Intern
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Energy Conservation in Buildings and Community Systems (BCS)

Strategy plan 1994 -97

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approved by the Executive Committee, June 1994

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Vice Chairman of the BCS ExCo

Ecexutive summary

This strategy document provides the framing of the IEA collaborative R&D programme within energy conservation in buildings and community systems BEC & CS. Seventeen countries and the European Community have elected to participate and have designated contracting parties to the Implementing Agreement covering collaborative research in this area. Participants in the programme are: Belgium * Canada * Commission of European Communities * Denmark * Germany * Finland * France * Italy * Japan * Netherlands * New Zealand * Norway * Greece * Sweden * Switzerland * Turkey * United Kingdom * USA * Poland (associated member).

Since the start of the Agreement in 1977, the Executive Committee has initiated 28 collaborative projects (Annexes) with 21 of them completed and reported. These collaborative projects resulted in a number of reports with results ranging from international state-of-the-art review to design guidelines to validated simulation models and energy analysis tools.

The objectives of collaborative work within BCS R&D programme can be derived from the major trends in construction and energy markets, energy research policies in the participating countries and from the general objectives of the IEA.

National programmes for energy research in the IEA countries have been concentrated on different aspects and developed in different ways during the period 1973-1993. The future situation is dominated by CO_2 reduction driven R&D programmes.

The construction sector is complex in structure and varies greatly in the different IEA countries. Similarly, the construction methods and culture as well as the age of the stock of buildings varies significantly. This implies a variation in the demand for R&D. The R&D needs of the construction sector are thus largely national, which means that R&D cooperation within the IEA framework should be directed towards generic energy-saving technologies and activities that support their introduction into practice and tayloring to different applications.

Technological opportunities can be found in material and system development, equipment development, automation and information technology. The energy saving technologies with the greatest potential in the time scale of 30 years can be assumed to be the following (FBF Workshop, Espoo 1992):

- New control and operational technology,
- Heat recovery technology,
- Cogeneration of electricity and heat on a local scale,
- New insulation materials (including transparent, vacuum, powder),

- New glazing technology (including aerogel, electrochromic, holographic, control strategies, sensor technology), and
- New lighting technology (including both artificial and daylighting).

A pre-requisite on well-performing buildings is integration of architecture, functionality and technology, that will minimize the energy demand and optimize the energy use to protect the demand.

In many IEA countries, the share of GNP accounted for by construction is on the decline. At the same time, renovations are claiming a greater share of the construction market. The integration of energy-saving technologies and their application within the present-day stock of buildings in order to improve their energy efficiency is a "main issue" which R&D activities in the construction sector should solve. These solutions will also have clear-cut markets within the existing stock of buildings and the construction field of countries that are non-IEA members. Other major trends in the building market are: growing significance of environmental questions and attention to healthy indoor climates, energy conservation, maintenance and repair and to the re-use of materials, growing professionalism and individualization of clients and users of buildings, ongoing internationalization, and retreating of the national government from the building market.

General objective of the BCS Implementing Agreement is to facilitate and to accelerate introduction of new and improved energy conservation and environmentally sustainable technologies into buildings and community systems. In order to achieve that both technical and non-technical goals are defined.

Specific objectives of the BCS R&D programme are
- to support the development of generic energy conservation technologies within international collaboration
- to support technology transfer to industry and to other end-users by dissemination of information, through demonstration projects, by case studies and attracting industry participation
- to contribute to the development of international standards, test methods, measuring techniques and evaluation/assessment methods
- to remove technical and to some extent also non-technical obstacles to the penetration of new advancements in energy conservation technologies
- to encourage non-Member countries to participate in BCS activities by inviting their institutes which are recognized in the specific area of the Annex, to accelerate the introduction of energy efficient technologies in these countries.

The work of the BCS programme covers the following areas:
- Design tools (early-stage, LCC-analysis, etc.)
- Community planning tools
- System engineering
- Building automation and energy management systems

- Advanced technical systems (lighting, envelope, HVAC systems, heat recovery)
- Operational technologies
- Advanced building materials and components
- IAQ and ventilation
- Energy retrofitting
- Integration of energy conservation and renewable energy technologies (in collaboration with SHC)
- Clean technology (clean combustion).

Products of the collaborative R&D work are:
- Design guides
- Design methodologies, tools, software
- Performance analysis, methods and tools
- Generic energy saving technologies, e.g. building and system concepts
- Demonstration, system analysis and assessment
- Information packages, technical reports
- Conferences, symposia, workshops.

The R&D activities cover both new and existing buildings, residential and office/commercial buildings, even though main emphasis is on improving the energy-efficiency of the existing building stock because of the declining trend in new construction.

Long term R & D needs are:
To develop concurrent design methodologies applying multiple decision making.
To develop design tools (software tools, image data bases, etc.) supporting early stages of design.
To collect and analyze information about experimental buildings and to synthetizise that information into data bases.
To introduce low-E building concepts based on optimized integration of energy conservation and utilization of renewable energies.
To develop, for environmentally oriented development, design and production of buildings, a basic knowledge of environmental effects and embodied energy of materials and components as well as the development of design and analysis methodology.
To introduce cost effective retrofit concepts for technical systems applying the newest energy saving technologies.
To introduce building technical-system concepts that can be upgraded using the advancements in building energy conservation technologies.
To assess improvement possibilities and their integration to minimize non-renewable energy used for heating, cooling and lighting.
To identify ways to improve HVAC-systems and components to use less electricity.

To improve the utilisation of building energy management systems by analyzing the needs of users and developing guides to design man-machine interfaces of technical systems.
To develop and assess real-time building optimization and diagnosis methods.
To assess the feasibility of advanced control strategies of HVAC systems.
To establish indoor air quality and optimal ventilation needs and to identify alternative strategies in controlling the indoor environment.

The proposed activities of the IEA BEC & CS Implementing Agreement over the years from 1994 to 1997 have been determined by the members of the Executive Committee and Operating Agents to cover

- Methods and tools supporting system approach in local energy planning
- Design tools supporting early stages of building and system design of new and existing buildings
- Basic knowledge of environmental impacts of construction
- Design concepts based on integration of energy conservation and utilisation of renewable energies
- Cost-effective retrofit concepts for technical systems applying the newest energy saving technologies
- Energy management, diagnosis and control strategies of HVAC systems
- Optimised alternative ventilation strategies in controlling the indoor climate
- Improvement of HVAC and Lighting Systems to use less electricity.

New Annexes will be focused on these activities but may be supplemented by activities arising from ongoing Annexes and from the Future Buildings Forum. The R&D priorities will be revised annually.

