ANNEX 31

DECISION-MAKING FRAMEWORK

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Annex 31

Energy-Related Environmental Impact of Buildings

November 2001

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A FRAMEWORK FOR DECISION-MAKING

A decision-making framework is required in order to effectively design and develop environmental assessment methods and tools. The framework serves to clarify how and when the many different actors become involved in decisions, the scope of the decisions, the terms used for evaluating decisions and the types of decision-support that may be beneficial.

The development of a decision-making framework begins with analysis of the planning and design process over the lifecycle of buildings. This process includes all the decisions that directly or indirectly influence energy and mass flow. Once key decisions are identified, the framework can then be fleshed out to provide a more complete understanding of how each key decision may be influenced by the many actors and by their decision-support tools.

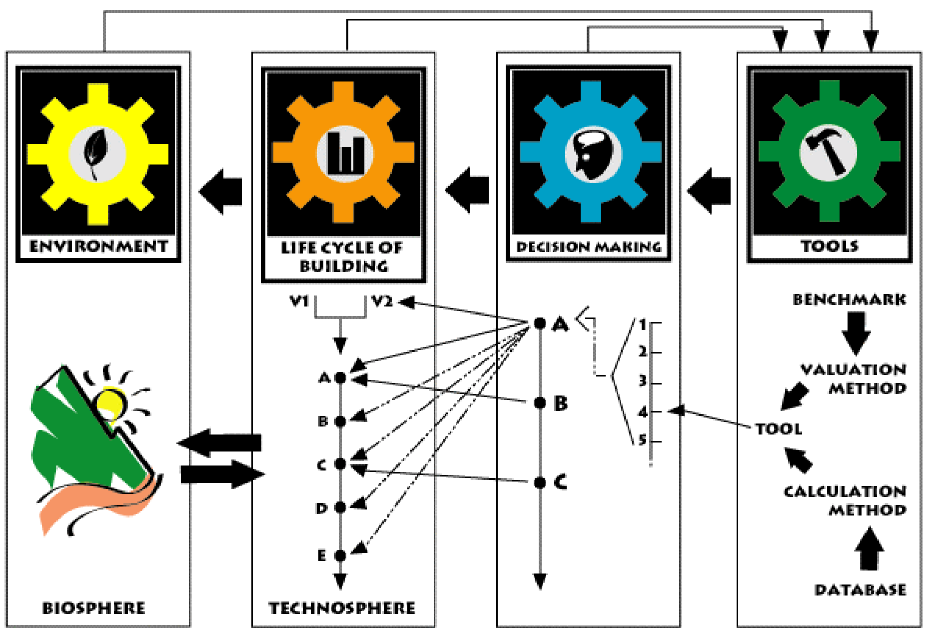


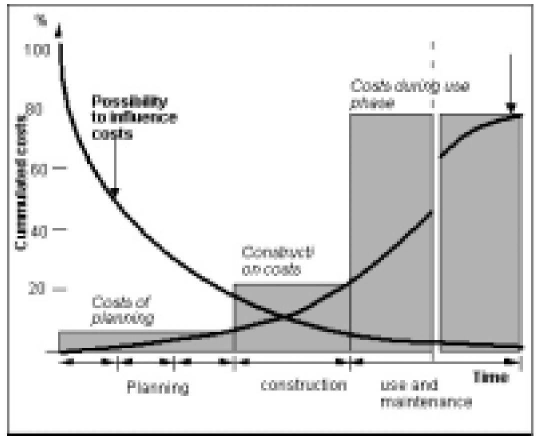
Figure 1 Decision-making Relating the to the Environment and Tools

Figure 1 illustrates the relationship between a decision-making framework, the environmental framework and decision-support tools. Of particular note are design decisions taken as part of the early planning phase (**A**). For example, knowledge of the material and energy costs (**v1** and **v2**) related to production of building materials can usefully inform planning decisions.

Compared to later phases, the planning process offers the widest scope for decision-making. Design decisions have a large (mostly indirect) effect on the entire life cycle of a building. They affect the maintenance and recycling ability as well as the energy expenditure required to run the building. As such it is especially useful to obtain support from simulation models and tools that evaluate different scenarios over the building's lifetime.

The planning process can be subdivided into several design stages (A 1 to 5). With each consecutive stage the freedom of choice decreases while the degree of definition and detail increases. The use of tools and instruments can inform the decision-maker at each design stage.

Figure 2 Impact of Time on Cost and Influence



Decisions taken during the construction process (**B**) also have an impact on the energy and mass flows, albeit to a lesser degree. Choice of construction technology and the level of quality are examples of key decisions. Later decisions about repair or renovation measures (**C**) also have a direct impact on these measures, although these choices may be constrained by limits 'prescribed' by the initial planning.

Complexity of Planning and Design Processes

The design process for buildings is culturally specific. It is impossible to create a universally valid description with any significant detail. Every building is a unique construction with its particular surroundings and context. Each country has different "codes of conduct" and professional standards - construction is still a very regional activity. The organisation of the planning team can vary greatly, and even the types of actors involved can be ambiguous.

It is not possible – or even desirable - to assume a standard influence-hierarchy among the disciplines involved at each decision-making stage. The importance of one perspective or skill-set relative to others will vary with the situation. For example, aesthetics are sometimes much more important than finances, even if the opposite is more often the case. In an integrated and effective design process it is the role of each discipline to establish the minimum acceptable performance standards, and then to work with others to find synergistic solutions that enhance overall value, while advancing the priority criteria.

The Iterative Nature of Planning and Design Decisions

A further complication to establishing a decision-making framework is the highly iterative nature of planning and design decisions. Decisions are re-made, sometime repeatedly. This is because the decision-making process is constrained by the amount of information and degree of detail that can be obtained or processed at a particular point in time. Depending upon the results of the assessment it may be necessary to repeat the cycle - or return to an earlier question – before progressing to the next higher or lower level.

In early design-phases the basic concepts are established – the building volume, its appearance (Gestalt) and its relation to the site. In the following design steps those rough ideas become always more detailed. This can be illustrated by looking at the design drawings. In early phases of design an external wall is portrayed as a thick, dark line; before the construction starts, it is a precise drawing of all constructive details indicating the different materials and ways of assembly; in the use phase it is a concrete wall protecting the indoor from the outdoor environment. This progression, from general to detailed, seems inevitable and helps to define the role of decision-support tools. It is important to recognise, for example, that a building's appearance and form are approximately known while the materials are not yet specified.

Another form of iterative process is the repeated investigation of a topic in differing degrees of detail within the same phase or individual step. This is most often the case with individual steps in task formulation, concept development, and design and work planning. The logical pattern takes the decision-maker from broad principles and visions to detailed specifications.

