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CONTRIBUTED PAPERS: PART TWO

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Session 4

"BUILDING-PASSPORT" – A TOOL FOR QUALITY, ENVIRONMENTAL AWARENESS AND PERFORMANCE IN THE BUILDING SECTOR

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INTRODUCTION

The Institute of Ecological and Regional Development (IOER) is a research institute, which is mainly publicly funded[1] and is active in the areas of documentation, evaluation, and communication of environmental properties of buildings. Some of the key terms in this context are 'Building Passport' and 'environmental labelling for buildings'. The term 'Building Passport' is currently being used with differing meanings. It can denote a two-paged certificate displaying the most important performance characteristics and technological data of a building - comparable with motor vehicle documents - as well as a comprehensive collection of various building-related documents (plans, calculations, lists and declarations of materials and products used, operating and maintenance guidelines etc.).

In this context, the federal state of Schleswig Holstein commissioned the IOER to develop the basic structure for a 'Building Passport'-scheme. With this project a welcomed opportunity was opened to transfer the theoretical preparatory work to a more practical and application oriented basis.

The main target of the project was to outline an instrument which was to render both information on building quality in general as well as open a perspective on environmental characteristics and performance criteria. The instrument is supposed to provide guidance for user groups (architects, planners, clients, owners, tenants, financiers) and thereby support appropriate decision making and at the same time serve as a means for strengthening the competitiveness of extraordinary voluntary environmental performance in building practice.

The results of this work are presented in the following. The first section contains general theoretical aspects of the 'Building Passport' approach and empirical findings concerning attitudes and expectations of players in the building sector. The second section gives an overall view on the example of the "Building Passport Schleswig-Holstein", which is here considered as a toolbox rather than a single instrument. The framework and starting points of the development are explained, the core elements of the scheme and recommendations regarding its implementation presented.

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1. IOER is jointly funded by the German Federal Ministry of Traffic, Building and Housing (BMVBW) and the Ministry of Science and Arts of the Federal State of Saxony. The project "Building Passport Schleswig-Holstein" was financed by the Ministry of the Interior of the Federal State of Schleswig-Holstein.

1. Theoretical basis and principal requirements

Sustainable development in the building and construction industry is faced with two central challenges (in addition to that of building economically): firstly, ensuring classic quality in building and, secondly, achieving a continuous improvement of the environmental performance of buildings that will take them above and beyond the general standard reached already.

The problem of ensuring classic quality in building, which is a task in itself and is also the minimum necessary requirement when it comes to building ecologically[2], is increasingly important as a result of deregulation and the presently difficult economic situation in the construction industry. In addition, the goal of high energy efficiency in buildings results in high requirements with regard to general quality. At the same time the necessary excellence in insulation and air tightness (e.g.) is not easily discernible in the finished product and advanced ecological and health related qualities of buildings are even more difficult to assess. Laudable voluntary environmental activities in the construction industry can today hardly be recognised amongst a host of fantasy and exaggerated declarations. The (self-) declaration as a “ecological building product“ (or “environmentally-friendly” or “sustainable” etc.) often appears arbitrary. Supporting and promoting high-quality construction that is earnestly ecologically oriented therefore first of all depends on increasing the degree to which good practice is recognised: transparency instead of “finish“[3] and real ecological orientation instead of “green-washing”.

1.1 Effectiveness of (environmental) labelling as an instrument for the promotion of quality and ecological orientation in building

It is a basic phenomenon that product characteristics which are directly perceptible, as a rule, have a greater effect on the investment decisions than characteristics of quality that tend to be more hidden: While it is difficult enough for experts to assess the quality of construction and environmental performance of buildings, this is almost impossible for the clients and/or users. This fact encourages providers of building services to (deliberately or immanently) take a low-quality “cost-dodging“ approach, which in practise leads to a decrease in the attractiveness of high-quality construction. This relationship becomes even clearer when looking at the possibilities consumers have to identify properties of a product. Product attributes can be divided into three theoretical categories, which are reference points for gathering information in a decision-making process[4]:

"Search attributes": This category deals with product characteristics that are directly perceptible when making a choice. The effort needed to gather information is low and is limited to the simple comparison of products. An example from an ecological perspective is how lavish the packaging is for products that are otherwise equal.

"Experience attributes" are characteristics or properties that can only be perceived or examined when experience with the product has been gathered. The effort needed to collect information is relatively high. These characteristics only result in a gain in information and improved decision-making on the part of the consumer in situations where the decision to buy is made frequently. For this reason, these characteristics are, in general, not helpful for the support of the decision-making processes where the “product“ is a building.

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2. For further information see notes on ‘Understanding Quality’ in Section 2.3.

3. One participant who took part in an interview of experts summarised the problem of quality by stating: “The Germans are experts when it comes to giving something a good finish“.

4. Karl et al (1999).

"Credence attributes": These are characteristics that can neither be recognised directly nor perceived by means of experience with the product. They are a matter of faith in the supplier.

Now, the problem in making an environmentally oriented decision for a product is that from the point of view of the consumer environmental properties of products predominantly are "credence"-properties. In the case of a building as a very complex commodity, this is also true for many general characteristics of quality. The result is a structural imbalance in the information that the suppliers and the consumers have on a large number of the essential qualities of a building. This in turn enables suppliers of relatively low quality to pass this off as higher quality whilst on the other hand little trust is shown in those earnestly offering high quality. A continuous process of "adverse selection" results, in which higher-quality products - such as buildings or building-concepts in this case - cannot succeed in the market to the degree desired.

Especially when establishing sustainable concepts for the building industry in which an attempt is made at balancing economic, social and ecological aims it is important to develop transparent methods of assessing and awarding respective performance[5].

Since the introduction of new standards cannot hope to gain general acclaim in the current building industry development, which tends to move towards deregulation, the promotion of high-quality construction essentially depends on the use of more subtle tools. Such tools (e.g. self-commitment, financial incentives, information and consultancy) may be combined into a label for good quality building (from documentation via certification to a quality label). On one hand, suppliers can emphasise their particular quality ("signalling"), and on the other hand customers receive an initial orientation on qualities, which are to a large degree invisible and comparatively difficult to comprehend. In this way, labels referring to quality contribute to transforming credence into search attributes thus increasing the chances that for instance real-estate customers, tenants, sponsors or financers can better include environmental as well as general and traditional characteristics of quality of buildings in their decision-making process ("screening")[6].

1.2 Basic requirements

In order to satisfy the requirements of the target groups appropriately, the tool should have certain characteristics, which can be derived from the general literature on product labelling as well as from experience with already existing similar tools[7]. In general, it can be stated that a label of (environmental) quality apart from turning "credence" into "search" attributes (cf. above) should mediate the poles of "no information" and "information overload" by transforming the input of information *required in practice* into information output *acceptable to the recipients*. Depending on the concept of the label, this transformation induces a major or minor aggregation of the information input. Figure 1 shows the main elements of an (environmental) quality label in a schematic graph.

5. According to BMBF (1996).

6. Rubik et al (1996).

7. Due to the limited space in this paper, no examples are presented in detail. However, some important examples are listed with the references.

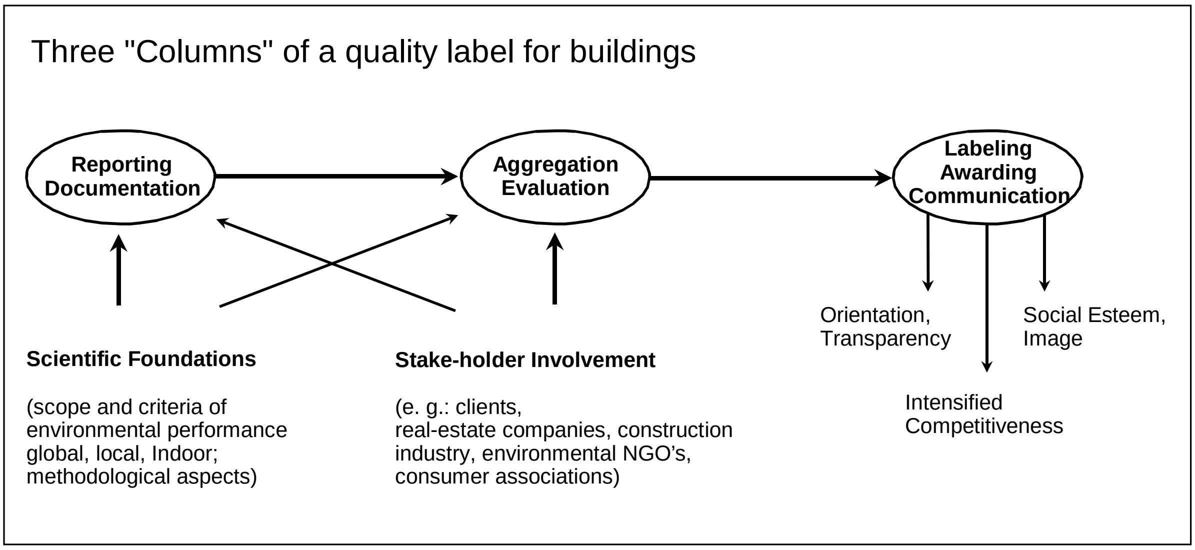

Figure 1: The main elements of an (environmental) quality label for buildings (Blum et al, 1998)

On the input side (Figure 1: Column 1, 'documentation'), the tool should first of all record the relevant information on environmental impact as comprehensively as possible. In the case of the assessment of buildings this may for instance imply adding site-dependent impacts to the product-induced ones. Furthermore, according to the concept of sustainable development, aspects of social usefulness and economic feasibility should also be taken into account. In addition it is important that the framework of a quality label is left open to revision and modifications so that both new knowledge and new aims can be included periodically.