Overall control and management of the programme is maintained by the Executive Committee, which not only monitors existing projects but identifies new areas where collaborative effort may be beneficial. The Executive Committee ensures that all projects fit into the strategy without unnecessary overlap or duplication but with effective liaison and communication. The Executive Committee undertakes the evaluation of R&D activities (Annexes).

The internal quality assurance system consists of the following elements:

1. Review of new R & D activities (Annexes)
2. Criteria for the project leader (Operating Agent)
3. Semi-annual progress reports
4. Post-annex evaluation.

The quality assurance manual is the Operating Agent's Handbook, where evaluation criteria and procedures are given.

Before accepting a proposal for a new annex the Executive Committee should evaluate the annex proposal. The following **relevance criteria** will be applied:

- Suitability for the Strategy Plan, energy and environmental impacts
- Technological advancements, potential and risks
- Goals and methods, clarity of the objectives
- Utilisation prospects; industry and other commercial impacts
- Industrial involvement/participation
- Plans for the dissemination of results
- Resources and contribution of participants; benefits/cost of collaboration
- Non-IEA member countries' involvement
- Capability and resources of the Operating Agent.

By the end of an activity (Annex), a final evaluation will be made on all important aspects but stressing now the **impacts and quality** of the activity. The focus of this evaluation is on the following main questions:

- quality
- relevance
- communication
- allocated resources
- effects and impacts and
- reaching of goals.

The importance of the **effects and impacts** of the activity will furthermore be evaluated through the following set of performance criteria:

- scientific quality
- economic value to national participants and industries
- cost of the activities
- information/technology transfer from the activity
- application of the research results
- educational effects and
- compliance to industrial needs.

In order to achieve high efficiency in the R&D programme and to eliminate duplication of work it is important to co-operate with other IEA Implementing Agreements with similar R&D areas. Such Implementing Agreements are Solar Heating and Cooling, Heat Pumps, Energy Storage and District Heating Implementing Agreements. In order to enhance the dissemination of information collaboration with IEA Information Centers like CADDET and ETDE, are important. For improving the use of results in practice co-operation with some international organisations like ISO, CIB, ... could be of great value.

A strategic instrument of the BCS programme is the Future Buildings Forum - "2025",which is established to identify long-term energy, environmental, economic, and technological issues, assess their potential effect on the future buildings, and encourage and begin research projects, based on these issues, that will ensure that buildings contribute to a sustainable society by the year 2025, and beyond.

The scope of the Forum includes energy, environmental, economic and technological research affecting buildings, and considers the effect of social and

demographic, natural resource, urban planning, and transportation trends. The Forum will serve to enhance future research projects of participating countries while broadening the scope and updating the strategy plan of the IEA BCS Programme.

The objectives of the Forum are:

- to identify and study energy, environmental, economic, and technological issues that affect the building industry by the year 2025, and beyond;
- to monitor technological advances affecting the state-of-the-art in building technology;
- to define research priorities to resolve these issues in light of emerging technologies;
- to positively influence the design, construction, and renovation of buildings.

Based on the EUWP recommendation, the Forum will be expanded to include other IA' representation to enhance coordination and collaboration between them on future research activities.

The Forum will:

- establish an international, multi-disciplinary network of "futurist" experts;
- on an on-going basis, identify and collectively agree on the relevant long-term issues to be studied;
- evaluate the issues to determine their potential effects on important topics such as energy supply, environmental quality, and the status of the built environment;
- employ methodologies for analyzing technological advances and determining how those advances might be used by the building industry to meet the challenges of the coming century;
- develop a method for consolidating the information collected and analyzed to allow Forum participants, their IEA counterparts, and researchers in the various participating countries to examine different impact scenarios based on the issues studied.

Contents

Executive committee strategy plan

This strategy document provides the framing of the IEA collaborative R&D programme within energy conservation in buildings and community systems. Seventeen countries and the European Community have elected to participate and have designated contracting parties to the Implementing Agreement covering collaborative research in this area. The designation by government of a number of private organisations, as well as universities and government laboratories, as contracting parties has provided a broader range of expertise to tackle the projects in the different technology areas than would have been the case if participation was restricted to governments. The importance of associating industry with government sponsored energy RD&D is recognised in the IEA, and every effort is made to encourage this trend. Participants in the programme:
Belgium * Canada * Commission of European Communities * Denmark
Germany * Finland * France * Italy
Japan * Netherlands * New Zealand * Norway * Greece
Sweden * Switzerland * Turkey * United Kingdom * USA
Poland (Associate member).

1 Introduction

The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organization for Economic Cooperation and Development (OECD). Its purpose is to implement an International Energy Programme. It carries out a comprehensive programme of energy cooperation among 23 of the OECD's 24 member countries, and allows for the participation of non-member countries. Figure 1 illustrates the organisation of IEA collaborative R&D work.

The challenges the IEA member countries face in the energy sector have evolved over the past two decades. Energy security remains a primary goal. But in recent years there has been increasing awareness of the significance, for energy policy and energy security, of two further factors: concern over the environmental impact of energy-related activities and the growing globalisation of energy issues, as countries' economies and energy markets become increasingly interdependent, but nevertheless different in terms of energy sources, price etc.

Member countries of the IEA recognise that they develop their energy policies within a context of increasing global interdependence, and seek to promote co-operative relationships among all energy market participants.