Usually each individual step involves the selection of alternatives based on technical, legal, economical and ecological criteria. In certain cases the use of complex planning tools can enable a parallel comparison of different alternatives over more than one stage.

Defining the Planning and Design Process

Despite the limitations described above, it is possible to describe a simple, generic process involving a range of disciplines and actors. The process can be represented in a liner schematic, recognising that much iteration can occur in reality. The result is a generalised sequence of decision-making and preparation processes that can help to identify suitable decision-support tools localise their usage.

Typical Levels in the Design Process

- Principles and Goals for Project
- User requirements and conditions
- The planning solution (volume, space programme etc.)
- The design solution (articulation of form, choice of colour etc.)
- The material construction (choice of material, dimensioning etc.)
- Technical services/energy concept

Surveys by Annex 31 researchers indicated that most countries have a norm or recommendation about the design process of buildings. This effort is often due to the desire to make costs for the design process more transparent. The standardised design process of Switzerland (SIA, 1996) for example indicates the percentage of the total fee, which can be charged for each design step. These different ways of standardising the design process are valuable guides to preparing a decision-making framework on a conceptual level.

Typically the design process includes both the phases of design and the life cycle stages for a building, as listed below:

- Preliminary study (basis information, study of feasibility, determination of purpose)
- Design process (development of concepts, design phase, preparation of approval)
- Preparation of working documents (building contracts/ specifications, tenders)
- Execution (organisation of construction site, construction, control/inspection, documentation)
- Use (utilisation, maintenance)

- o Deconstruction or demolition (design of retreat/deconstruction, preparation of deconstruction, deconstruction, disposal/recycling)

Table 1 presents an more detailed example of such a generic process. The generalised sequence of steps and decisions is applicable to high-level and low-level decisions, from planning a building to selecting a specific material. The actors involved may be an individual (planner/architect), or an integrated design team or a partnership (employer/employee).

Step	Description
Identifying the problem	- recognise the problem - engender 'awareness' of the problem
Describing the problem	- analysis and description of the starting point - analysis and description of requirements
Determine tasks	- establish programme of requirements - state technical, legal boundary conditions - state economical, ecological boundary conditions - evaluate *guidelines* possibly - establish *evaluation criteria* - establish *limits and target values* - arrange solution of problem
Establish prerequisites	- chose *calculation methods and tools* - chose evaluation *methods and tools* - evaluate *information sources (databanks)* - evaluate *case studies, benchmarks, precedents*
Generating alternatives	- generate alternatives - describe technical parameters - generate balances - use *calculation methods and tools*
Evaluating alternatives	- evaluate technical, economical and ecological performance - use *evaluation methods, indicators and tools*
Pre-selection stage 1	- establish whether solutions are legally 'permissible' - use (technical) *limits/thresholds* - use *exclusion criteria*
Pre-selection stage 2 (*)	- compare 'advantages' of solutions - use technical/economical/ecological *target values* - use *recommendation criteria*
Decision-making	- select alternatives (to follow up) / stop (no decision**) - use multi-criteria *decision methods* - use *decision-making aids*
Special cases:	
Preparation of specifications	- specify important building measures - prepare technical, legal, and organisational documents
Execution	- judge performance
Verification	- measure, monitor and compare performance relative to limits and target values

(*) The pre-selection stage 2 is intended to reduce the amount of possible solutions after the initial pre-selection. Stage 2 selects the more advantageous solutions from the technically possible and permissible solutions selected in stage 1. The aim is to reduce the quantity of final alternative solutions to a manageable amount.

(**) Breaking off the decision-making process due to inadequate solutions is usually accompanied by the identification of a new problem and leads to a new decision-making cycle on the same or a higher level.

Table 1 A description of decision-making and preparatory processes

Establishing the Scope of the Assessment Questions

If we begin by looking at a standard planning process for a single building, it is possible to identify a range of key questions that can be answered from a detailed environmental assessment. The key decisions can thus be summarised as follows:

1. Which kind of building function shall be investigated?
2. Which one of two buildings performing the same function is ecologically better?
3. Is it better to renovate or demolish or reconstruct a building?
4. How might improved performance translate into benefits for other parties?
5. How might changes in the original function of a building effect performance (i.e. how adaptable is the building)?

Questions that are usually not answered from life cycle assessment methods (like ”where to build a house?“) may require other types of assessment.

Extending the Design Process

The *design process begins* at the point, where, for the first time, an idea for a new project or the need for new space arises. The process may pause when the building is finished, but it doesn’t end. The use and demolition phase of a building’s lifetime are part of the same process, even if overlooked by the actors. Once the use and demolition phase of the building are included, the specific building enters as a whole into the design process; influencing the design context. This transition is shown in Figure 3.

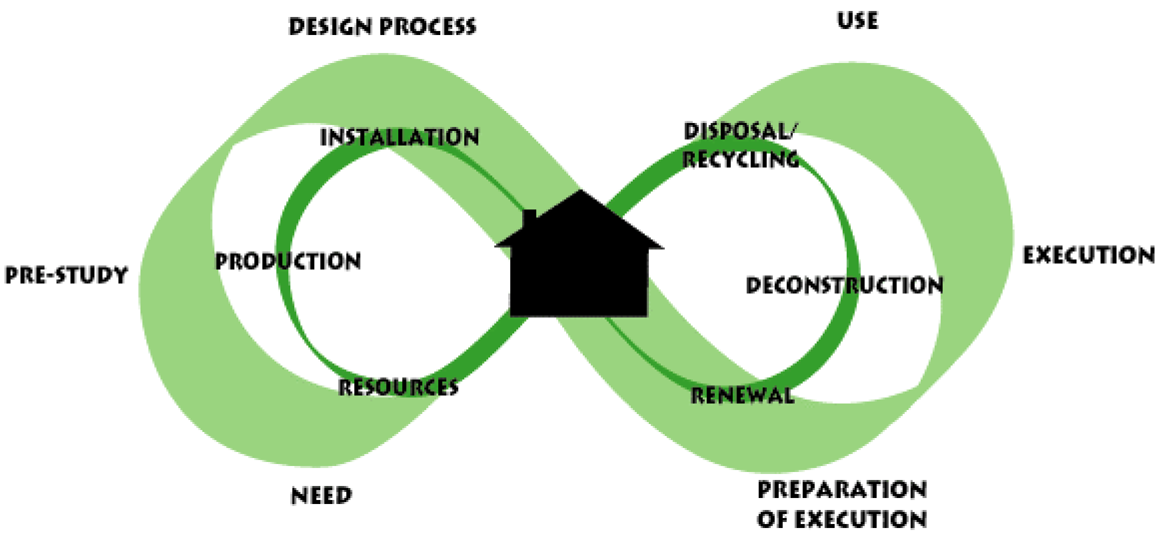


Figure 3: Illustration of the design process showing the interference of conceptual work and the concrete building.