The attractiveness of a label signalling and rewarding (outstanding) quality of a building (Figure 1: Column 3) is a further important aspect. Benefits to be expected from a label (transparency in the market, social rewards, competitiveness) are one point, questions of the formal data presentation (accessibility and readability) and an aesthetically attractive presentation (symbolism etc.) another. For an effective use of the label it is not enough to use pure symbolic labels (typical eco labels[8]) alone to communicate the very complex qualities of buildings (Figure 1: Column 3). Rather what is needed are tools that on one hand quickly give a general impression relevant to environmental aspects and health issues by means of *striking messages*, but on the other hand offer *detailed information in the background*, which can be referred to as need arises. At the same time this also makes the processes of aggregation and evaluation more transparent (Figure 1: Column 2) and in turn substantiates the tool's credibility.

In the conception of this tool it must be kept in mind that from the viewpoint of suppliers of high-quality buildings organisational expenses and actual costs are decisive for the acceptance of the procedure. Also, suppliers will naturally want to emphasise the positive aspects of their products. A 'Building Passport' and quality label as a voluntary instrument can fulfill this requirement especially when a choice between several approaches exists. It has to be noted, though, that the existence of different procedures improves the performance and usefulness of a labelling approach for the *applicants* but at the same time usefulness and acceptance for the *users* depend on the compatibility and comparability of approaches and evaluation systems at least in basic characteristics (for instance via a "fourth party establishment", cf. below).

The character of the institution providing the label plays a significant role in the acceptance of the tool. It is plausible that a quality label devised by an individual company will be viewed as less credible than that

8. The "Blue Angel" in Germany or the European "Marguerite" are examples.

devised by neutral institutions, especially when these are well known and have a good reputation. Three forms of institutional establishment may be distinguished depending on the institution's position in the market: "first party", "third party" and "fourth party" establishment[9].

"First party" establishment

This notion summarises self-declarations of products or product-lines established by individual private companies. These labels vary significantly with regard to content and concept and use a most varied range of terms[10]. It is not excluded that purely private labels are backed by a serious commitment, but in public view acceptance and usefulness are often marred since objectiveness and quality of the results are questioned.

"Third party" establishment

This category deals with reviews, certificates and labels that are offered by neutral third parties. A distinction can be made between tools that are private, semi-public, public or publicly authorised.

Private labels are assessment and certification tools that are supplied as a neutral service, for example, by engineering consultancies. Examples of combinations of first party *declarations* and private third party *certification* are found in product advertising.

Semi-public tools can, for example, be supported by general business or consumer associations or quality assurance associations and may be designed for specific product groups (e.g. timber-frame construction, low energy building etc.). Although the improvement of the competitiveness of the applicant company is of importance here, too, the outstanding goal however is better market transparency. (Environmental) quality labels that are provided by independent associations require more expenditure on the side of the applicant but provide more credibility and thus have a potentially greater effectiveness.

Public tools or publicly authorised tools primarily aim at promoting initiative and innovation. As voluntary achievements in particular are generally at a disadvantage on the market (see "adverse selection" above), these public tools are a form of intervention in the market in order to support good practice. Nevertheless this interventionalistic character at the same time is the major reason why in Germany up to now a 'Building Passport' and in particular an (environmental) quality label for buildings have not yet been very far developed in public institutions, at the contrary encouraging the private sector to provide appropriate services[11].

Whilst public or publicly authorised third party approaches can generally be expected to be acceptable as far as their credibility is regarded, they at the same time display another weakness in that as far as the content is concerned, they tend to set low standards. The reason is that public institutions have to achieve consensus amongst groups with the varied interests. When influencial groups with vested interests in low requirements win over the standard is lowered altogether. Fourth party concepts reflect on this aspect.

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9. Karl et al (1999).

10. Examples of such terms for Germany, some of which also have a corresponding logo, are "Eco-House", "Naturehouse", "close to nature", "Naturebuilding"; "Bio-House", "Eco-domo" etc. (from the small ads section of the German "Oeko-Haus" magazine, translated freely by the author)

11. For example to the former German Minister for the Environment Toepfer in a paragraph in the press; Toepfer (1997).

"Fourth party" establishment

In fourth party schemes, the various options for establishing quality labels as described above are maintained. However, a general authority is appointed as a means of safeguarding the reputability and comparability of the programs involved. The tasks of this institution include, for example, monitoring the quality of the criteria applied, integration of ecological information, monitoring of internal processes and involvement of interest groups (including the issue of financing) as well as various methods of sanctioning, if failures to meet the stipulated requirements[12] arise. A central element is that of ensuring minimum standards regarding conception and content whilst allowing for a certain variety and competition of tools that have differing and possibly higher requirements (e.g. regarding the scope or standards for environmental criteria).

1.3 General requirements and expectations of target groups for the tool

Irrespective of what conception is chosen, both a 'Building Passport' and an (environmental) quality label should not only be based on scientific expertise but should also meet the subjective requirements of the target groups[13].

In order to gain an insight into general attitudes and expectations in the building sector towards environmental labelling for buildings[14], a survey of major player and interest groups in the German building sector was conducted in 1999[15]. The groups involved were the associations of architects/planners, owners/clients, tenants/users/consumers, and estate agents at federal and federal-state level. In addition, the federal associations of major environmental organisations and numerous prefabricated house suppliers were surveyed, as well as financing institutions. The survey was divided into a pre-survey by telephone and a subsequent standardised questionnaire. A total of about 160 associations and institutions were contacted. Roughly a third were then approached within the sample telephone survey, whilst roughly a quarter returned the questionnaire (46). The survey was essentially divided into questions on specific content and conceptual requirements as well as questions on how the general approach was accepted. The following presentations are limited to the results on the general aspects.

General findings

Although the findings from the exploratory investigation cannot claim to be representative in statistical terms, the synoptical evaluation of the qualitative and standardised sections of the survey does yield a useful initial picture of the general mood[16] amongst the various player groups in the building sector. Both the qualitative impression and the quantitative data reveal that approximately a quarter of those surveyed are clearly amenable to the idea of an "environmental quality seal for buildings" (Figure 2). Roughly half are vaguely in favour or adopt a cautious attitude. Besides acknowledging positive aspects of the approach and showing a general willingness to debate the issue, this grouping also offers serious criticism. Doubts are aired, for example, with regards to the practicability of the tool, the accessibility of data or the costs involved. The costs issue in particular is a matter of some sensitivity for all respondents. Only just above 10 % of respondents regard higher costs for certification as acceptable without reservation, whilst about

12. According to Karl et al (1999).

13. Rubik et al (1996).

14. For the context of this survey „Environmental quality seal for buildings".

15. Blum et al (1999).

16. The values given in the Figures relate exclusively to the written part of the survey.

30 % consider them to be "possibly acceptable" (Figure 2). Opposition to higher costs was particularly voiced by planners' and architects' associations, whereas greater acceptance was found with consumer/tenant associations and prefabricated house suppliers.