Organisation of R & D Collaboration

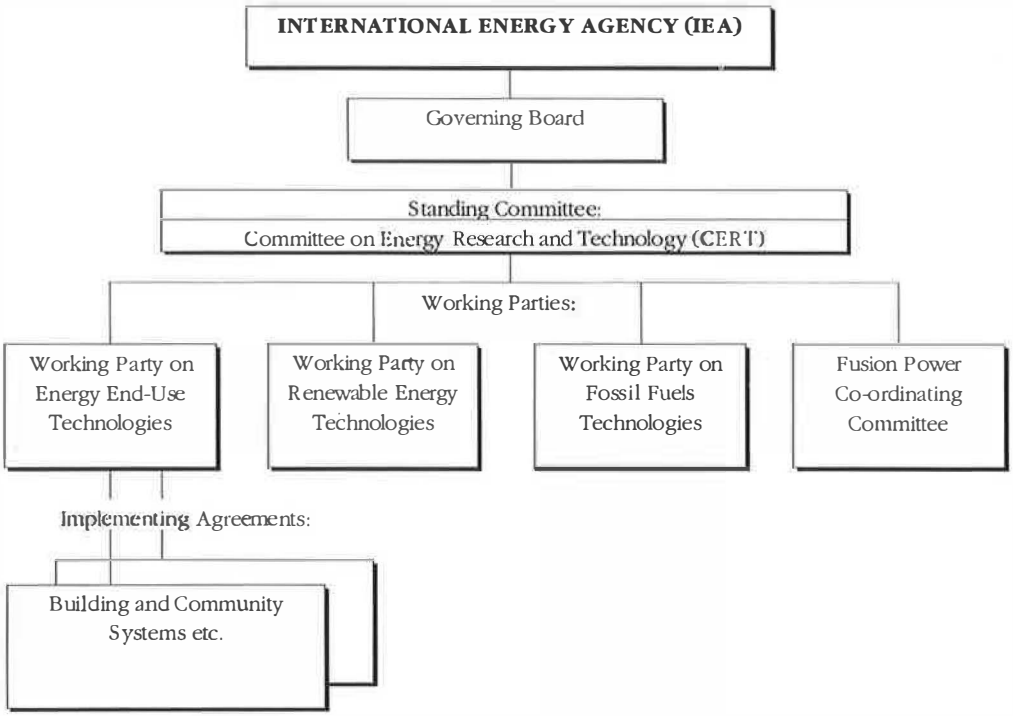


Figure 1. An extract from the organisation of IEA collabortive R&D work.

In order to secure their objectives, the member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity and flexibility within the energy sector are basic conditions for longer-term energy security.

2. Energy systems should have the ability to respond promptly and flexibly to energy emergencies.

3. The environmentally sustainable provision of energy is central to the achievement of these shared goals.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is one option. The development of safe and economic non-fossil sources is also a priority.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner.

6. Continued research, development and market deployment of new and improved energy technologies make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices are necessary for markets to do their work properly. Energy prices should not be held artificially below the costs of production: to the extent necessary and practicable the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a stable framework for investment contribute to efficient energy markets and energy security. Distortions to trade and investment conditions should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourage the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. In turn, IEA Committee of Energy Research and Technology (CERT) has given priority to the following options and initiatives:

1. **enhancing multilateral co-operation in energy technology:** E.g. strengthen existing Implementing Agreements by defining long-term rolling work plans, establish new projects on critical energy technologies, while indentifying areas for possible co-operative relations with non-Member countries;

2. **removing barriers to market deployment of new technology:** E.g. identify and analyze barriers to market penetration and explore measures for encouraging spin-off applications by the energy industry;

3. **establishing a technology information exchange**: Promote international means and networks for exchanging know-how on energy technologies for the control and reduction of greenhouse gas emissions, helping IEA/OECD Member countries to provide an internationally credible service to interested parties from Member and non-Member countries.

2 Markets, trends and visions

The objectives of collaborative work within BCS R&D programme can be derived from the major trends in construction, energy markets, energy research policy and from the general objectives of the IEA. Some of these issues are addressed in the following sections.

2.1 Energy consumption in the building sector

The percentage of the total energy used in non industrial buildings varies from country to country and varies from 30 to 50 %. Most of the countries in Europe and Canada use 40 % in buildings and in USA 30 %. Exceptions are the countries without heavy industries, e.g. Denmark, The Netherlands. The energy used of the built environment is correspondingly estimated to vary from 50 to 70 %. Figure 2 gives an estimate of energy used and its CO_2-emission in the building sector in the OECD countries.

The two main areas of energy use in non industrial buildings are domestic buildings and others (e.g. schools, hospitals, offices and commercial, hotels, restaurants, shops). A qualified estimation is that:

- 3/4 of the non-industrial buildings are dwellings,
- 2/3 of the energy used in non-industrial buildings are used in dwellings,
- 1/4 of all energy is used in dwellings and
- 1/12 in other building types.

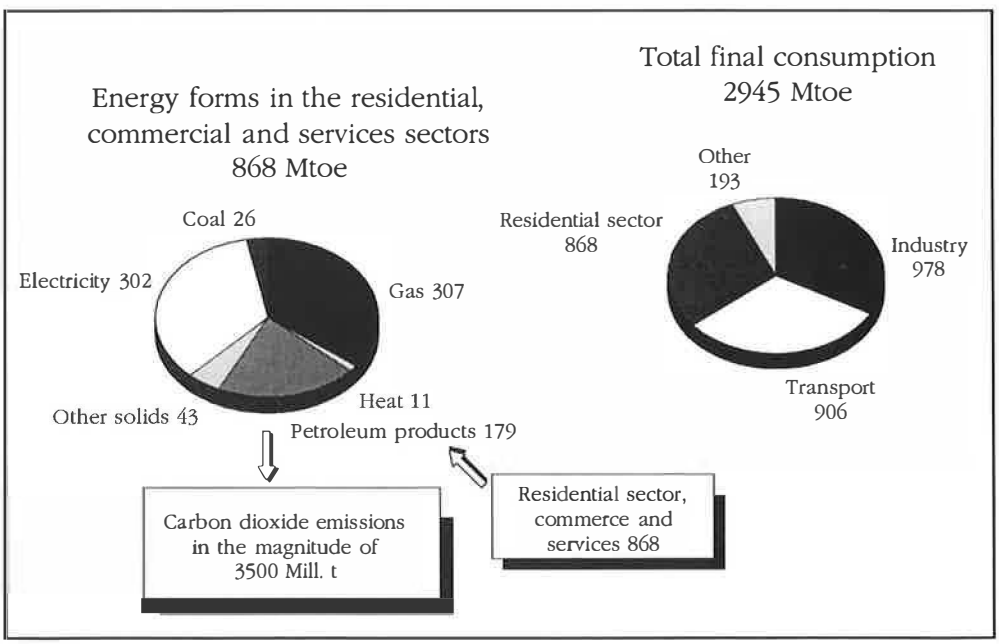


Figure 2. Energy used in the building sector of the OECD-countries. Source: Energy Statistics of OECD countries; OECD/IEA.

2.2 Technological Opportunities

Technological opportunities can be found in material and system development, equipment development, automation and information technology. Some of the energy saving technologies with the greatest potential in the time scale of 30 years include the following (FBF Workshop, Espoo 1992):

- New control and operational technology
- Heat recovery technology
- Cogeneration of electricity and heat on a local scale
- New insulation materials (including transparent, vacuum, powder)
- New glazing technology (including aerogel, electrochromic, holographic, control strategies, sensor technology)
- New lighting technology (including both artificial and daylighting).

