based information to contribute to the ethical discussion on environmentally sound construction.

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7. APPENDIX 1 : MEMBERS OF THE SCENARIO GROUP

Technology Development Centre:

- Osmo Koskisto

Ministry for the Environment:

- Aila Korpivaara

Finnmap Partners:

- Harto Räty — coordinator of the national Technology Programme: Environmental Technology in Construction

VTT Building Technology:

- Ilari Aho — energy issues, building services
- Pekka Huovila — construction process, chairperson of the group, responsible for the report
- Tarja Häkkinen — building materials, sustainable construction coordination
- Markku Norvasuo — architect, secretary of the group.

8. APPENDIX 2 : FIVE MAIN THEMES

A preliminary definition for sustainable construction was given:

the creation and responsible maintenance of a healthy built environment, based on ecological principles, and by means of an efficient use of resources

five main questions were asked (using short, mailed questionnaires):

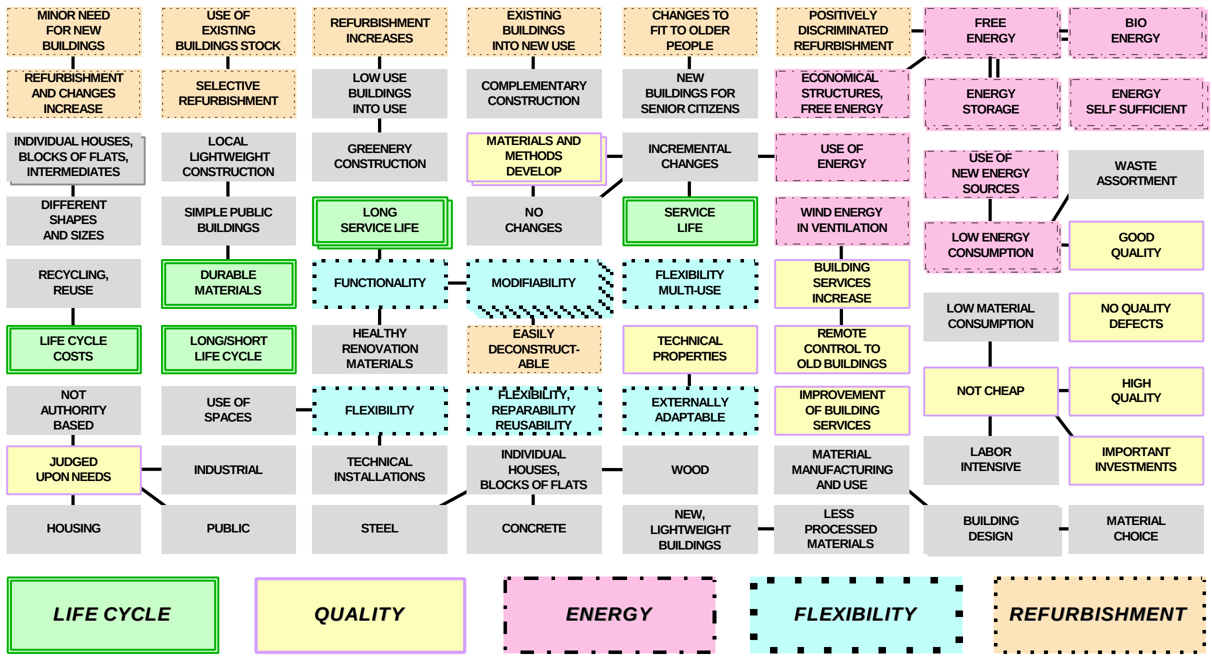
- **what kind of buildings will be built in 2010, and how will we adapt existing buildings?**
- **how will we design and construct them?**
- **what kind of materials, services and components will be used there?**
- **what kind of skills and standards will be required?**
- **what kind of cities and settlements will we have then?**

by 22 experts of different backgrounds answered:

VTT building research (5 engineers & 1 architect)	**6**
VTT urban planning research (1 engineer & 1 architect)	**2**
coordinators of sustainable construction programs	**2**
building material producers (3 from the same company)	**4**
building material research organizations	**1**
engineering practice	**2**
architectural practice	**1**
contractors	**1**
professional owners	**1**
professional interest groups	**1**
nature conservation organizations	**1.**