Organising the Design Process by Categories of Decision Makers

It is possible to organise the design process to reflect categories of decision-makers. Four different actors can be identified: client, designer, administrator, and builder. Accordingly, the design process is divided in four stages: program, design, elaboration and construction. These four stages are in turn subdivided into eleven phases. Figure 4 illustrates this design process.

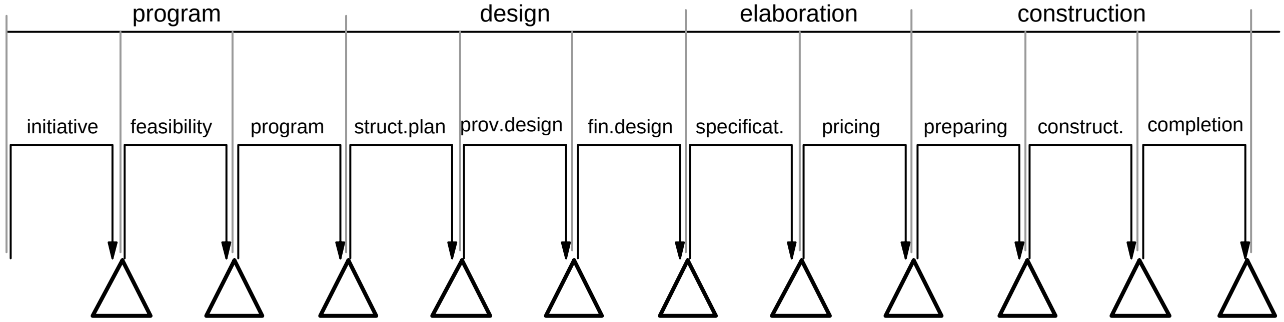


Figure 4: The design process subdivided into four stages and eleven phases[1]

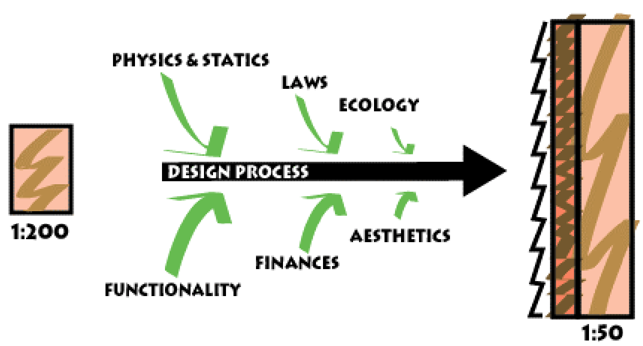
Accomodating a Multidisciplinary Process

A building always has to fulfil a wide variety of functions: it has to protect occupants from the elements, while simultaneously letting air and light penetrate and providing space for many activities. Many functions must be borne in mind when designing a building, and thus the design process is very complex.

In architectural theory the interrelationship of major functions is a basic criteria of good design. Architecture strives for equilibrium between technique, function and form[2]. Whereas in early times the architect or engineer was responsible for the whole work, today a diversification has taken place. The design and construction of a building has become a multifunctional and trans-disciplinary domain. Many different actors and disciplines are involved.

A wall, for example, has a physical function; it also has organisational, aesthetic, and environmental functions, and contributes to the financial performance of the building. All these different functions require input into the design from the respective disciplines as shown in Figure 5.

Figure 5: Disciplines influencing the design process of an external wall (Schematic shows the transition from a conceptual wall at scale 1:200 to a cross-section of the construction element at scale 1:50)



As the wall moves from a thick dark line to a construction element each of the functions needs to be addressed and integrated. The six major functions are described below:

1. Functionality

A building always has to serve a certain function. Functionality concerns itself with different aspects: on the one hand we talk about the later function of the building (we

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[1] from Regener, 1997
[2] Vitruvius, 1991

need the mirror on the wall at the correct height), on the other hand each construction element has its one constructive function. This second aspect was often taken into account in modern architecture: “form follows function“. For the user the functionality is a very important argument, which has to be integrated into the design process.
At the beginning of the design process, the function is often expressed in a general typology of the building. The more the design process evolves, the more precise requirements have to be considered. For some specific functions very precise target and limit values are available.

2. Technical Aspects

Every building has to respect physics, construction technology, material technology and many more technical domains. Often specialised actors are involved in the design process to guarantee the technical details. At the detailed level of the design process, and for technical aspects, a lot of benchmarks and limit values are available. For some characteristics, e.g. physical aspects, in some countries, benchmarks and limit values have been established.

3. Legal Conditions

To build a house is not only a private activity. The change in landscape can be enormous, so buildings are - depending on their function and size - of general public interest. In some countries, such as Switzerland, the legal regulation of where and how and what to built are very strict and cannot be ignored. The legal conditions are important from the beginning of the planning (use of land, height of the building, etc.) until the end, where issues like fire and security gain a lot of importance.

4. Finances

Buildings are expensive. Nearly every client puts a priority on cost savings and economy of constructions. Buildings can even be used as capital investment. It is very interesting to see that the decision support tools for cost estimates are the most developed and standardised tools in the whole building process. Some very interesting, hierarchically organised tools are available in different countries. Also in this case the principle “from general to detail“ is followed (e.g. (CRB, 1995))

5. Aesthetic

Buildings can also have cultural value. The aesthetic of buildings is a very important factor, influencing above all the decisions of the designer. The problem is that aesthetic is not measurable, but that the form and shape (the ‘Gestalt’) of a building are very important factors concerning the historical value or the acceptance in the public. Different theories about architecture, design and history of architecture exist and are learned in schools of architecture. However, this knowledge is often not appreciated.

6. Environment

The environment is not a new factor influencing a building. In older times, the climatic situation, the available materials were always very important and decisive aspects. The physical performance of a building is directly correlated to the site. More recently the concern is the impact of buildings on the environment, which greatly expands the environmental functions of good design.

Even if the analysis is limited to just environmental criteria (resources, waste, miscellaneous pollution, comfort and health), the choice of a project or a solution is founded on multi-criterion analysis, anyway. Actually, if it is assumed that there are a certain number of variants to be rated, there is not necessarily a solution that is better than all the others in all the criteria. If one wishes to rate the solutions, it is necessary to establish priorities, to make rankings, that is, to define the degree of importance that one grants to each environmental criterion. If there are several actors present in the decision phase, it is necessary to weight the actors' ranked opinions among themselves.