A pre-requisite on well-performing buildings is integration of architecture, functionality and technology, that will minimize the energy demand and optimize the energy use to protect the demand.

2.3 Expectations of inhabitants

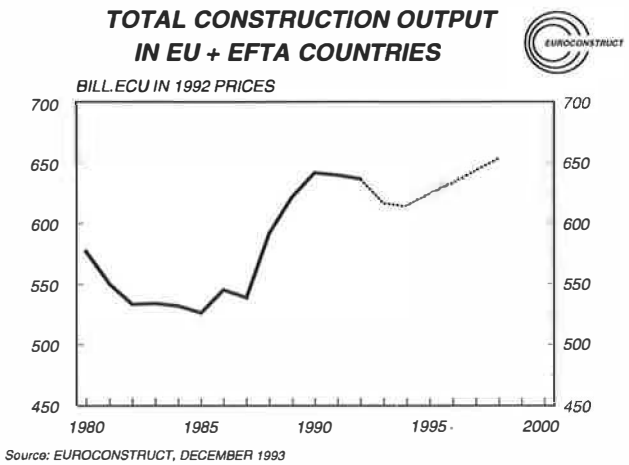
Individuality will mean individual needs and requirements for the construction process and construction products. A demand led, occupants' viewpoint has led to the home viewed as a system of interrelating components, including the structure, furnishings, appliances, services, garden and surroundings. Major identified themes are: flexibility, controls, ambience and sustainability and environmental friendliness. In practice however, it is very difficult for clients to formulate their demands, expectations and restrictions in such a way that they can steer a design process adequately.

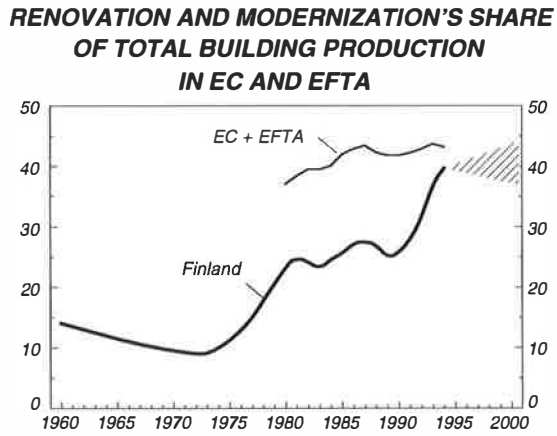
An increase in spare time will also influence the construction in many ways: new structures and areas for spare time activities will be constructed, do-it-yourself-construction and maintenance of the environment will increase.

Special professional clients are becoming better in judging the characteristics of a building project and based on that in choosing the best method of procurement and also in choosing the firms whose profile best fits in this method of procurement. Consumer-oriented building means to fulfil the wishes of an individual occupant and to supply a high performing building at agreed time for the agreed price and with the requisite quarantees.

2.4 Trends in construction

The construction sector is complex in structure and varies greatly in the different IEA countries. Similarly, the construction methods and culture as well as the age of the building stock varies significantly. This implies a variation in the demand for R&D. In addition, climatic factors and the structure of the countries' energy supply system affect the R&D needs in each country. In a number of





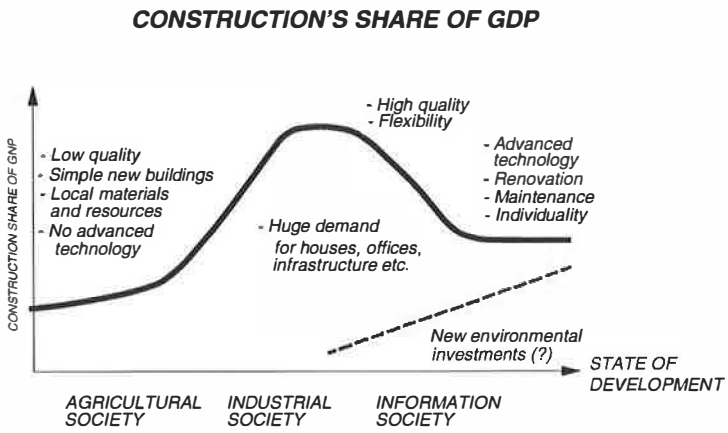


Figure 3. Trends in construction markets.

IEA countries, the management of the environmental impacts of energy use and the reduction of emissions are also primary concerns in building construction. The R&D needs of the construction sector are thus largely national, which means that R&D cooperation within the IEA framework should be directed towards generic energy-saving technologies and activities that support their introduction into practice and tayloring to different applications.

In many IEA countries, the share of GNP accounted for by new construction is on the decline (Fig. 3). At the same time, renovations are claiming a greater share of the construction market. The integration of energy-saving technologies and their application within the present-day stock of buildings in order to improve their energy efficiency is a "main issue" which R&D activities in the construction sector should solve. These solutions will have markets not only within the existing building stock but also within the construction field in non-IEA member countries.

The age of buildings and their technical systems vary. A building can stand several centuries while e.g. automation systems can age in a few years. Thus new buildings should be designed so that introduction of new energy saving technologies would be easy in a later day.

Other major trends in the building market are: growing significance of environmental questions and attention to healthy indoor climate, energy conservation, maintenance and repair and to the re-use of materials, growing professionalism and individualization of clients and users of buildings, ongoing internationalization.

Industrialization of building component production, growing importance and sophistication of building services, and growing application of information technology are probably the dominant trends in technological innovation in the construction industry.

In the design, construction and operation of buildings a growing share of the building costs is spent on building services, e.g. systems for indoor climate control, security, and internal or external communication.

3 Analysis for the strategy plan

3.1 Trends in national R&D programmes

National programmes for energy research in the IEA countries have been concentrated on different aspects and developed in different ways during the period 1973-1993. The future situation is dominated by CO_2 reduction driven R&D programmes.

Period 1973 - 83

Energy research programmes in many countries in the first period after the energy crisis of 1973/74 were concentrated on bringing existing knowledge and techniques into practical use. They consisted of short term (3-5 years) projects with the goal of achieving energy savings in the short term. R & D programmes were often coupled to plans for national energy saving targets. Cost effectiveness of energy saving measures played a major role, and saving money was often synonymous with saving energy.

During this decade in many countries the source of energy used for space heating has been substantially changed, and the amount of energy reduced. Large reductions in oil consumption are a result of

- the expansion of district heating, where oil has been replaced by solid fuels, waste material and heat pumps.
- conversion to gas/electric heating in individual buildings
- energy conservation measures, e.g. better insulation.