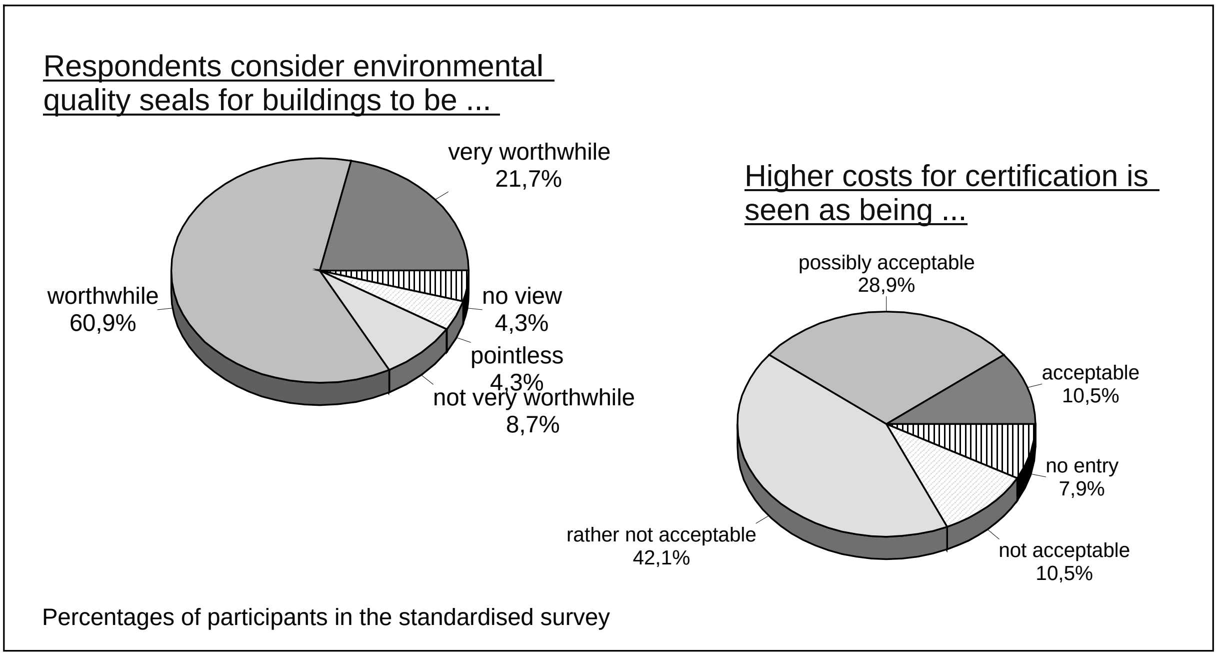

Figure 2: General attitudes towards environmental labelling for buildings (Blum et al, 1999)

A stance of opposition to environmental quality seals for buildings was taken up by around a quarter of respondents, backed in some instances by explicit resolutions by the institutions concerned. The approach is rejected primarily on the grounds that, given the complexity and uniqueness of a building, any attempt to assess its environmental impacts or special characteristics in a comprehensive and comparable way will be fraught with great difficulties. Attention is also drawn to the organisational and financial input associated with testing and certification. Any not purely private - and voluntary - tool is criticised as being unnecessary governmental intervention in the market and causing further bureaucratisation of the building sector. Even endeavours to standardise existing (private) schemes are likewise rejected as first steps towards legal regulation and compulsory adoption.

An environmental quality seal for buildings is given a predominantly positive rating by tenant and consumer associations and also by financial institutions. The former in this approach see in the first place an important information tool for the demand/user side. Above all, tenant and consumer associations hope that market transparency in the sphere of ecological construction will be enhanced and that knowledge of how to operate and use a building will be provided - for tenants and owners alike. Also, information on health matters as well as on operational characteristics and costs (energy consumption, servicing/maintenance etc.) is of particular interest. Financial institutions appear to be increasingly viewing ecological factors as an important aspect of the long term value of a building. Environmentally-oriented financiers in particular, but some general financing institutions too, are already including environmental issues in their valuations of real estate and credit management activities. An environmental quality seal is viewed as a helpful information tool in this respect. Some of these institutions are also currently developing their own specific environmental assessment tools. Due to the economically focussed background energy consumption in particular is often addressed. A very interesting tool for example - even under the ambition of sustainability - is the “ImmoPass”, developed on initiative of the German HypoVereinsbank[17].

Regarding the building industry and trades, notably representatives of the growing building materials recycling sector welcomed the dismantling information expected to be provided within the frame of a ‘Building Passport’. In the case of associations representing real estate agents and the construction industry, it became apparent in the course of the telephone survey that these groups see themselves as heavily dependent on customers’ choices. They therefore do not regard themselves as suitable discussion partners on the issue of environmental quality labels.

On the whole, it can be deducted on the basis of this survey - and further work in Schleswig-Holstein has confirmed these assumptions - that serious interest in the building and construction industry exists in having a tool such as the environmental quality label/’Building Passport’ at disposal. Nevertheless any development of such tools should take seriously the criticism and be carried out in close cooperation with all players in the building sector.

2. “Building Passport Schleswig-Holstein” as an Example

2.1 Basic conditions

The development of the “Building Passport Schleswig-Holstein” was carried out in three stages: stock-taking of existing specific conditions and possible ‘anchor-points’, definition of the aims and requirements of the political players and interest groups in the building and construction industry, and finally a draft of the basic concept and development of an implementation scheme. Basic orientations on the topic of environmental product labelling were taken from the ISO standards 14020 f.[18].

Existing tools and possible ‘anchor-points’

The political and economic conditions in Germany, (especially with the upcoming energy saving ordinance expected to be enacted in 2001, increasing energy prices and a tendency towards a tenant-dominated market[19]) along with the numerous initiatives and programs in ecologically-oriented construction in Schleswig-Holstein, provide a good starting point for the development and implementation of a ‘Building Passport’. In particular, a committed *“Low Energy Standard for Buildings”* [20] has recently been included in the public guidelines for subsidised housing development of the federal state; measures in the *“Initiative Program for Thermal Refurbishment”* [21] attempt at supplying information as a basis for environmentally responsible action.

The *“Criteria for ecological planning and building”* published by the Ministry for Nature and the Environment of the federal state of Schleswig-Holstein as far back as 1993 are also particularly noteworthy. Irrespective of the degree to which some of the criteria today had to be revised (in the area of energy requirements, for instance), the content of the brochure may, on the whole, be seen as a public

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17. DEKRA (2000).

18. ISO (1998).

19. During the series of expert-interviews, the average rate of residential vacancy was stated to be 3 to 5%.

20. “Niedrigenergie-Haus-Standard” (NEH-Standard).

21. “Impulsprogramm waermetechnische Sanierung“.

consensus and thus provides an excellent starting point for the conception of an updated ‘Building Passport’.

Expectations, reservations and requirements expressed by the interest groups

In order to achieve a high level of acceptability communication with the interest groups made up a large part of the project work. Representatives in Schleswig-Holstein of the major institutions concerned were interviewed by telephone and questioned on their opinion on issues of a ‘Building Passport’. Additional information came from the nationwide study mentioned above. The results of the survey were presented as a feedback to the participants at a workshop with the aim of focussing major topics. The following essential issues were recorded for the conception of a ‘Building Passport’:

- the basic problem of *formulating clear goals* and the identification of target groups,
- the main focus of *quality assurance* (with integration of ecological goals and in particular goals related to health issues),
- the *simplicity* of the tool with regard to *readability/comprehensibility,* as well as
- orientation on *information for the end user*.

The necessity of continuous updating and amendments as an important element of the concept of a ‘Building Passport’ was discussed in this context. Regarding the content, the topics of building materials choice (ecological aspects and health issues) and energy were stressed as being most important.

Political targets

With the aim of defining the central objectives of the political players involved four typical scenarios were outlined for appropriate ‘Building Passport’ concepts and were presented for discussion with the advisory board of experts[22]. The four scenarios were labelled *“Good construction Practice / Assurance of Quality”* (main focus: traditional/classic qualities in building and construction as the basis for ecological orientation), *“Ecological performance through competition”* (main focus widespread implementation and transparency), *“Ecological excellence ”* (main focus in environmental policy: promoting innovation) and *“Foot in the Door”* (a combination of (low level) tools and long-term implementation).

The discussions resulted in the decision to use a combination of scenarios one and two as the primary orientation with the main target being assurance of quality. Some important key words were: ecological aspects as an important component of general quality in building, building stock as the primary working area, simple and pragmatic tool as a starting point and to ensure widespread use. The public players clearly signalled their support for the tool to be developed, but considered a widespread implementation to be achievable essentially through the market. In introducing the tool it was, though, suggested that the “protected sphere” of the semi public intermediary organisations be used. This suggestion referred in particular to the “Working Group of Contemporary Construction“ (ARGE)[23] in Schleswig-Holstein.

ARGE was established in 1946 to organise emergency programs and self-help programs in post-war housing, and is today still a very interesting institution both politically and professionally. Almost all

22. The advisory board of experts was made up of representatives of the important participating public and semi-public institutions of the federal state of Schleswig-Holstein.