Furthermore, where environmental quality or, more generally, innovation is concerned, it is necessary, in the assessment of a technical or architectural solution, that such solution be systematically compared to a sufficiently complete list of criteria (environmental, technical, financial, human). How would it be possible to assess the environmental quality of a project if this approach would not utilise it, that is, if that environmental quality was not to be re-positioned in a broader overall quality context? The developers of building environmental assessment tools would need to pose that question to them.

Different disciplines and actors are involved at different times and places, depending upon the objectives and the types of problems. In general the problem solving exercise requires a team of experts both to define the problem and to explore solutions of experts both to define the \problem and to explore solutions.

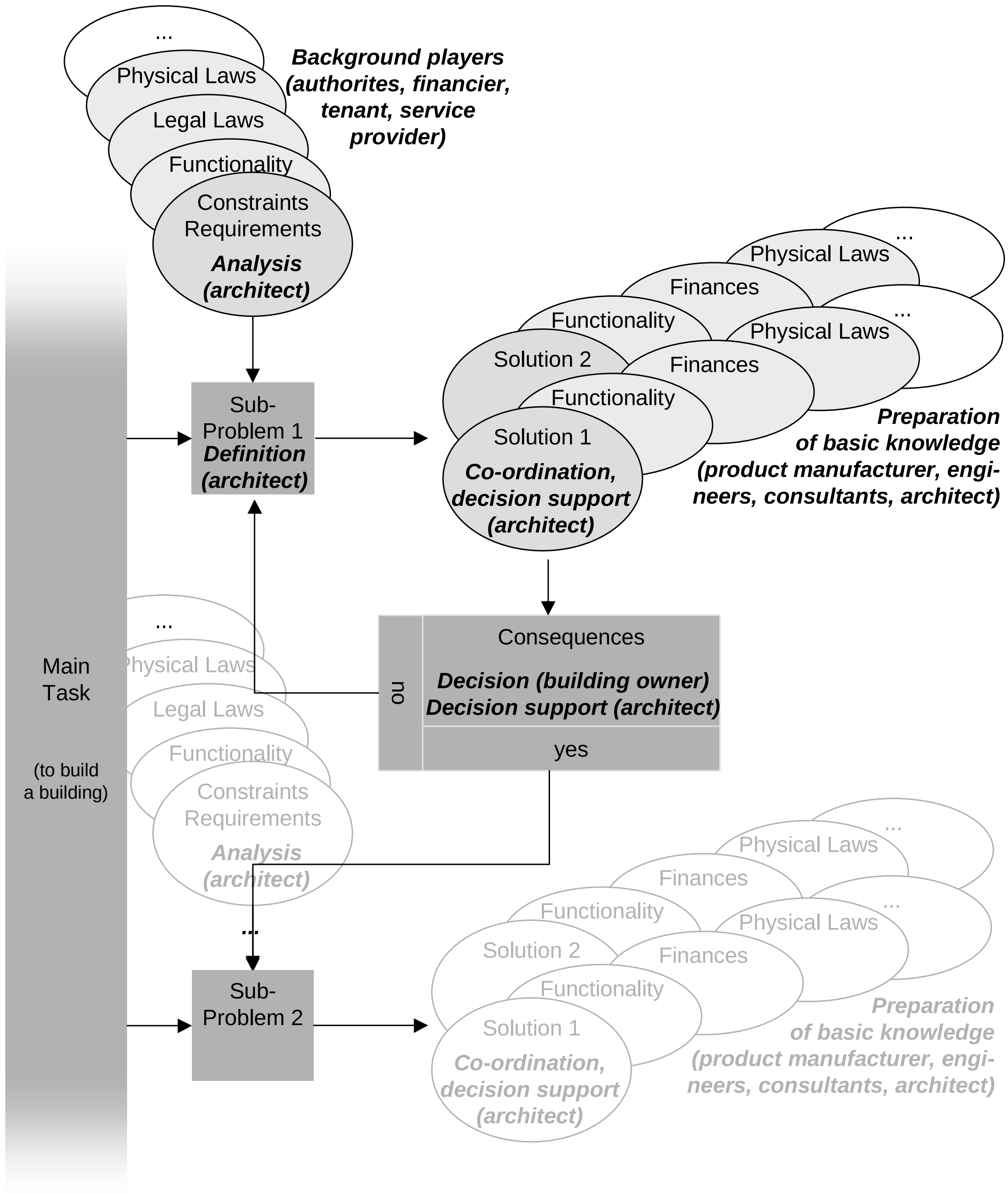


Figure 6 shows schematically how different levels of expertise can feed into the on-going problem identification and problem solving processes. In this simplified schematic, it is assumed that a problem (need for a building) has to be solved. The problem is strongly influenced by diverse requirements and constraints, resulting from natural sources (land, climate, etc.) legal and physical laws, and financial, functional, aesthetic, or environmental requirements. The goal is to find the optimum solution.

The solution is to divide the house problem into sub-problems. Each sub-problem itself meets constraints and requirements and for each sub-problem the relative importance of expertise can be defined. With the help of different actors, solutions can be posited. Each solution itself has consequences on the environmental quality, which create new requirements or constraints for the next sub-problem.

The actors are involved on different levels. The building owner takes the concrete decisions and gives (sometimes intuitively) the different disciplines their relative importance. The architect or consultant can analyse the problem and attempt to assess solutions until an optimum solution is found. Other actors contribute basic information and solutions.

Adopting an Integrated Design Process

The Integrated Design Process (IDP) is the best way to address the multi-disciplinary nature of design, and to functionally integrate environmental performance with other major functions. IDP involves creating a design team with a wider range of technical experts, local stakeholders, and partners than is normal. It engages more of these actors at very early stages of the project, and uses their expertise to influence seminal design decisions. The entire design team may participate in a target-setting workshop at the beginning of a project. Energy modelling and value analysis may be conducted in parallel with concept design work. 'Whole-system engineering' may be used to provide broad thinking about technical options. A facilitator may be hired to ensure successful communications at team meetings with large numbers of actors.

Because IDP involves more extensive decision-making in the early stages of design, more time is needed up front in the design process. However the additional time taken up front is usually recovered during the construction documents phase, due to early decision-making and better co-ordination between disciplines. IDP allows for effective and controlled public input, and for improved designs.

ACTORS

A Decision-Making Framework includes the human interface: all the people who make decisions, develop decision-support tools, and supply information. These people are generically referred to as actors. The interrelationship between actors and the phases of the building life cycle is illustrated in Figure 7.