Period 1984 - 93

More attention has been given in this period to improving the existing techniques for energy conservation, and to developing and implementing energy management in buildings and communities. It also became important to construct long term R & D strategies (5-10 years).

The awareness of the close links between energy use and the pollution of air, ground and water increased considerably. It was recognized that in order to achieve the objectives of a combined energy and environment policy, the type and extent of energy conservation in the built environment were decisive. The development and introduction of new low-energy and minimum-pollution heating technologies were topical.

In the last years of the period there have been signs in some countries that the increasing trend in energy conservation was slowing down. The readiness to invest in energy-related improvements of existing buildings appeared to be

declining, and the same is true for new buildings, where energy efficiency no longer had a top priority.

Future situation 1994 -

The environmental effects of the use of fossil fuels are becoming more and more obvious, and concern is increasing rapidly. The Brundtland Commission report ("Our Common Future", from the United Nations) has already resulted in actions in several countries. In calculations of the cost-effectiveness of energy savings such factors as acid rain and the green-house effect have not yet been included. At such a time that this will be possible, the previous strong connection between energy saving measures and cost-effectiveness will be lessened, and instead energy-saving will be associated with protection of the environment and quality of life.

Target values for energy savings in the building sector have been set in many IEA countries to complete their CO_2-reduction programmes. Typical measures to promote energy efficiency are energy standards, new building codes, energy trusts, taxation, dissemination of information, demonstration and Demand Side Management projects. Technical solutions are based on minimizing thermal losses (high performance windows, envelopes, heat recovery); on efficient use of delivered energy (advanced technical systems); and on the optimized active and passive usage of solar energy. Furthermore, the next decades are in many countries seen as a period during which fossil fuels will be replaced by renewable energies in heating and cooling of buildings.

In the building sector energy saving objectives are from 15 to 30 % in terms of specific energy consumption, and in individual cases the target is to introduce low-E building concepts with consumption of less than one-fourth of the standard in new buildings, and less than a half in existing buildings, respectively.

The main issue in the national programmes is not only the development of energy efficient technology but to demonstrate and to commercialize new technologies and to remove obstacles as well. The building codes are now being updated in many IEA Member countries resulting in regulation of total specific energy consumption instead of requirements on components. Furthermore, an objective of R&D work is cost reduction of advanced building energy technology.

3.2 Previous BCS activities

Since the start of the Agreement in 1977, the Executive Committee has initiated 28 collaborative projects (Annexes) with 21 of them completed and reported. Most annexes had a wide participation by many countries reflecting the relevance and timeliness of these projects. The work addressed five main R&D areas. These areas were reaffirmed as part of the Strategy Plan in 1990 (R&D for the Future). These collaborative projects resulted in a number of reports with

results ranging from international state-of-the-art review to design guidelines, to validated simulation models and energy analysis tools.

To enhance the dissemination of the program results, the Executive Committee encourages participation of the industry in collaborative projects as much as possible. It also publishes a semi-annual Newsletter (17 issues to date) that is distributed widely in participating countries, and encourages presentations of the annex work and results at relevant national and international conferences.

Description of all collaborative projects and a list of resulting publications are given in the booklet "Publications and Annexes". The main R&D areas and annexes addressing these areas are:

Buildings with Minimum Heating and Cooling Loads:

Annex 1: Load Energy Determination of Buildings
Annex 3: Energy Conservation in Residential Buildings
Annex 11: Energy Auditing
Annex 12: Windows and Fenestration
Annex 13: Energy Management in Hospitals
Annex 14: Condensation and Energy
Annex 15: Energy Efficiency in Schools
Annex 19: Low Slope Roof Systems
Annex 20: Air Flow Patterns within Buildings

Building Energy Performance Analysis:

Annex 4: Glasgow Commercial Building Monitoring
Annex 10: Building HEVAC Systems Simulation
Annex 17: Evaluation & Emulation Techniques
Annex 21: Environment Performance
Annex 24: Heat, Air and Moisture Transport
Annex 25: Real Time Simulation of HVAC-Systems for Building Optimisation, Fault Detection and Diagnosis

Energy Efficient Ventilation:

Annex 5: Air Infiltration and Ventilation Centre
Annex 8: Inhabitant Behavior with Regard to Ventilation
Annex 9: Minimum Ventilation Rates
Annex 18: Demand Controlled Ventilating Systems
Annex 20: Air Flow Patterns within Buildings
Annex 23: Multizone Airflow Modellling
Annex 26: Energy Efficient Ventilation of Large Enclosures

3.3 Strengths, weaknesses, opportunities and threats (SWOT-analysis) of the BCS implementing agreement

In order to set realistic and executable objectives to find means to improve the management and to increase the productivity and efficiency a SWOT-analysis of the BCS Implementing Agreement has been made by the ExCo members.

Strenghts:
- Large number of country participants
- Task shared; no complication of money transfer
- Extensive leverage of efforts
- Forward looking (Future Buildings Forum)
- ExCo members have high complementary technical expertise
- Strengthen international network
- Supports pre-competitive/generic research

Weaknesses:
- Task shared; weak enforcement mechanism
- Long lead time to obtain commitment of participants
- Most work is sponsored by government bodies
- Building industry is weak supporter of R&D
- Low industry participation (pre-competitive research)
- Little or no central funds for technology transfer / demonstrations / dissemination of information
- Little or no industry-driven R&D
- Little or no evaluation of activities

Opportunities:
- Importance of the scope of the IA, increasing awareness of environmental impacts of energy use
- Globalization - wide application of results
- Growing interest in non-IEA countries (E. Europe): Potential impact in non-IEA countries
- Growing demand for energy efficient retrofit and energy saving technologies
- Potential to get more industry involvement
- Countries can satisfy their energy R&D goals at much reduced cost
- Increased collaboration with Other IA's

Threats:
- Reduced Government funding in many countries
- Reduced new construction activities (lower demand)
- Too low industry participation
- Potential overlap with other IEA implementing agreements
- Increased administrative load on ExCo.

4 Strategic objectives

4.1 General policy

General objective of the BCS Implementing Agreement is *to facilitate and to accelerate introduction of new and improved energy conservation and environmentally sustainable technologies into buildings and community systems*.

In order to achieve that both technical and non-technical goals are defined.

Specific objectives of the BCS R&D programme are

- to support the development of generic energy conservation technologies within international collaboration
- to support technology transfer to industry and to other end-users by dissemination of information, through demonstration projects, by case studies and attracting industry participation
- to contribute to the development of international standards, test methods, measuring techniques and evaluation/assessment methods
- to remove technical and to some extent also non-technical obstacles to the penetration of new advancements in energy conservation technologies
- to encourage non-Member countries to participate in BCS activities by inviting their institutes which are recognized in the specific area of the Annex, to accelerate the introduction of energy efficient technologies in these countries.