23. "Arbeitsgemeinschaft zeitgemaesses Bauen e.V." (ARGE, o.J.).

important institutions of the building and construction industry and housing development are represented in this association. This situation predestines the association as a link between private economy and public players in the development and implementation of a 'Building Passport' for Schleswig-Holstein.

2.2 Basic models

As a starting point for the design of the "Building Passport Schleswig-Holstein" *three typical separate models* were drafted. These models represent the three basic components of a comprehensive approach[24]:

Model 'Building Logbook'

Key words: transparency, widespread use, comparatively low costs, integration of all participants, communication, responsibility

Especially in the case of owners of buildings and tenants, there is a need to introduce a tool that besides presenting data on the properties of the building and archiving relevant documents also provides guidelines for operation and maintenance. As a "building logbook" it should be kept up-to-date by the user or owner, for instance with regard to resource consumption (water, energy etc.), maintenance, and structural changes. The "building logbook" itself does not include any assessment but is the basis for further modules that can be added.

Model 'Building Passport'

Key words: regulation and assurance of quality, avoidance of building damages, consumer protection, marketing, promotion of competition

As inspection regulations under public law are being increasingly reduced there is a shortage in monitoring the technological properties of buildings. At the same time requirements on planning and good building practice grow steadily and the need for new forms of quality assurance achieved by means of free market tools increases.

The concept of a building passport as an independent tool therefore is a good starting-point. Although buildings are not explicitly assessed, a widespread use of 'Building Passports' can lead to better market transparency by means of gradually developing a reference system.

Model 'Quality label'

Key word: Best practice

A quality label for buildings as an element of an ambitious building and environmental policy formally puts into operation the main goals of the issuing institution - in this case the federal state of Schleswig-Holstein - with regard to a sustainable development in the building and construction industry. The quality label honours outstanding voluntary and innovative achievements concerning environmental and health aspects in building projects. As well as being effective in marketing, a label, which is awarded as publicly as possible, should also communicate best practice.

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24. Documentation, evaluation, awarding/communication; see Section 1 Figure 1.

2.3 The basic conception of the "Building Passport Schleswig-Holstein"

Due to the tight framework of the project, the aim of designing a tool for the building stock has been postponed and the basic concept was oriented towards new buildings, which are somewhat easier to handle. Nevertheless significant information has been provided for adapting the tool to the building stock.

Whilst working on the project, different primary aims and requirements of the "Building Passport Schleswig-Holstein" became clear. The following aims in particular should be mentioned: achievement of widest possible utilisation (to make the application of the tool affordable!), creation of a tool that is marketable ('Building Passport' as a service), achievement of quality assurance and promotion of environmentally oriented construction that also takes health issues into account.

Integrated definition of quality

An integrated definition of quality is necessary if the passport is to comply to the concept of sustainable development[25]. In detail the integrated definition of quality in the basic concept of the "Building Passport Schleswig-Holstein" compiles the following core elements:

Quality of Building / Quality of construction and planning[26]

The necessity for all parties involved in construction to develop an awareness of quality and sensitivity to typical weak points, especially with regard to buildings that have requirements for low energy consumption stands in the foreground. Quality in this sense denotes a reduction in the risk of shortcomings in quality especially with regard to typical cases of damages in buildings[27]. Consultancy during the planning stage, monitoring throughout the construction process and final inspection of the building (cf. below) are central to an appropriate process.

Environmental Quality

Unlike problems of (technical) building quality, which at least can generally be dealt with objectively by means of technology and legal requirements, the definition of the environmental quality of a building heavily depends on a political (or more general: social) consensus regarding environmental aims and criteria. For this reason, the 'Criteria for Ecological Planning and Building' mentioned above were referred to in this project. Particularly regarding a widespread implementation, the 'minimum standards' laid down in this manual provide a very good starting position for development of a basic conception for the 'Building Passport'. By listing 'further measures' the criteria are made dynamic: The guidelines presented are more than just the political consensus of the moment (at the time of publication, 1993) but rather include further reaching recommendations that opt as the basis for future development.

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25. Ministry of the Environment, Nature and Forestry of the federal state of Schleswig-Holstein (2000 / Oeko-Institut).

26. Technical characteristics of a building, which can be treated objectively, are central to the term 'quality of a building'. The inclusion of other, notably aesthetic, aspects will be examined during later development.

27. Comprehensive information provides the "3rd report on damages in buildings"; BMBau (1996).

Health Aware Construction

The assessment of the degree to which a building considers health issues in a 'Building Passport' is methodically difficult due to various reasons. This applies both to the methodology of actual measurements and the standards used in evaluation along with the fact that well-being and health cannot be separated from individual user-specific requirements and sensitivities. Therefore, the examination of the finished building with regard to health-related issues by means of comprehensive monitoring of chemically, biologically and physically harmful substances in the 'Building Passport' does not appear appropriate. It would also not comply to the aim of keeping costs low[28]. Estimation of health risks and their reduction to a minimum should be handled beforehand by measures such as choice of location, careful planning, well-targeted choice of building materials, documentation and declaration (!) (e.g. through product and material lists). Monitoring for harmful substances should only be restricted to cases of actual doubts and then be selective and well targeted.

Components of the basic conception of the 'Building Passport'

Based on the integrated definition of quality laid down above a concept for the tool was suggested that combines 'soft' pragmatic elements (checklists, consultancy) with actual requirements regarding priority target areas (air tightness, energy consumption, building materials etc.). In accordance with the general aim of supporting high quality construction, this approach cannot be limited purely to documentation of the (eventually inadequate) *status quo*. Therefore the range of tools covers consultancy during the planning and monitoring during the construction process before entering the phases of documentation, certification and up-dating. It is important that the tool is not centred around control and the imposition of 'correct' solutions but rather around cooperation according to the principle that "two heads are better than one". The basis for this cooperation is the approach already described, i.e. promotion of high quality construction not by means of stipulating desired characteristics of a building but rather by creating a general awareness of quality issues and especially the risks of quality failure. Experience of external consultancy in the area of subsidised building in Schleswig-Holstein shows that it is possible not only to qualify a project but also as a general rule to save costs in this process.

The basic concept for the "Building Passport Schleswig-Holstein" developed as a basis for further discussion and development contains five main components (Figure 3):

1. Consultancy

The consultancy component includes an initial review, which is free of charge (clarification and discussion of project aims) and a more detailed consultancy as a basis for planning. In order to prepare detailed consultation the parties interested are handed out a "Planning Checklist". The specification of monitoring focuses during the construction process is also discussed during the second consultation stage. The consultancy is primarily aimed at the building contractors' architects or project managers. The participation of the client is desirable (team orientation, 'awareness of quality').

2. Guidance / Monitoring / Final inspection

28. This differs when the tool 'Building Passport' deals with existing buildings: compiling an inventory of the used building materials often proves to be considerable difficult, monitoring is necessary where harmful substances are suspected in order to record the extent of the contamination qualitatively and quantitatively and undertake appropriate steps in refurbishment.

Guidance includes one or several intensive on-site inspections during which sensitive/problematic points or building phases identified in the consultation are monitored, as well as random checks as need arises. The final inspection consists of a review of the completed building and in particular includes a test for airtightness ("blower door" measurement).

3. Documentation / 'Building Logbook'

The documentation corresponds in principle to the building documentation described as last planning stage in the German federal regulations on remuneration of architects and engineers[29]. Nevertheless it is supplemented by documents specific to the 'Building Passport' such as the planning checklist, records of the inspections or the list of materials used. A pre-prepared index is provided as a formal basis ('Building Logbook'). The 'Building Logbook' is a supplement to the actual 'Building Passport' (cf. certification).

4.Certification / 'Building Passport'; extension to a 'Quality label'

The certification process leads to the actual issuing of the 'Building Passport'. Certification primarily refers to the formal requirements of the 'Building Passport' procedure. Regarding the content compliance with the ordinance on energy saving in buildings mentioned above is a central point. In addition, fulfilment of certain criteria in the planning checklist will be checked including the degree to which the material recommendations have been adopted. An extension of the 'Building Passport' into a graded quality label by coupling it with minimum standards regarding procedures or content is possible. The 'Building Passport' is valid for a period of four years at first.

5. Continuous Use / Updating

Structured updating and archiving of important documents and information on a building over the whole lifetime is a significant element of the "Building Passport Schleswig-Holstein". A logbook that has been kept up-to-date provides important basic information both in the case of letting or selling of the building, and in building operation in general from everyday use to modification or maintenance and renovation. Maintenance of the building logbook and updating of the 'Building Passport' is supposed to take place during and after the four years' validity and is required when applying for an extension of the passport.