Decisions made at different levels of planning and at different stages in the building life cycle have impacts on the environment both obvious and obscure. These impacts occur over different time frames and can occur over different geographical areas. A fundamental objective of applying modelling approaches to environmental performance assessment is the need to support the decision-making process with information on the potential nature and volume of such impacts.

The Involved Actors

As introduced earlier in this report, different actors are involved in the design of a building: All the actors have different ways of acting in the process. Some of them are administrators, others are decision-makers, others are developers of new technologies (not directly dependent on the specific building), and others are "background players". Background players are those influencing the building in an indirect way, for example later users, which are during the design not yet known, but whose interests are indirectly respected due to financial or social or other reasons. Table 2 shows the correlation between the different users and how they participate in the design process.

Actor	Participation	Example
Product manufacturer	Indirect, via products and their functionality, and their physical characteristics. They're influenced indirectly via the demand created by the occupants, building designers and authorities.	Supply of basics, technical support
Building designer / consultant	Directly via the support of the building owner. He has to collect all information, prepare the information and show the different possible solutions (including their consequences)	Supply of basics, technical support, decision preparation, co-ordination of work
Contractor / Engineers	Directly via the concrete test and calculation of possible solutions. He often gives a palette of solutions indicating the technical and functional advantages. He supports the architect and perhaps also the building owner.	Supply of basics, technical support, decision preparation
Building owner	Directly, the owner ultimately makes the decision from the choice presented. Support is provided by the architect or consultant.	Main decision-maker
Financier / stake holder	Indirect via the grant of credits	
Tenant / user / manager	Indirect via their predicted demands and needs	Background player
Service Provider	Indirect via their service palette	Background player
Authority	Direct, the authorities are responsible for the general	Background player, controller, both limiting the solution-space and enforcing quality standards

Table 2: List of actors and their way of participation in the design process

The Parties Involved in a Building Project

Although each country has its own organisation, the actors can nevertheless be grouped into 5 categories:

1. Collective interest
   (elected representatives, administrations, agencies, regional and local authorities, institutions, associations)
2. Operational decision-making
   (development companies, building owners, backers)
3. Design
   (prime contractors, architects, engineering firms, town planners, landscape engineers, quantity surveyors)
4. Execution
   (manufacturers, contractors, verification offices), and
5. Use & operation
   (service providers, building managers, users, insurers)

The phases in the life of a project

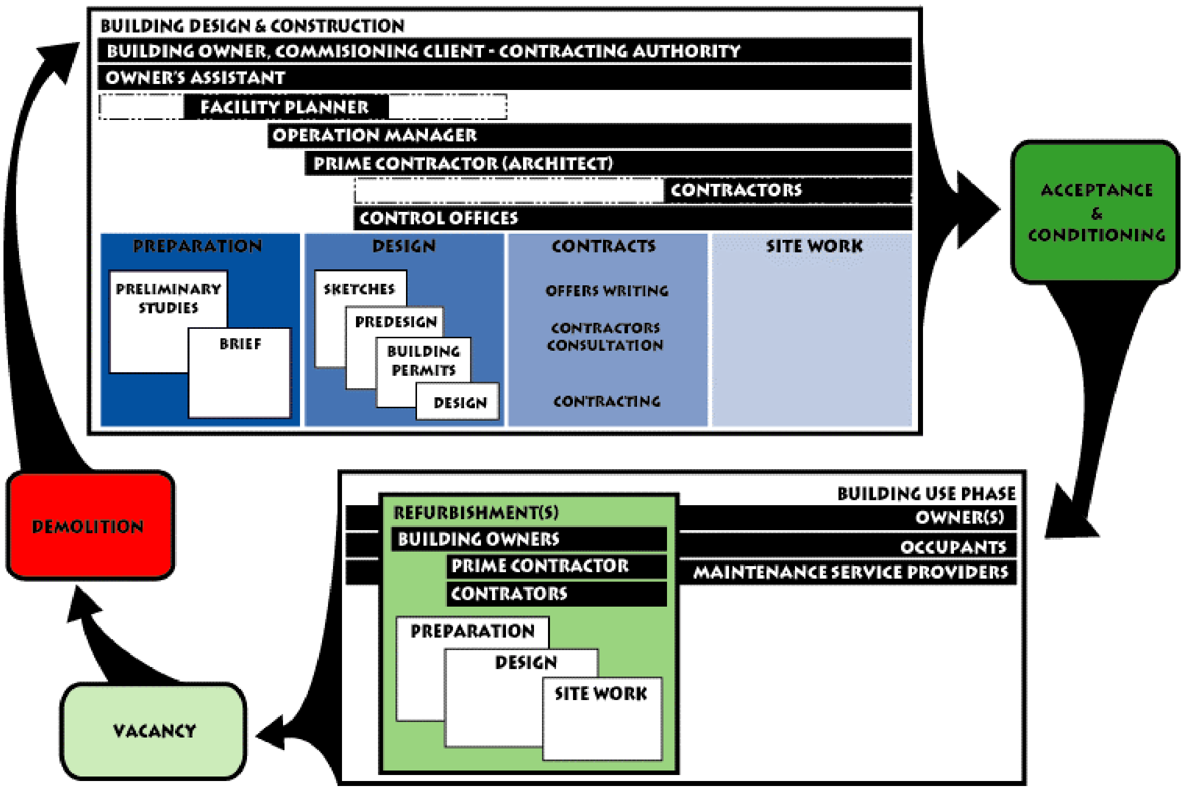
One must be careful not to confuse the phases in the life of a building, in the operational sense, and the phases of a building's life cycle, in the sense of the life cycle analysis. These represent two different viewpoints. Operationally, the main phases of the life of a building project are as follows:

- Preliminary studies and design
- Programme or brief
- Sketches
- Preliminary project

- Building permit
- Project
- Offers writing, contractors consultation, contracting
- Building site (preparation, management)
- Commissioning / Completion / Placing into service
- Use of the building (operation, maintenance)
- Refurbishment during the life of the building (preparation, design, building site)
- Desertion / Demolition

A decision-making framework identifies which actor intervenes at each of these phases.

Figure 6 Building phases and actors[3]



Interactions between actors, phases and the decision-making process

It is necessary to identify, in terms of decisions, what are the questions, which are asked of the actors, which questions relate to energy and environmental issues, when each question is posed and what data are available to respond to the questions.