The R&D activities cover both new and existing buildings, residential and office/commercial buildings, even though main emphasis is on improving the energy-efficiency of the existing building stock because of the declining trend in new construction.

The work of the BCS program covers the following areas:

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- Community planning tools
- System engineering
- Building automation and energy management systems
- Advanced technical systems (lighting, envelope, HVAC systems, heat recovery)
- Operational technologies
- Advanced building materials and components
- IAQ and ventilation
- Energy retrofitting
- Integration of energy conservation and renewable energy technologies (in collaboration with SHC)
- Clean technology (clean combustion)

Products of the collaborative R&D work include:

- Design guides
- Design methodologies, tools, software
- Performance analysis, methods and tools
- Generic energy saving technologies, e.g. building and system concepts
- Demonstration, system analysis and assessment
- Information packages, technical reports
- Conferences, symposia, workshops

Development from initial idea to practical application is highly demanding of resources in terms of both time and money, and so it is important that the whole development chain should be as efficient as possible. In Figure 4 is shown a step-by-step strategy for various R&D projects which makes it possible to increase efficiency in the chain of development from the original idea to practical application. In order to shorten that period of time industry involvement is necessary.

4.2 Strategic long term R&D needs and goals

The long term R&D needs are derived from

- Objectives for the IEA collaborative R&D work and for the BCS Implementing Agreement
- Technological opportunities to save energy in the building sector
- Means to remove technical obstacles of market penetration of new energy conservation technologies.

1. The continued reduction in energy consumption requires an integrated approach to the energy aspects of the built environment. At present adequate methods of optimising between alternative solutions are lacking. The enlarged design philosophy based on ecology, energy, economy, aesthetics and user needs thus requires a change in the architectural and technical design methodology as well as new building concepts. The basic principle will be the service life design.
   Goal: To develop concurrent design methodologies applying multiple decision making.

2. At the design stage, the architects play a central role. The priority of architecture should be shifted more to the internal performance of the building. This leads to the concept of a good physical environment inside the building.
   Goal: To develop design tools (software tools, image data bases, etc.) supporting early stages of design.

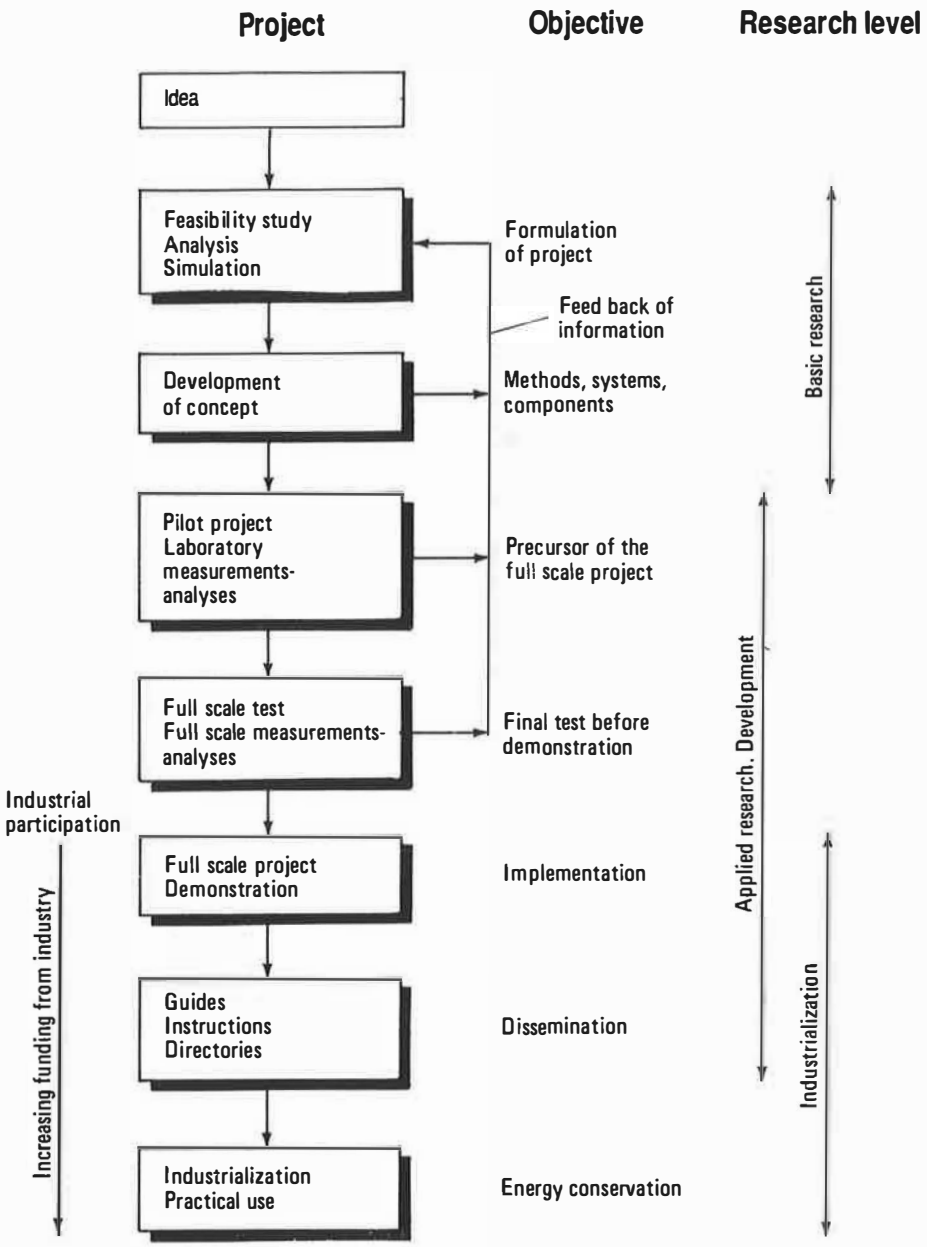

Figure 4. Step-by-step strategy for new energy saving technologies.

3. Different kinds of new building concepts have been applied in experimental houses e.g. in the concept of Villa Vision, Denmark (ecological and life aspects), in the METOP, Finland (totally prefabricated low-energy office building prototype), in the Freiburg self-sufficient solar house (zero energy house/with own energy production, and Ecolonia, Netherlands (environmentally oriented low-energy buildings).
Goal: To collect and analyze information about experimental buildings and to synthetizise that information into data bases, to benefit from the experience.