29. Honorarordnung Architekten und Ingenieure (HOAI).

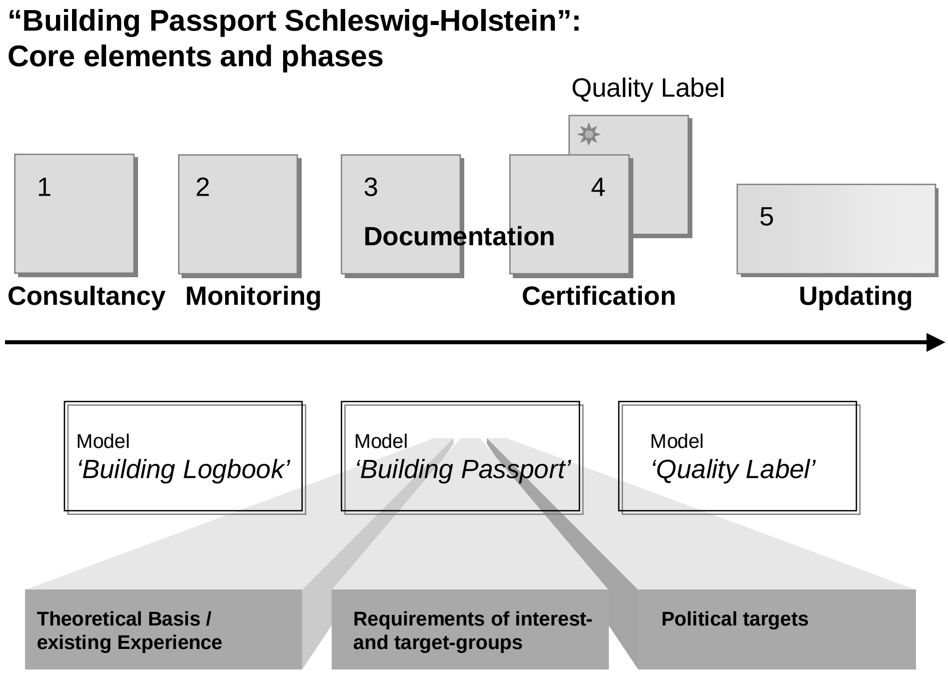

Figure 3: Basis, starting points and core-elements of the basic conception for the "Building Passport Schleswig Holstein" (Blum et al, 2001b)

Building passport for existing buildings

A building passport for existing buildings must be structured more flexibly and open than one for new buildings. The section of a 'Building Passport' dealing with documentation will be prevalent and the sections on assessment will be more difficult to organise than those for new buildings. The agreements on on-site reviews cannot simply refer to the installation and/or modification of (new) building components but rather will be determined by the need to scrutinise the existing structure and condition of the building-substance (e.g. with the help of specialists on structural damage, timber experts, checking for harmful substances etc.). Instead of consultancy in the planning stage and the first on-site inspection, as suggested for new buildings, a more detailed review will need to be conceived, indeed including analyses on possible harmful substances.

If the tool for existing buildings is to contain more than just documentation, it will be necessary to provide an evaluation in three or four categories. A section on evaluation would only be possible if a criterion on adequacy is included. Reasons for such a restriction are for example the location of the building (taking into account the local real estate market), aspects of preservation of historical buildings and last not least the age of the building (concerning for instance the adequateness of contemporary building technologies).

2.4 Suggestions for implementation

Organisational structure

For further development and later implementation and use of the “Building Passport Schleswig-Holstein” it was suggested that a ‘Building Passport’ working group be formed that is established by the Ministry of the Interior (Chairmanship). All relevant ministries and important (semi) public institutions of the building and construction industry in Schleswig-Holstein should be represented. The working group (or steering committee) should furthermore involve the specialised public by means of an additional extended advisory board in which private organisations dealing with certification are also represented (Figure 4). With regard to an organisational basis, it was suggested that the Working Group of Contemporary Construction (ARGE, cf. above) would be a suitable organisation supervising the tool.

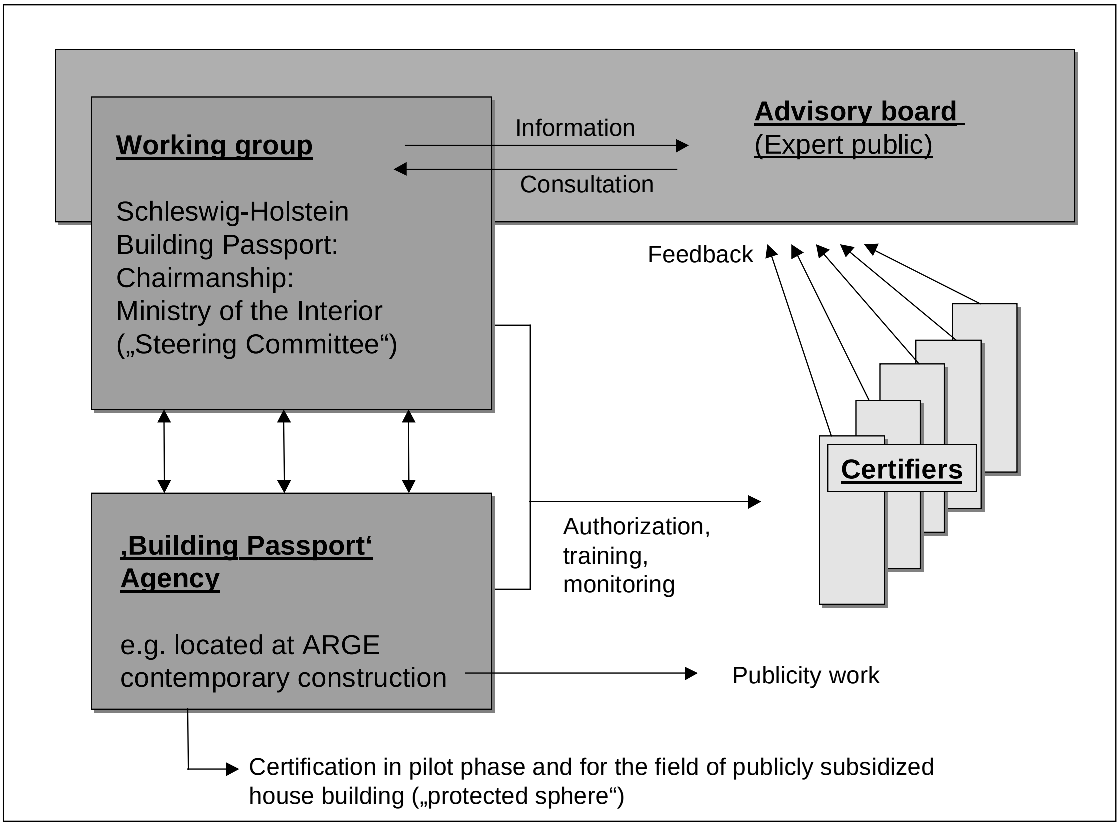

Figure 4: Outline of an institutional structure for administration of the tool (Blum et al, 2001a)

Pilot model and pilot phase

With the aim of achieving the widest level of acceptability possible a pragmatic basic concept for a ‘Building Passport’ was developed as a first step. Development of a committed tool will require a significantly longer period of development and indeed would have endangered the success of the project as conceived here[30] at an early stage. Conflicting interests (e.g. expenditure and demands regarding a

30. See the theoretical notes on publicly established quality labels in Section 1.2.

comprehensive scope) were discernible during discussions with the player groups. It was therefore suggested that the outlined basic concept should in the future be developed into a first *pilot model* that can be tested in a *pilot phase*. The 'Building Passport' agency will then have the task of putting the tool into practise in a pilot phase and supervising the further development. The 'protected sphere' of subsidised public housing projects may be an appropriate starting point.

Authorisation / Integration of other approaches

The widespread establishment of the "Building Passport Schleswig-Holstein" among the various existing tools for quality assurance and certification is a basic goal. Ideally, a number of specialised 'Building Passport' models will later be developed on the basis of the pilot model. Each of these will contain the same core elements (basic concept) but will have a different main focus or degree of detailing. In this way differing requirements are satisfied whilst at the same time ensuring compatibility by referring to the common basis. Authorisation to issue the 'Building Passport' will be granted when the institute applying adopts the basic conception and trains its employees accordingly.

Updating

To ensure the tools' functioning the content (criteria, recommendations) as well as methods and procedures will regularly be reviewed and if necessary modified (possibly every two to three years).

Financing

In principle the "Building Passport Schleswig-Holstein" is supposed to be established as a marketable service. This means that the issuing costs are to be covered by a fee, which will be paid by those applying for a passport. As far as acceptability of such charges is concerned only estimations are possible. With planning costs as a guideline, a figure of 1% of the project costs appear as realistic. Nevertheless, costs that are incurred by the public (fourth party-) establishment (administration, further development etc.) should, at least in the initial phase, be carried by public institutions, keeping in mind the political target of a widespread use of the tool.