In a schematic way, the main choices that affect the energy field and the associated environmental impacts are as follows:

- Choice of project (demolition, new construction, refurbishment)
- Choice of site and local interfaces (climate, utilities)
- Choice of Design Concept (relation to the site, geometry, configuration of the premises, zoning, glazed parts)
- Choice of the thermal performance of the envelope

[3] S. Sidoroff, France, derived from a diagram made by J. Guerry, France

- Choice of the energies (for running the building)
- Choice of energy systems (efficiencies, pollution)
- Choice of management of the energy systems (control)
- Choice of constructive systems
- Choice concerning the building's durability and adaptability
- Choice of materials (energy for manufacture, transportation)
- Choice of comfort level for occupants (thermal, visual, acoustic, olfactory)
- Choice of Cost Accounting Methods (life cycle costing, for example)
- Choice of consequences in servicing and maintenance
- Choice in the area of users' health
- Choice of demolition

Phase	Energy and environment-related activity	Responsibilities: Building Owner	User	Design Team	Con-tractor	Oper-ator
1 Preliminary study						
1a Basis information	Checking of possibilities concerning new construction/rehabilitation/surrender	●				
1b Study of feasibility	Selection of site, analyses of site, orientation	●		●		
	Checking of possible impacts to the environment (EIA)	●	●	●		
	Checking of energy supply systems, ports of media (Medienanschlüsse)	●	●	●		
1c Determination of purpose	Formulation of geometric boundary conditions (use-surface, ceiling height)	●				
	Formulation of user requirements (temperature, light)	●	●			
	Formulation of user conditions like moisture production, heat release	●	●			
	Formulation of limit and target values (consumption of energy, water, comfort)	●	●			
	Identification of special problems (allergies, electrosmog)		●			
2 Design process						
2a Development of concepts	Concept of the rooms/of the building	●		●		
	Concept of energy systems (e.g. determination of facade construction)	●		●		
	Pre-selection of energy systems and building control systems	●		●		
	Simulation of energy use by calculation			●		
2b Design phase	Selection of construction principle, main building materials	●		●		
	Design of building control components			●		
	Simulation of life cycle (energy and material flow, costs)			●		
2c Preparation for approval	Submitting of supporting documents			●		
3 Preparation of building contracts/execution						
3a Preparation of execution	Selection of materials for surfaces and finishing elements	●		●		
	where appropriate: studies of indoor air quality and comfort at a level of single rooms			●		
	and consideration of special problems like allergies, ...			●		
3b Description of specifications	Formulation of ecological requirements for specification, for building site and building site equipment, for products and quality checks and for construction processes	●		●		
3c Elaboration of tenders	Examination of risks for the environment & for health due to products/processes				●	
	Selection of environmentally friendly construction and transport processes				●	
	Selection of environmentally friendly and healthy products				●	
3d Comparison/Tendering	Checking of offers using ecological criteria	●		●		
	Comparison and checking of offers concerning technical & physical compatibility			●		
4 Execution						
4a Organisation of building site	Organisation of environmental protection and health care (Schutzzonen/-zeiten)				●	
	Preparation of separation of various wastes				●	
4b Construction	Guarantee to meet its commitments about environ. protection and health care				●	
	Self-control of quality through enterprise				●	
4c Control/inspection	Quality checks			●		
4d Documentation	Elaboration of a building certificate/energy consumption certificate/...			●		
	Preparation of use manual for building control systems			●		
	Organisational and technical preparation of controlling and of consumption coverage,	●		●		
	identification of target values			●		
	Instruction of operators of the building control systems	●				
5 Use						
5a Utilisation	Constant control of resource consumption (energy, water,...)		●			●
	Bill for heating costs	●				●
	Constant control of conventional use and of the building state	●				
5b Maintenance	Management, execution and quality of maintenance/renewal	●				
	Periodical maintenance of building control systems	●				●
	Use of best available technologies if parts of the building control system have to be replaced.	●		●		
6 Deconstruction, Demolition						
6a Design of retreat/de-construction	Basis decision about rehabilitation or demolition	●				
	Selection of deconstruction technology			●		
6b Preparation of deconstruction	Selection of enterprises considering also ecological aspects	●		●		
6c Deconstruction	Execution of deconstruction, separation of construction elements				●	
	Disposal and Recycling				●	
6d Disposal/Recycling	Respect the recycling potential of different construction elements or materials					●

Table 3: Interactions between interested parties and decision-making structure

Factors Influencing Successful Decision-Making

Successful decision-making by actors is highly dependant on three significant factors:

1. Clear goals and environmental performance objectives (well-defined in the beginning, realistic, balanced, measurable using practical tools),
2. Motivated actors
3. An environmental management system

Each of these factors is described below.

1. Clear Goals and Objectives

In the implicit or explicit decision-making process, it is necessary to consider the actors' points of view and their concerns, in other words, the assessment criteria they bring into play when they are choosing technical or architectural solutions.

These criteria are of different nature:

- Social and Political (environmental requirements, public health, quality of life, conservation of the natural and built heritage, territory development, socio-economic stakes, image & exemplarity, conflict management),
- Environmental (ecological sensitivity, emissions, biodiversity)
- Economic (investment cost, running cost)
- Technical (environmental and non environmental) (functionality, technical guaranties, maintenance, comfort, health, air water & soil pollution, waste, resources, relation between the building and the site, architecture & landscape).

It is necessary to be conscious that each actor has his own weighting or ranking (often implicit) of these criteria, environmental or not. This weighting is also necessary to be able to take decisions, since these often result in compromises among several criteria.

Clients and designers have a significantly different approach towards information, and therefore they have a different need of information. The decision-making process is different for each. The client has to make decisions in a rational process of goalsetting, assessing and control usually organised in steps and procedures. However, the designer works in a more instinctive way. Designing is considered to be a mixture of continuous problem definition and -solving, error-elimination combined with handling enormous amounts of data.

2. Actors' motivation to Improve Environmental Performance

Three categories of benefits can motivate actors' desire to improve environmental quality:

Level 1: Profitability for the project itself, in life cycle cost,

Level 2: Improvement of the service functions (comfort, air quality, quality of life),

Level 3: Limitation of damages and costs to be borne by the community (at the various geographical scales).

These levels are especially relevant to building owners, since they often dictate the level of investment in environmental quality. These motivation levels are linked to the political determination of the building owner in terms of leadership, and also to legal responsibilities. All three levels are symbolized in Figure 7.

Level 1: Life Cycle Profitability means that the main decision criterion is economic profitability. An environment-friendly solution may be accepted if, on a certain time horizon, it saves money, compared to conventional solutions (for example, technical solutions leading to more rational use of energy). With this type of viewpoint, the "green" solutions which don't meet the economic criterion will be rejected, because too expensive. The building owners who are only at this level 1 of motivation need tools integrating life cycle cost analysis. They also need educational tools that broaden the 'bottom-line' perspective to include the less tangible benefits of green buildings such as

- Improved marketability,
- Speedier approvals,
- More satisfied customers
- Competitive advantage
- Reduced vulnerability to environmental regulations.