4. The current state of development shows that it is technically possible to produce real zero energy buildings, but the building cost will be high. On the other hand, it is, however, possible to produce very low-energy buildings at about the same cost level as the current normal energy buildings.
Goal: To introduce low-E building concepts based on optimized integration of energy conservation and utilization of renewable energies.

5. Building production, use and demolition also causes other environmental effects, e.g. through energy use in the production of materials and components (embodied energy), the emission of harmful compounds into inside and outside air, the consumption of non-renewable material resources, disposal production and impacts on the landscape, ground water, soil and water resources.
Goal: To develop, for environmentally oriented development, design and production of buildings, a basic knowledge of environmental effects and embodied energy of materials and components as well as the development of design and analysis methodology.

6. A major trend in the building market is the growing maintenance, repair and replacement culture. In many industrialized countries retrofitting of buildings will dominate the building market during the next years.
Goal: To introduce cost effective retrofit concepts for technical systems applying the newest energy saving technologies.

7. In the design and execution of building a growing share of the costs is spent on building services. A great energy saving potential is possible from advanced technical systems.
Goal: To introduce integrated building technical-system concepts that can be upgraded using the advancements in building energy conservation technologies.

8. The building envelope already serves a number of different functions. It should be treated as a total system rather than separate components.
Goal: To assess improvement possibilities and their integration to minimize non-renewable energy used for heating, cooling and lighting.

9. The use of electricity has a major impact on both fossil fuel use and environmental impact. In many countries energy standards have been given for HVAC systems and home appliances.
Goal: To identify ways to improve HVAC-systems and components to use less electricity.

10. The office buildings of the future will be a new type of infrastructure capable of accepting a variety of work-modules which plug into the supporting structure.
Goal: To encourage the development and to evaluate task-air-conditioning and lighting systems and their design guides.

11. The technical systems of buildings tend to become more complex and their optimal operation is often much too difficult for an ordinary operator to understand. New control strategies of HVAC systems are the fastest adoptable and the most efficient energy saving technologies both in new and existing buildings.
Goal: To improve the utilisation of building energy management systems by analyzing the needs of users and developing guides to design man-machine interfaces of technical systems.
Goal: To develop and assess real-time building optimization and diagnosis methods.
Goal: To assess the feasibility of advanced control strategies of HVAC systems.

12. Ventilation and air movement is expected to become the dominant heat and cooling loss mechanism in buildings of the next century. Its impact on global energy use will increase substantially. The reason for this is that ventilation and air movement in buildings play an essential role in controlling the indoor environment (e.g. supply of fresh air, removal of indoor contaminants, transport mechanism for heating and cooling). Improving living standards throughout the world will mean that occupants of buildings will demand an increasing standard of comfort.
Goal: To establish indoor air quality and optimal ventilation needs and to identify alternative energy efficient strategies in controlling the indoor environment.

4.3 R&D priorities

The proposed activities of the IEA BCS Implementing Agreement over the years from 1994 to 1997 have been determined by the members of the Executive Committee and Operating Agents to cover

- *Methods and tools supporting system approach in local energy planning*
- *Design tools supporting early stages of building and system design of new and existing buildings*
- *Basic knowledge of environmental impacts of construction*
- *Design concepts based on integration of energy conservation and utilisation of renewable energies*

- *Cost-effective retrofit concepts for technical systems applying the newest energy saving technologies*
- *Energy management, diagnosis and control strategies of HVAC systems*
- *Optimised alternative ventilation strategies in controlling the indoor climate*
- *Improvement of HVAC and lighting systems to use less electricity.*

New Annexes will be focused on these activities but may be supplemented by activities arising from ongoing Annexes and from the Future Buildings Forum. The R&D priorities will be revised annually by the Executive Committee.

4.4 Removing obstacles

General, non-technical goals are linked to removing obstacles for achieving the existing energy saving potential related to new and improved energy conservation technologies.

Based on a comparison of the average efficiency of existing capital stocks to the efficiency of the best available new technology, the total energy savings potential is estimated to be (according to the IEA) 10 - 50 % in residential space heating and conditioning, 10 - 50 % in residential water heating, 30 - 50 % in residential refrigeration, 50 - 70 % in residential lighting, "mixed" in commercial space heating and conditioning, and 10 - 30 % in commercial lighting. However, only parts of these potentials are likely to be achieved under current market forces and government policies. Some of the obstacles to achieve full energy conservation potential and the steps to reduce or remove them are listed below.

The information-related obstacles

Distorted, biased or confusing *signals* to the energy user can affect the entire energy efficiency cycle. The consumer often lacks information on why to save energy and how to do it. Sometimes the information provided is conflicting, manipulative or even wrong. For small and medium-sized companies the information available is often too theoretically oriented and not scaled down to fit the concrete situation of the company. The present professional training of architects, consulting engineers and installers in the field of efficient energy use does not meet the current requirements. Price does not include long-run marginal total cost; nor does it include all externalities over the life-cycle of the product.
Means: To provide industry and practitioner with practically orientated information that can be utilized according to national needs.

The motivational obstacles

Energy efficiency is perceived rather negatively. In the residential sector in the case of private home-builders and in small and medium-sized companies, aspects of efficient energy use are often neglected, because energy-saving investment competes with other investments. Energy efficiency has become a priority only in periods of crisis which triggered large increases in energy prices. To

overcome inertia in most people, an immediate threat is needed, e.g. irreversible environmental catastrophe touching everybody. For local government units, lack of finance is a severe constraint in many countries. Energy-saving investments also have low priority because of the small share of energy costs in the total public budget. In addition, energy-saving investments do not contribute to politicians' public profiles. Fixed standing charges for electricity, gas, and district heating reduce the profitability of energy-saving investments perceptibly.
Means: To disseminate (in collaboration with CADDET and other IEA information centres) useful information on successful energy conservation technologies and their application, including technical, ecological and economic assessment.

The marketing obstacles

The "greening" of energy is sometimes seen as an image problem of energy efficiency. Furthermore, the energy efficiency service industry is only slowly emerging, thus the public does not have a real grasp of what it is and of who belongs in it. So far not enough stress has been put on reduced energy consumption as a sales feature. In most small and medium-sized companies, nearly all investments are decided on payback periods rather than on internal rates-of-return calculations. Financing schemes are still unavailable in most parts of the world to facilitate investments by individual buyers, especially sales contracts with long payback periods.
Means: To undertake projects aiming at reducing the cost and technical risk of energy conservation technologies and their application.