Setting a good example

The Guideline of Sustainable Building[31] which was published at the beginning of 2001 by the German Ministry of Transport, Building and Housing for federal buildings already today provides a good basis for handling buildings in possession of the federal state of Schleswig-Holstein. As a concluding result it was therefore suggested that - accompanying the 'Building Passport' process - a system of environmental and quality management - including a 'Building Passport' - be set up for these public buildings. This would not only incur positive environmental (and economic!) effects but also state a good public example in order to support the implementation of the general tool " Building Passport Schleswig-Holstein".

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Session 4

INFORMATION, THE KEY TO SUSTAINABILITY?

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1. Introduction

If the concept of sustainable waste management is to be adopted society must change from the 'extract and dump' nature of most current industrial systems, in which materials and energy are extracted, processed, used and dumped, in a complex chain through the economy and the environment. An alternative industrial system is needed, based on processes minimising the environmental impact of industry, whilst improving the economic performance of the member companies and strengthening the local economy. To this end the use of secondary (recycled) materials can reduce the environmental impacts and lead to a more circular use of resources.

In the building sector the use of secondary materials generally implies re-using materials that have previously been used in the same sector. However it can equally mean using materials that have been generated in other sectors or are the waste products of other sectors. For example, pulverised fuel ash from coal fired power stations can be used in the production of building blocks. In general however we are concerned with cycling materials within the building sector so are concerned with re-use and recycling construction and demolition waste. However many of the tools described also relate to other sector wastes.

In Europe as a whole 25% of C&D waste is recycled, but certain Member States have achieved rates of more than 80%. Thus the technical and economic feasibility of recycling has been proven (European Commission, 2000). Why then have many countries failed to achieve similar recovery rates despite national mandates to do so? And is recycling always the best way to minimise the adverse impacts of the building sector? Where re-use and recycling are the best solutions what are the barriers that impede the achievement of optimal recycling of C&D waste. Several of the constraints are concerned with the lack of information or access to information regarding C&D 'waste'. This report will determine and examine the information barriers and explore the various ways of overcoming them.

2. Definitions

The term recycled can be defined as a material that has undergone some form of processing to change its physical or chemical nature, e.g. crushed concrete to form an aggregate. In the building sector re-use is usually termed reclamation, the use of a product or material without changing its form, e.g. an oak beam, or reclaimed floor tiles. The environmental benefits of recycling and re-use cannot be achieved unless the secondary material genuinely displaces primary materials. Although this may seem obvious there are many cases where 'so-called' recycling is carried out merely to avoid the cost of disposal or to claim a benefit from recycling. For example crushed concrete can be spread around a building site, supposedly to improve the load bearing of the ground, whereas primary materials would not be purchased for this purpose.

For most purposes the terms ‘buyer’ and ‘seller’ used by economists are clear. However when discussing secondary materials the terms may not be appropriate as, in some instances, the ‘buyer’ may get the materials for nothing and the ‘seller’ may have to pay to get rid of their waste material. In this report when discussing the market in general terms the terms buyer and seller have been used, but when applied to secondary materials the terms are usually changed to ‘producer’ or ‘developer’ and ‘user’.

3. The identification of information-related market barriers and failures for secondary materials

The constraints on the recycling of C&D waste have been categorised into nine areas; statutory controls, local planning policy, feedstock, investment in processing, quality control, environmental concerns, market conditions, standards and specifications and liability (Howard Humphrey & Partners, 1994).

Many of these areas are concerned with information flows, or the lack of information. For example, the planning process is based on the flow of accurate and clear information, the lack of which can lead to conflict and planning refusal. The construction industry requires an adequate supply of good quality feedstock but information on the availability of suitable materials is not easily accessible. Contaminated flows of recyclables can be due to poor levels of source separation. This can be due to a lack of information and communication at the site, with the unsorted materials being regarded as waste, rather than a potential source of income (Howard Humphrey & Partners, 1994). The general preference for primary materials are due to them being seen as predictable, available in quantity and can meet standards and specifications (Howard Humphrey & Partners (1994). However information on the cost of disposal of the waste materials plus the comparative costs of transport of primary and secondary materials may not be taken into consideration.

Waste materials are usually seen as a problem to be dealt with rather than a potentially valuable resource and this view prejudices operators against using reclaimed materials. Many operators are not prepared to accept the risks associated with these materials, which often originate from variety of sources and have different, and perhaps unknown, chemical and physical properties. An important element of the issue of quality and risk is that **perceived risk** may be significantly greater than the actual risk present and this greatly restricts innovative materials use and design (BRE, 1993).

Markets, for all commodities, should be information rich, appropriately regulated and competitive, with prices functioning well as an allocation mechanism. However there are instances when markets do not work as they should. The failure of the market for secondary materials has main two aspects; the lack of the market to take externalities into consideration and the lack of complete information (Turner & Powell, 1992). In both cases there is a problem with information flows. Markets are at their most efficient when there is complete information, but in many instances the buyer and the seller have different levels of knowledge about the product. This imbalance is known as **asymmetrical information**.

For a buyer to obtain more information about the product they may spend increasing his knowledge, possibly by physically examining the product. However additional costs will then be incurred by the buyer (or user) to locate an appropriate seller, examine and purchase a product. These are termed **search costs.**

3.1 Asymmetrical information

A good example of information asymmetries is given by Varian (1990). When someone buys a used car they do not know if it is a good one, a ‘plum’ or a ‘lemon’, whilst the seller of the car knows of it’s quality and value. This in-balance can cause problems with the efficient functioning of a market. The buyer will not pay the full value for a ‘plum’ as s/he doesn’t know if it is a plum or a lemon. If the seller reduces the price the buyer will be more convinced it is a lemon and will therefore reduce the price they are willing to pay. If half the cars are plums and half are lemons a buyer will be prepared to pay the mean price. But the sellers of plums will not be prepared to sell at that price, only the sellers of lemons.

In the case of secondary construction materials, inert waste for example, can be contaminated with unwanted materials such as paper, plastic or metal. Little information about its quality may be provided by the producer. Unless the user physically examines the aggregate waste they will have less information than the producer. Thus the user may pay more for the waste (or may require less money to remove it) than if they knew of its quality. Other examples of asymmetrical information is where the producer knows of the availability, location and quantity of a secondary material they wish to get rid of, whilst a potential user of the waste does not know one or more aspects of this information. Alternatively the potential user may fully informed about the waste but may not know if it is a good substitute for a primary material.

3.2 Search costs

These include the opportunity cost of time spent searching as well as associated expenditures such as driving, telephone calls, computer fees, magazine subscriptions etc (Bakos, 1997). In the traditional models of commodity markets search costs can result in monopolistic pricing by the sellers (Stiglitz, 1989). The use of electronic marketplaces would appear to reduce the cost of obtaining information about additional sellers and may also clarify the quoted prices by quantifying what is, or isn’t included in the price (e.g. transport costs) (Bakos, 1997).

Reducing the cost of price and product information is likely to improve market efficiency but can reduce seller profits due to the improved efficiency of instantly available market information to all investors and traders, regardless of their size or location (Bakos, 1997). It is also due to the reduction of asymmetrical information, as with complete information the seller cannot take advantage of the buyer’s lack of knowledge of the market. However this theory assumes that the location of the product is immaterial. In the case of secondary construction materials this is clearly not the case. The relative locations of the secondary and primary material and the development site and the cost of transport is likely to be of greater importance than the usually low cost of the material.

Most secondary materials markets are characterised by differentiated products. Consequently the buyers need to consider both the price and the characteristics of the product. Electronic market places therefore need to provide both price and product information to enable the comparison of different products. While the price information is relatively easy to convey, providing adequate product information poses a challenge for system designers (Bakos, 1997). However revised standards and specifications based on performance will provide a good basis for product information.

Another aspect of search costs is design costs. These are the costs incurred by a designer who is unfamiliar with the use of reclaimed or recycled materials due to the time involved in exploring the new materials, specifications and sources. However as designers become more familiar with these materials their costs will become comparable with those using primary materials (Coventry, 1999). As the ISO 14001 Environmental Management System becomes more prevalent knowledge of reclaimed materials will become more valuable.

3.3 Perceived risk

There is little evidence to suggest that secondary materials' performance is unsatisfactory (ENDS, 1998). Construction insurers have stated that their clients do not raise the issue of risks associated with secondary aggregates as a problem (Smith, 1998b).