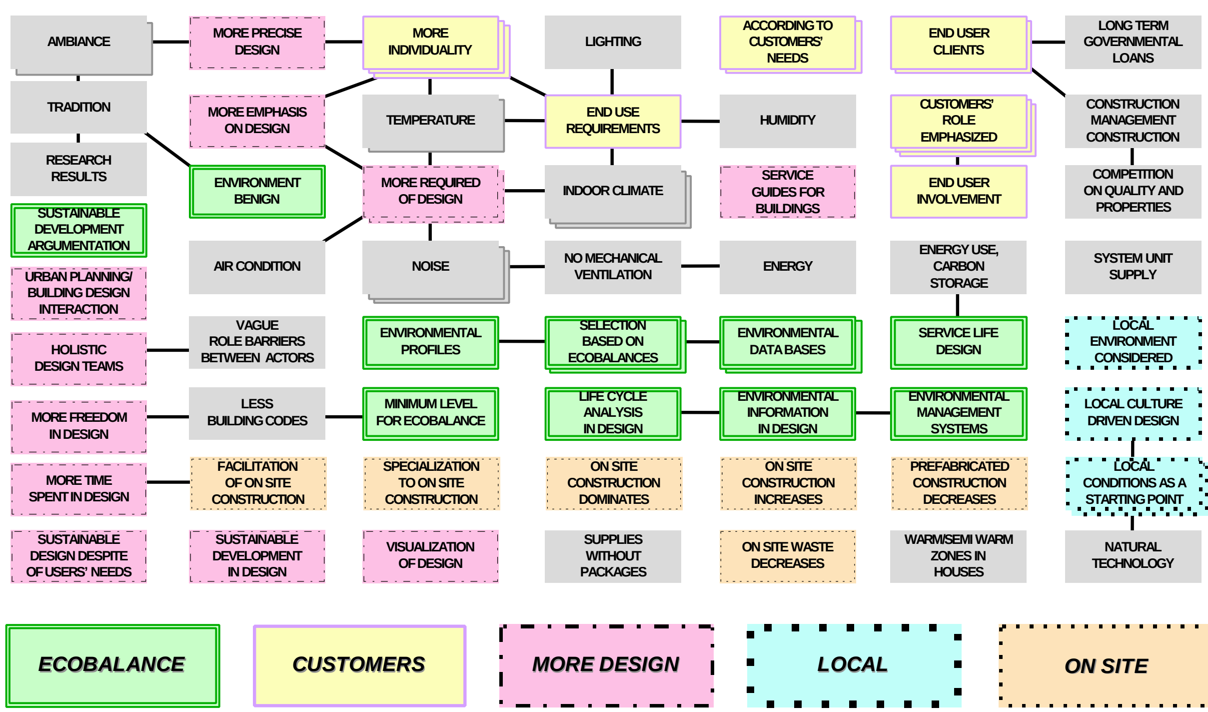
and different “maps” of answers were obtained:

BUILDINGS



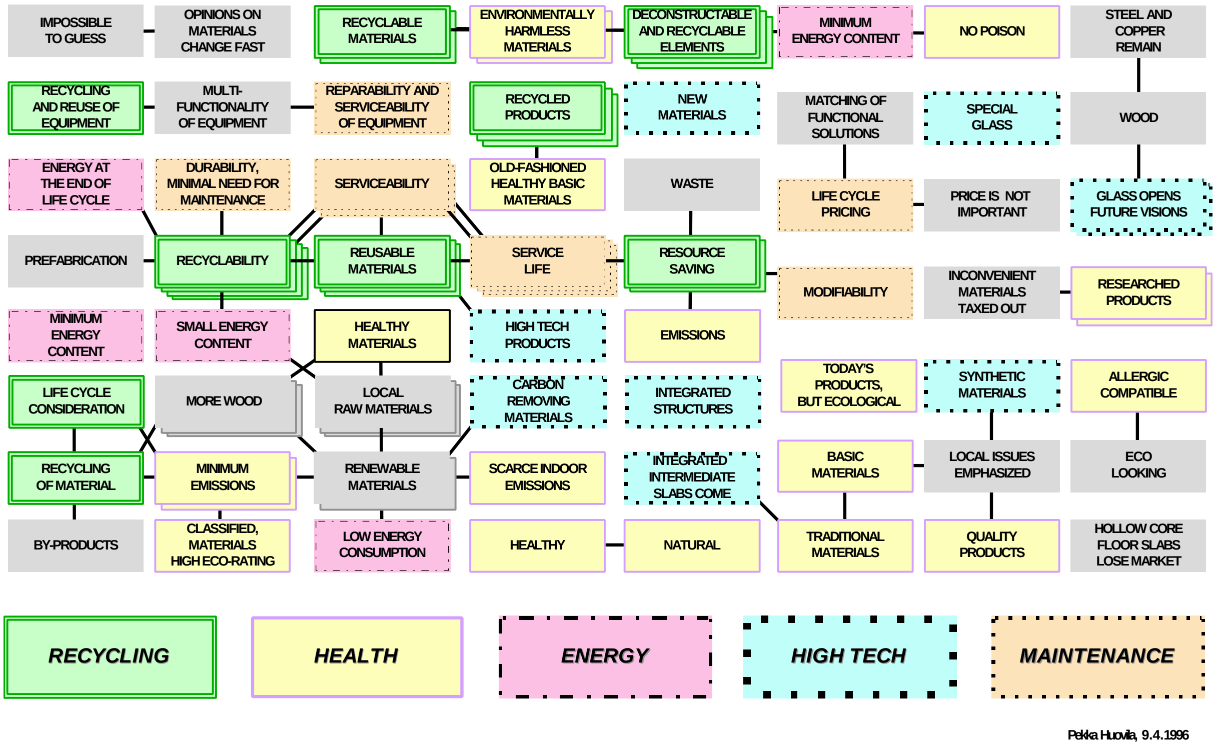
Pekka Huovila, 9.4.1996

DESIGN & CONSTRUCTION

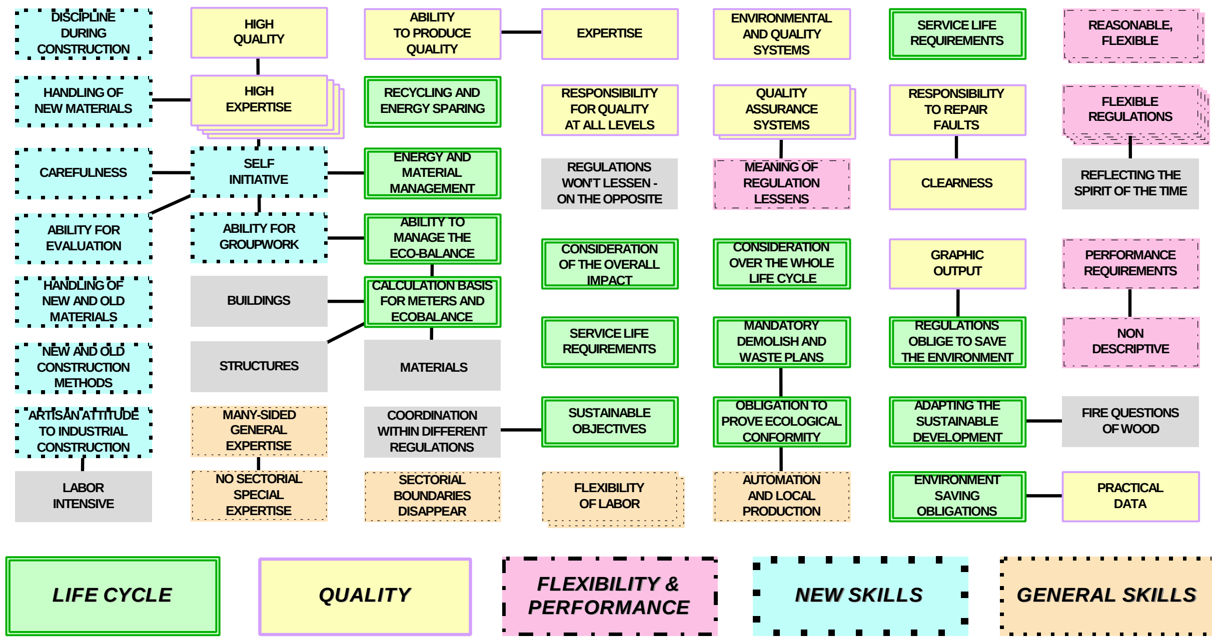


Pekka Huovila, 9.4.1996

MATERIALS & COMPONENTS

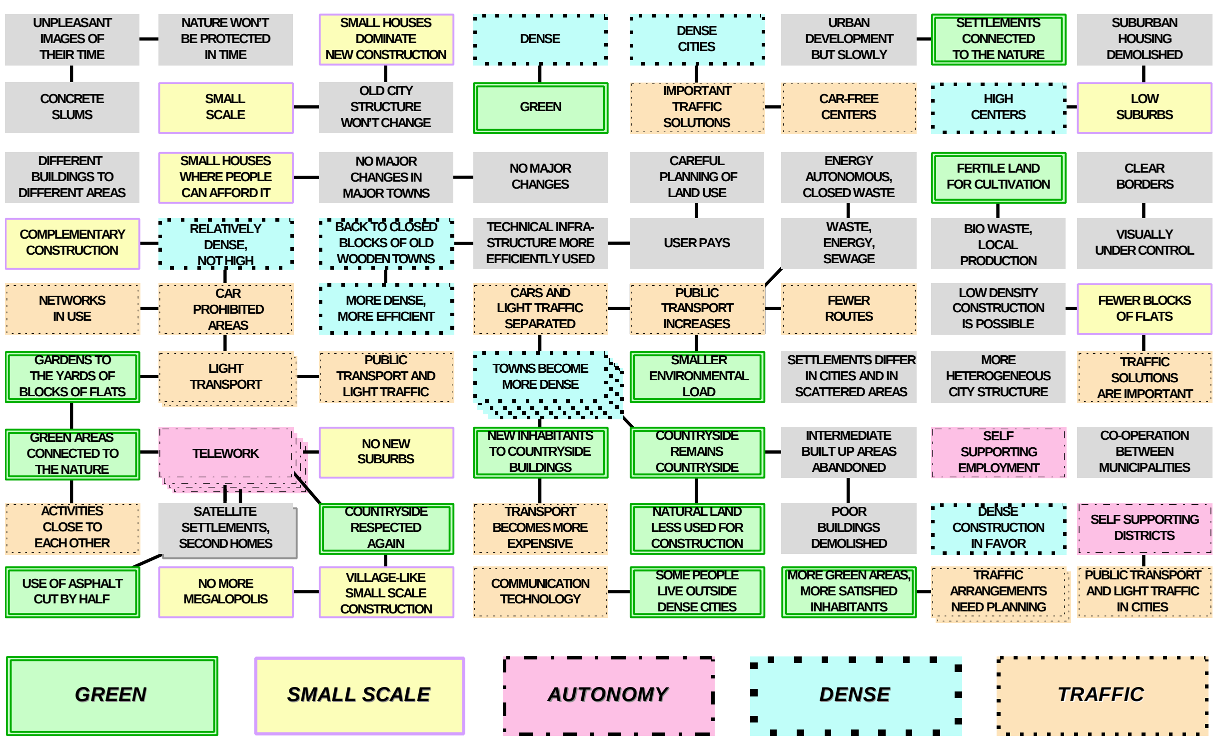


SKILLS & STANDARDS



Pekka Huovila, 9.4.1996

CITIES & SETTLEMENTS



Pekka Huovila, 9.4.1996

These results present a range (of clusters) of answers concerning possible (desired) sustainable futures. The focus was not to describe that future and its boundaries in detail, or to explain how it could and should be realized.