The institutional obstacles

A bias can exist against energy efficiency policies and programmes in government ministries (including energy) and other agencies. Lack of policy integration resulting from contradictory priorities sends conflicting signals to a confused public. More agencies in decision-making on the demand-side should be taking part in energy efficiency policy design. Lack of resources to "experiment" or adequately develop programmes (results expected too soon) have sometimes led to failure, giving a bad reputation to efficiency programmes. Furthermore, it is difficult to evaluate how much energy is really "saved" by some measure. Therefore results of efficiency programmes should be evaluated specifically and also in non-monetary terms.
Means: To undertake (in collaboration with CADDET) rigorous analysis of successful energy conservation technology demonstrations, case studies and to document the results.

5 Organising the R&D work

5.1 Executive committee

Overall control and management of the programme is maintained by the Executive Committee, which not only monitors existing projects but identifies new areas where collaborative effort may be beneficial. The Executive Committee ensures that all projects fit into the strategy without unnecessary overlap or duplication but with effective liaison and communication. The Executive Committee undertakes the evaluation of R&D activities (Annexes).

The strategy plan is carried out through task-shared projects (Annexes), that gives an opportunity to countries to integrate their national activities with IEA activities and to participate only in the research projects of most benefit and that their resources allow. Thus obstacles/barriers for participation are lowest possible to the IEA member countries.

5.2 Quality assurance

The Committee of Energy Research and Technology (CERT) stresses the necessity of evaluation in the management and planning of R & D activities, because the output of IEA, and more generally international co-operation, is not easily measured and the benefits are contingent upon actions outside the activity. The quality assurance system in the BCS program comprises internal and external evaluation and review processes.

The internal quality assurance system of BCS Implementing Agreement consists of the following elements:
1. Review of new R & D activities (Annexes)
2. Criteria for the project leader (Operating Agent)
3. Semi-annual progress reports
4. Post-annex evaluation.

The quality assurance manual is the Operating Agent's Handbook, where evaluation criteria and procedures are given.

Besides the internal review, the Executive Committee reports to the IEA Secretariat annually on the progress of R & D projects. Each Implementing Agreement is reviewed externally before the end of their terms according to the request of CERT.

Before accepting a proposal for a new annex the Executive Committee evaluates the annex proposal. The following **relevance criteria** will be applied:

- Suitability for the Strategy Plan, energy and environmental impacts
- Technological advancements, potential and risks
- Goals and methods, clarity of the objectives
- Utilisation prospects; industry and other commercial impacts
- Industrial involvement/participation
- Plans for the dissemination of results
- Resources and contribution of participants; benefits/cost of collaboration
- Non-IEA member countries' involvement
- Capability and resources of the Operating Agent.

By the end of an activity (Annex), a final evaluation will be made on all important aspects but stressing the **impacts and quality** of the activity. The focus of this evaluation is on the following main questions:
- quality
- relevance
- communication
- allocated resources
- effects and impacts and
- reaching of goals.

The importance of the **effects and impacts** of the activity will furthermore be evaluated through the following set of performance criteria:
- economic value to national participants and industries
- cost of the activities
- information/technology transfer from the activity
- application of the research results
- educational effects and
- compliance to industrial needs.

The final evaluation will be done in connection with the activity (Annex) presentation at an Executive Committee meeting. During ongoing Annexes, the quality of the work is evaluated through semi-annual progress reports and technical presentations. This will be accomplished by applying the above performance criteria. In addition, progress against timeplan and committed manpower against planned will be assessed.

5.3 Dissemination of information & technology transfer

A major barrier to market deployment of new technology is the slow transfer of R&D results to industrial utilization. The IEA general policy is, therefore, to encourage and implement exchange of information among all participating countries and non-Member countries as well.

Because principal products of the BCS Implementing Agreement are "information type", efficient and "targeted" dissemination of results is most important.

A strategic objective is to improve the dissemination of information among the important target groups of the building sector. In order to achieve this a data base containing the output from annexes will be established and coordinated with similar activities of ETDE and information centres. The information will be designated for different professions.

The target groups, type of information and dissemination means are:

- Annex description sheets
- Annex results summaries
- BCS activity brochure
- Newsletter
- Seminars and workshops

5.4 Collaboration

In order to achieve high efficiency in the R&D programme and to eliminate duplication of work it is important to collaborate with other IEA Implementing Agreements with similar R&D areas. Such Implementing Agreements are Solar Heating and Cooling, Heat Pumps, Energy Storage and District Heating Implementing Agreements.

The coordination of strategy plans is a starting point in order to identify common R&D topics. Other actions are exchange of information, joint meetings and joint projects in areas of common interest. The duty of the chairmen of the Executive Committees is to keep the other informed about their activities.

In order to enhance the dissemination of information collaboration with IEA Information Centers like CADDET and ETDE, are important.

For improving the use of results in practice co-operation with some international organisations like ISO, CIB, ... could be of great value.

5.5 Future buildings forum

A strategic instrument of the BCS programme is the Future Buildings Forum - "2025", which is established to identify long-term energy, environmental, economic, and technological issues, assess their potential effect on the future buildings, and encourage and begin research projects, based on these issues, that will ensure that buildings contribute to a sustainable society by the year 2025, and beyond.

The scope of the Forum includes energy, environmental, economic and technological research affecting buildings, and considers the effect of social and demographic, natural resource, urban planning, and transportation trends.

The Forum will serve to enhance future research projects of participating countries while broadening the scope and updating the strategy plan of the IEA BCS Programme.

The objectives of the Forum are:

- to identify and study energy, environmental, economic, and technological issues that affect the building industry by the year 2025, and beyond;
- to monitor technological advances affecting the state-of-the-art in building technology;
- to define research priorities to resolve these issues in light of emerging technologies;
- to positively influence the design, construction, and renovation of buildings.

Based on the EUWP recommendation, the Forum will be expanded to include other IA' representation to enhance coordination and collaboration between them on future research activities.

The Forum will:

- establish an international, multi-disciplinary network of "futurist" experts;
- on an on-going basis, identify and collectively agree on the relevant long-term issues to be studied;
- evaluate the issues to determine their potential effects on important topics such as energy supply, environmental quality, and the status of the built environment;
- employ methodologies for analyzing technological advances and determining how those advances might be used by the building industry to meet the challenges of the coming century;
- develop a method for consolidating the information collected and analyzed to allow Forum participants, their IEA counterparts, and researchers in the various participating countries to examine different impact scenarios based on the issues studied.