If the client for the building is planning to occupy the space, additional economic motivations might include the impacts of improved indoor environmental quality on workers, including:

- Increased worker productivity;
- Reduced absenteeism for employees,
- Reduced turnover rates for employees,
- Reputation for quality

Level 2 Improved service means that an intrinsic value is given to occupant experiences. In this case, actors are focused on enhanced functionality, comfort (thermal, acoustic, visual, olfactory), health, security, and quality of life. They need tools adapted for this purpose. Such tools need to balance the enhancements to indoor environments and landscaping with possible negative impacts on outdoor environment (for example too much air conditioning will lead to increase environmental impacts).

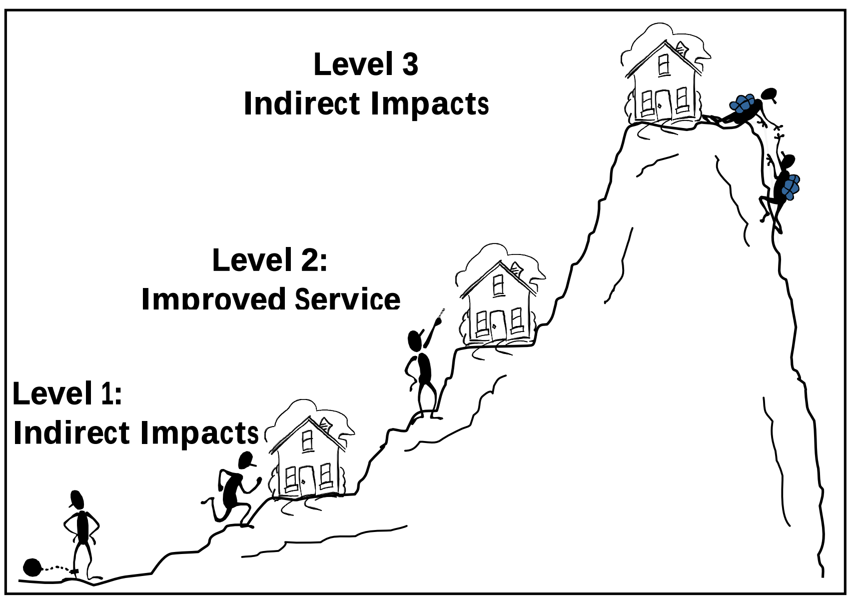


Figure 7 Increasing levels of motivation

Level 3 Indirect impacts indicates that the user has adopted a broader environmental ethic. This is most common when the building owner has a local or regional responsibility (as a regional authority for example). It may be the case for other building owners well informed and aware of environmental effects of buildings on the different geographic scales. This level can be broken down into 3 sub-levels, corresponding to the 3 geographic scales: local, regional and global. Generally, environmental assessment tools, as they are focused on environmental outdoor effects, are well adapted to this level of motivation. The problem is that this type of tool is generally too focused on this motivation level 3, ignoring the interactions with costs (investment and running costs) user requirements and benefits to occupants. Certain methods or tools might be used to help the building owners to translate motherhood environmental goals into more tangible goals and to set firm priorities and measures for accountability.

3. Environmental Management Systems

Effective implementation of complex projects incorporating environmental criteria always requires teamwork. Tools are needed to help mobilise all the actors on a team (building owner, designers, contractors, users) around goals that are shared and well understood. By far the best tool for this purpose is an "environmental management system". Such a system helps to organise actors and all the policy and working documents related to environmental quality, and ensure that each actor is coordinated with the others and held accountable for achieving the team's performance targets.

Ideally an environmental management system is used continuously to direct and redirect the decisions, based upon actual performance, and changing opportunities and constraints. This is sometimes referred to as adaptive management, and is suitable for long life projects and for building management that encompasses new design, refurbishment, operation and maintenance. A number of EU and international standards exist for corporations that want to apply environmental management systems to large-scale projects and company operations (e.g. ISO 14001). These standards are suitable for the building sector.

A typical EMS can be represented as a pyramid framework that has, at its top, a definition of environmental quality and green buildings, along with the fundamental principles of good design and a vision of project success. From this pinnacle, the framework divides into a spreading tree of elements, at increasing levels of specificity, until at the bottom it addresses the monitoring of performance for new systems. Each level in a typical framework is described below.

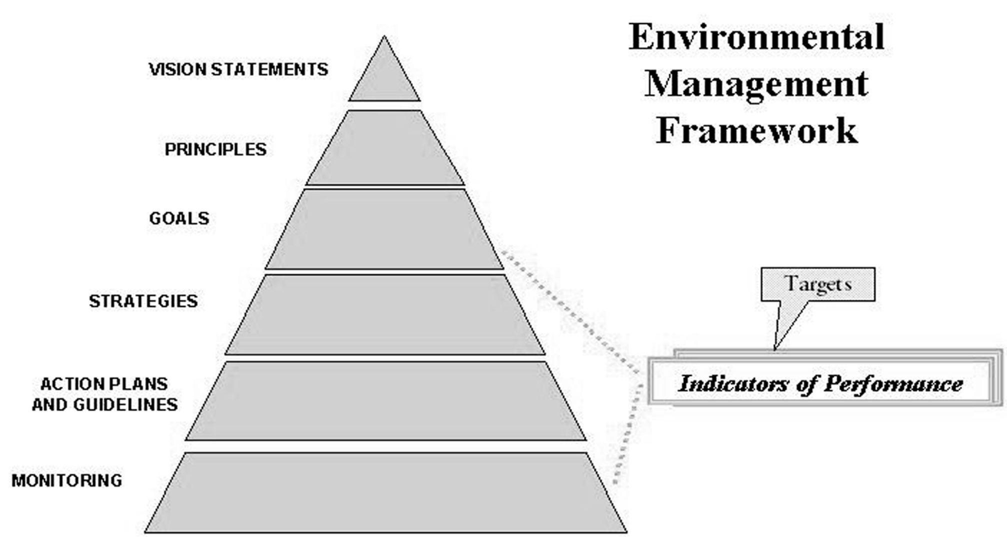


Figure 8 Environmental Management System for Developers

Key Strategies identify the basic approaches that can be implemented in order to achieve a goal or a set of goals. A goal can be linked to a number of different key strategies. Generally strategies should be selected that are known to address more than one goal, as this demonstrates a comprehensive approach and the achievement of synergies. Preserve natural drainage patterns on the building site is an example of a key strategy.