The possibility of legal action was seen to be greatest against designers specifying the use of secondary materials, although for legal action to be brought they must have broken the terms of their contract or specified an inappropriate use for the materials. Nevertheless, the requirement of the designer to provide information and possibly demonstrate the appropriateness of the materials may remain as a barrier to the use of some reclaimed materials (Smith, 1998b).

The success of aggregates recycling depends on establishing its credibility (Beaumont, 1995) and this can only be achieved by more local authorities and businesses using recycling techniques. There is still some ignorance about the processes available particularly amongst smaller firms and there is a lack of performance records to provide information, although experience is growing steadily. There is also a reticence of engineers to experiment with new techniques and materials, which they perceive to be full of hidden risks.

4. Addressing the identified barriers through public policy measures

In order to address the barriers to information flows two areas of information have been identified:

- the availability, location and quality of secondary materials
- the substitutability of secondary materials

One of the key barriers to the increased use of secondary construction materials and the recycling of construction and demolition wastes is considered to be the lack of information relating to their availability, quantity, quality and location, and the purposes to which they can be used. There is also the problem that secondary materials are likely to be more dispersed than primary materials their location so will incur greater search costs. To some extent these problems can be overcome by the use of **waste and trading exchanges**, particularly those that use the internet.

Although the identification of the substitutability of secondary materials may initially be a technical matter, informing the building sector of these opportunities is concerned with information flows. One way to improve the provision of information is to provide examples of **best practice** and to provide an eco-labelling **scheme** for buildings that comply with high standards.

Whether a secondary material is suitable for a given task also requires improved information flows. For example the **standards and specifications** of materials have, in the past, been difficult for secondary materials to achieve as they are based on composition rather than on performance

When markets fails to take externalities adequately into consideration it is necessary firstly to identify the environmental impacts, and secondly to introduce a mechanism to internalise (include) the externalities into the cost of a product. A technique that provides information on the environmental impacts of a product throughout its lifetime is **lifecycle assessment**. Mechanisms to include the externalities into the market price are **eco-taxes** such as disposal taxes (e.g. landfill tax) or a primary materials tax such as the UK aggregates tax.

4.1 Waste and trading exchanges

In an attempt to overcome the lack of information on available secondary materials and to reduce the search costs for buyers (users) numerous waste exchanges have been set up, usually aided by the internet. Some exchanges are physical warehouses that advertise available commodities while others are web sites that put suppliers of secondary material in touch with potential users. Some are co-ordinated and funded by governments, whilst others are private businesses.

Ogalvie (Recycling Forum, 1999) identified 84 electronic exchanges with 85% of these classified at waste exchanges and 15% classed as trading exchanges. A third of the trading exchanges were specifically for recyclables. Most of the trading exchanges were not well developed compared with waste exchanges, however they were considered to show promise for specific materials. Half of the waste exchanges were operating as ‘information-only’ exchanges. Metals and paper already traded internationally and may not need a recyclables exchange. For trading exchanges to be successful Ogalvie considered that many players needed to be interested, the traded materials need to have value, standards, specifications and test methods should be available to foster confidence and the system needs to be transparent.

An example of a waste exchange is the UK Department of the Environment, Trade and the Regions Materials Information Exchange, operated by the Building Research Establishment. Launched in 1998 the exchange allows contractors with unwanted materials or wastes to post their availability on the internet and then wait to hear from someone who wants them. The web site has four parts: unused over-ordered materials and stocks, recycled materials and demolition products, a materials wanted board and news of future demolition projects (Coventry et al, 1999). The service is free to both disposers and users, being funded by the UK government as part of its program to increase the use of secondary materials.

Recytrade is an internet-based exchange for plastics administered by EuPC. There are about 100 specifications on recycles available in the system and comprehensive ranges of waste categories are traded. As the exchange is run on a minimum budget an evaluation of the performance is not quantified (Recytrade, 2001).

4.2 Information services

Many countries have public funded programmes that provide information and promote environmental issues in the building sector. These include Best Practice Programmes, pilot and demonstration schemes, advisory services and networks. These usually cover the efficient use of resources particularly waste management and the use of secondary materials.

4.2.1 Best practice programmes, pilot and demonstration schemes

The UK Construction Best Practice Programme (CBPP) (http://www.cbpp.org.uk/cbpp/) provides guidance and advice to UK construction and client organisations so that they have the knowledge and skills required to implement change. The key objectives of the Programme are; to identify, publicise and support the use and benefits of adopting improved business practices; provide an initial point of contact for organisations wishing to improve; facilitate links between such organisations and those with the knowledge of how to improve; provide techniques, advice and knowledge about and tools for best practice. The Programme is supported by the Department of the Environment, Transport and Regions and the Construction Industry Board (DETR and CIB).

The Construction Industry Environmental Forum (CIEF) is managed by the Construction Industry Research and Information Association (CIRIA) in association with the BRE and the Building Services

Research and Information Association (BSRIA), and supported by the Government. It provides an information exchange on environmental and sustainability matters, produces guidance information on future issues, promotes environment-related research and identifies opportunities for innovation. Regular discussion workshops, best practice conferences and site visits are organised.

Another information provider is the construction industry's Knowledge Exchange web site (www.knowledgeexchange.org.uk/). This site includes examples of Best Practice particularly related to reducing the disposal of waste to landfill. Examples of secondary materials use are less common. A BRE building used recycled aggregates in ready-mixed concrete for the first time in the UK. In addition reclaimed brinks, parquet wooden flooring and flagstones were reused in the new by building. There are also several examples of waste products such as slag, china clay sand, and crushed concrete being used in road construction Coventry *et al*, 1999).

4.2.2 Advisory services and networks

In order to promote the efficient use of aggregates the UK Department of the Environment, Trade and the Regions (DETR) funded a trial Aggregates Advisory Service. Its objective was to promote the efficient use of both primary and secondary aggregates, and the greater use of reclaimed materials. The service provided a means of exchanging information and a database. The free service was expensive to operate. Based on the average 10-15 enquiries per week the marginal cost of dealing with a single telephone enquiry was of the order of £50, and the all-inclusive cost was more like £300. This was far higher than enquirers would have been prepared to pay if the service had not been free (DTI, 1999). A Monitoring Survey revealed that although the users of the service valued the information received many recipients of information and contacts had not actually followed these up, suggesting that some of the demand was 'opportunistic' (DETR, 1999).

In an evaluation of the service the DETR (1999) concluded that there was a demand for a long-term aggregate advisory service but it would require external support, including both Government funding and industrial 'sponsorship. The service was wound up in 1999 due to its failure to attract further industry or public funding.

Another UK government service, funded by the UK DETR and the DTI is the Waste and Resources Action Programme (WRAP). The main role of this not-for-profit company is to remove barriers to waste minimisation, re-use and recycling, and to create stable and efficient markets for recycled materials and products. Its main areas of activity are market facilitation, the promotion of investment strategic research and development, and the provision of advice, support and guidance. Initially WRAP is concentrating on four material streams; paper, glass, plastics and wood, using the tools of commercial instruments, procurement and standards and specifications (WRAP, 2001)

There is wide consensus that to increase the use of recycled materials and products, a sustained and intensive programme on procurement must be implemented (WRAP, 2001). This will include the specification of waste reduction, recycling and the use of secondary materials in the contracts both for designers and construction companies. As a first step towards this WRAP will produce an annual report, including data on the quantity of virgin and secondary glass, paper, plastics and wood used in the UK. This will identify the main sectors in which the materials are used, the utilisation rates for recycled materials and the proportion of products containing secondary materials (ENDS Report, 2001; WRAP, 2001)

4.3 Standards & specifications

There are many national, European and international standards and specifications for the use of materials in industry. For example, British Standards (BS), European Committee for Standardisation (CEN) standards, and those relating to the International Standards Organisation (ISO). However the lack of standards and specifications for secondary materials has long been identified as a major constraint on their use. Some existing standards and specifications are thought to discriminate against the use of recycled materials in the production process. In the construction industry although recycled aggregates have been for a long time their use has mainly been for lower grade applications. The main barriers to their use in high-grade applications has been the lack of specifications or any kind of quality assurance (BRE, 2001a).

A Building Research Establishment (BRE) report examined the permitted uses of mineral wastes in construction according to specifications and discussed the future use of these materials in relation to the harmonisation of standards across Europe. They found that some recovered materials were being excluded unnecessarily because the specifications did not make clear the opportunities for their use, plus there was a lack of information concerning quality assurance for waste materials. The authors conclude that specifications should be used to promote rather than hinder the use of waste materials as it is only through some kind of ‘positive discrimination’ towards recycled materials that their use is likely to significantly increase. In a separate study on plastics the Fraunhofer Institute examined 171 standards. They also found that unjustified (and justified) barriers exist in the standards (Collins and Sherwood, 1995).