Specific Actions provide a range of activities that can be implemented in order to fulfil the key strategies. By virtue of the clear link of key strategies with goals and principles, it is also clear how the specific actions address the higher layers of the framework. Reduce the impermeability of surface covering on the site is an example of a specific action.

Guidelines and Specifications provide much more detailed information on how to implement specific actions. For example, guidelines on reducing site impermeability can be prepared.

Monitoring Systems close the loop of the process through tracking and measuring changes in performance on an on-going basis. This information can be used to demonstrate whether strategic direction is appropriate or whether further changes are required. Monitoring and communication of results are linked to improved environmental performance.

Frameworks like this work best when combined with performance indicators and targets. Performance indicators quantify the impact of specific actions, and therefore help to determine if the specific actions are being successful in their intent. Targets are a kind of policy tool that set ideal levels of performance. Two kinds of indicators are useful:

1. **Design indicators** are performance values that can be measured or estimated at the design stage, and that can be used to set targets for challenging designers and coordinating and apportioning their effort. Percentage of site area covered in effectively impermeable surfaces is an example of a design indicator. An example of a desirable target would be 10% effectively impermeable area.
2. **Monitoring indicators** are performance values that can be used to measure how well a particular project is actually performing. They can assist in learning and in setting procedures for managing systems and allocating costs. Percentage change in quality and quantity of water running off the site is an example of a monitoring indicator. An example of a desirable target might be no net change.

The Actor's Need for Decision-Support Tools

Each actor involved in a building design process has his or her own scope for decision-making, and may become involved in decisions at a number of stages. Decision-support tools must reflect this complex context, and recognise that all actors are unlikely to benefit from the same tool. Specific tools are needed to support good decision-making at the most appropriate stage of the design process. For example, it is necessary to have good tools to provide environmental assessments even at the very early design stages, at the brief and sketch design stages.

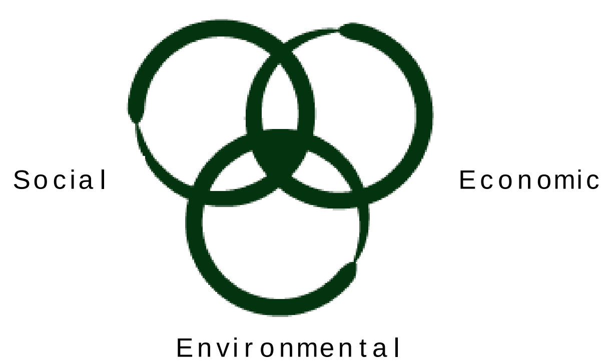
As a first approach, the actors need:

- Decision aid and assessment tools
- Tools for creating new awareness, tools for educational purposes
- Design aid tools (catalogues of solutions or of products)
- Tools to carefully consider the environment at the local scale
- Tools to aid the actors in making the right decision at the right time, without making the decisions in their place
- Tools which speak their language, which are transparent, easy to use and suitable to their operational context

Actors need quick, effective, affordable tools adapted to their needs and culture. The tools also must adapt to the different levels of decisions involving tool application, including:

- The actor who **initiates** an approach to the assessment of the environmental quality of a project (example: a local political entity),
- The actor who **selects** the most suitable tool (example: an environment consultant),
- The actor or the actors who **provide** the necessary **input data** (examples: the architect, the engineering firms, the manufacturers),
- The actor who **implements** the assessment tool (example: an engineering firm),
- The actor who **interprets** the results of the assessment (example: the engineering firm with relation to the building owner),
- The actor who **takes the final decisions** (example: the building owner or the contracting authority).

Building owners are typically very sensitive to issues of cost, affordability, and quality of life. Environmental concerns are often treated as if they are achieved at the expense of these concerns. However the recent emphasis on sustainable development in urban areas has repeatedly emphasized the potential for true synergy when an integrated design process is adopted. By simultaneously addressing the three spheres of sustainability, - economy, social welfare and environment – it is possible to improve all three. While the larger issues of sustainable design are beyond the scope of Annex 31, they are unavoidable. Only by achieving synergy across a broad range of goals is it possible to have significant success in reducing the energy-related environmental impacts of buildings.



Improving Role Played by Key Actors

It is clear that the actors involved in building projects are numerous and diversified. They have different concerns, choice criteria, and priorities. The term 'environment' carries different meanings – and is often restricted to only the types of impacts historically related to each respective discipline. This broad variety of perspectives, and the predominance of non-environmental criteria in decision-making, presents a major barrier to the development of green buildings. Efforts must now be focused on training building owners, architects, and other actors, and increasing awareness among occupants and the entire design team.

It is important to reposition environmental quality of building in a broader overall quality context. That means that each technical or architectural green solution has to be systematically compared to a sufficiently complete list of criteria (environmental, technical, financial, social) as part of an integrated, multi-criteria approach.
Ideally the entire design team should be educated and sensitised regarding environmental phenomena, the use of assessment tools, and environmental management procedures. The design team for building project should include actors knowledgeable in use of assessment tools.

An overview of the decision-making process has also emphasized the need for purpose-built tools that can assess solutions throughout the project lifecycle. Such tools need to be quick, effective and low-cost, adapted to the actor's needs and culture. Each actor has special needs that need to be addressed at this time, as discussed below:

> For **owners and financial controllers**, it is important to translate improved performance for green buildings into opportunities for financial incentives, increased productivity, enhanced marketing opportunities, innovative financing schemes, improved technical guaranties, and reduced liability and risk. Life cycle cost thinking is fundamental to such an approach. Environmental methods or tools can be used to help building owners translate general environmental goals into tangible goals, and set priorities.
>
> For **architects**, decision-support tools must be adapted to the day-to-day realities of work processes. Tools must accommodate fast-paced, visual decisions, and allow for rapid iterations. Environmental criteria need to become another layer of information, integrated into a multi-criteria analysis.
>
> For **engineers**, access to objective and detailed information on appropriate tools is the greatest need. Engineers also need 'just-in-time' training, and regular feedback on actual performance of existing green buildings.
>
> For **contractors**, the major issue is managing the changes and developing new standards for specific applications. Results from decision-support tools need to be transparent, and closely tied to information on best practices.

Ultimately the use of relevant environmental assessment tools should lead to better knowledge of environmental impacts related to buildings, and to an improved dialogue between all parties involved in a building project. Tools must provide precise answers to questions on environmental impact of buildings on their life cycle, and satisfy the environmental objectives mentioned in the brief. They should contribute to a rationale for choosing environment-friendly solutions, and emphasise the importance of life cycle environment impacts during the critical early design phases.