Specifications may be based on a ‘recipe’ of constituent materials or they may be based on performance. Recipe-based specifications are often favoured but because there is no distinct specification for secondary materials under some schemes this has been a barrier to their increased usage. The CEN is producing standards for a range of construction products and materials, but the package will not be released until 2003. It is believed that forthcoming European standards for aggregates will incorporate waste materials more explicitly and fortunately there is now a trend within the industry towards using specifications based on performance rather than ingredients.

In the UK there is an initiative to overcome the barriers to using C&D waste by improving the information on using secondary materials for specific purposes. For example, the “Specification for Highway Works” allows a greater use of recycled aggregates in UK highways work. In essence, aggregates used for different purposes must meet the appropriate specifications for that purpose. Aggregates used for construction fill, for example, will be subject to less demanding specifications than those used for road sub-bases or surfacing.

4.4 Lifecycle assessment

A good technique for providing information on the relative environmental impacts of primary and secondary materials is lifecycle assessment (LCA). It is used to determine the environmental impacts of products and services throughout their life, in terms of materials and energy use, emissions to air and water, and solid waste. LCA can also take into consideration the benefits gained by replacing primary with secondary materials, or from recovering energy from a waste material. Thus the recycling of aggregate waste can include the benefits from reduced quarrying and the transport of primary aggregates. However it must also include the environmental costs of transporting the waste aggregates and for processing the waste.

Publicly funded LCA projects have been developed to provide information on alternative methods of managing waste. The UK Environment Agency, funded the development of LCA software for the regional management of municipal waste. The program has been used successfully by many local authorities but has proved too complex for local authorities unable to commit significant personnel time to operate it. An LCA for construction and demolition waste, is currently being developed by Craighill (2001). This program compares alternative disposal options for the waste taking into consideration the transport distances to the disposal facilities and re-use sites, and the costs and benefits from recycling such any reduced quarrying and energy used in transport and materials processing.

4.5 Eco-labelling

The objective of an eco-label award scheme is to promote products, which have the potential to reduced negative environmental impacts, as compared with the other similar products. This will contribute to the efficient use of resources and a high level of environmental protection (Council of the European Union, 2000). The EC eco-label uses lifecycle assessment to determine the environmental impacts. Other eco-labels include the Nordic Swan or Nordic Environmental label, and the German ‘Umweltzeichen’ or the ‘Blue Angel’. Nearly 4,000 products now bare this mark, that is awarded to products with positive environmental features on the German market. Building-related eco-labelling schemes mainly deal with issues of waste minimisation and indoor air qualities that are often related the choice of materials. Eco-labelling schemes for building products are found in six countries, with the Blue Angel and the Nordic Swan both including recycling and re-use of building products (Hasegawa, 2001).

The UK Building Research Establishment has developed the BRE Environmental Assessment Method (BREEAM) a tool that allows the owners, users and designers of buildings to review and improve environmental performance throughout the life of a building. It is a widely accepted and respected scheme that sets a benchmark for environmental performance and provides a wide range of benefits. A BREEAM Offices assessment comprises three parts; a core assessment of the building fabric and services which is carried out in all cases, and two optional parts deal with the quality of the design & procurement and management & operating procedures.

The Building Research Establishment also operates a similar scheme for homes called EcoHomes. This is an environmental assessment method for houses and apartments. It rewards developers who improve environmental performance through good design, rather than high capital cost solutions. Criteria include energy and water efficiency, lower dependence on the car and good use of resources, including the use of reclaimed and secondary materials (BRE, 2001).

4.6 Eco-taxation

Environmental taxes can help to stimulate the use of secondary materials by internalising the external cost of using primary materials, by encouraging the supporting investment into research and developing the necessary infrastructure. Many European countries are well advanced with taxes already in place on consumer items as well as a landfill tax in several countries including Belgium, France, Germany, the UK and The Netherlands. In the UK there is also to be a primary resource tax on aggregates. As well as encouraging the use of secondary aggregates these taxes provide a useful source of information on the flows of primary and secondary aggregates.

The UK landfill tax, which came into effect in 1996, has a current rate of £12 per tonne for active waste and £2 per tonne for non-active waste. The tax is effectively an emissions or externality charge on the provision of waste disposal services by landfill sites, where this service is directly associated with the generation of landfill externalities (Turner et al, 1998). Prior to the tax being introduced a study was carried out to assess and value the externalities associated with landfill and incineration (CSERGE et al, 1993). To increase the acceptability of the tax a proportion of the revenue can be diverted to fund projects in approved areas including waste management research and education. There is some evidence that the landfill tax has raised the profile of recycling amongst industry and commerce and encouraged investment in recycling facilities (Hogg, 1997) thus providing a useful source of information.

Since the introduction of the landfill tax in the UK the disposal of inert waste to landfill has reduced by more than a half. However one of the problems with a disposal tax is that it can divert materials from landfill without necessarily increasing recycling or displacing primary aggregates. It has been found in England and Wales that 28% of construction and demolition waste is being spread on sites exempt from waste management licensing such as farms and golf courses.

The displacement of primary aggregates is more likely to be encouraged by the introduction of the UK primary aggregates tax in April 2002. The tax rate will initially be set at a rate of £1.60 per tonne for rock, gravel or sand used as aggregates. The funds will be used to reduce National Insurance contributions by 0.1% and provide a new Sustainability Fund. The latter could be used for; overcoming market barriers and promoting increased use of alternative materials as aggregates; funding research into more sustainable construction and demolition practices; promoting conservation and increased biodiversity; restoring the natural landscape; promoting environmentally friendly quarrying practices; and local community projects (HM Treasury, 2000).

5. What kinds of information tools should or should not be implemented

In many OECD countries there is a conviction that one of the main barriers to increase the use of secondary materials and reduce waste in the construction sector, is the lack of information. This, combined with the desire to reduce waste, has resulted in a proliferation of schemes to provide information. This is particularly the case in the UK as shown in the examples above. Many of the information services provided by the UK government and industry have considerable overlap and lead to a confusing amount of information. Some consolidation would seem appropriate, particularly considering the potential new funding available arising from the Aggregates Tax.

Much of this enthusiasm has arisen from the introduction of the UK landfill tax, which has focused many contractors thoughts initially on the cost of waste disposal and subsequently on the environmental benefits (and public relations benefits) of recycling and the use of secondary materials. However, although the landfill tax has reduced the disposal of construction and demolition waste to landfill it seems unlikely that it will sufficiently promote the use of secondary materials unless there is a financially good reason to do so. Landfill taxes need to be substantially increased in order to achieve a significant rate of diversion.

The Aggregates Tax would seem a better tool to increase the use of secondary materials but it is limited to aggregates, and may also result in encouraging only the low level use of aggregates. The tax rates would need to be set at a politically unacceptably high level before they would change the behaviour of engineers and demolition contractors in areas with easy access to landfills (or quarries). Varying the tax rate to match local conditions would create considerable distortions to trade, and would therefore probably be equally unacceptable

The UK Quarry Products Association consider that the maximum market penetration of recycled or secondary aggregates is 25% due to the availability of feedstock, environmental impacts, the distribution of infrastructure, transport costs and customer specifications (Shelley, 2001). Would higher levels of penetration be achieved with better information particularly on the availability of feedstock and improved specification?

Electronic marketplaces, such as waste exchanges, can provide useful information on the availability of secondary materials, and at the same time reduce asymmetrical information by providing additional information for the buyer (user) without increasing the search costs. Bakos (1997) found electronic marketplaces increased the efficiency of the market, increasing competition between sellers and possibly reducing prices. However the market for construction and demolition wastes are often severely constrained by the location of the material. When there is a limited supply of secondary materials in a given location the concept of asymmetrical information becomes less important although search costs are still highly relevant. However as the market and the use of such tools increases the need for complete information will become more important.

Whilst the use of secondary materials can be encouraged by relative pricing and better information, there is still a danger that they are seen as being of inferior quality. Therefore, establishing Good Practice, demonstration projects and environmental labelling can make a significant contribution to furthering the use of secondary materials as quality products, and would help to reduce the liability fears of clients and engineers. Confidence in performance will then begin to grow with more widespread applications. This needs to be reinforced with clear standards and specifications based on performance rather than ingredients.

Lessons from countries with high levels of construction and demolition waste recovery however seem to indicate that improved information is not sufficient. Dutch demolition contractors are obliged by law to separate all construction and demolition waste into different waste streams, and re-usable C&D waste may not be landfilled at all. In Germany mixed or recoverable C&DW may not be landfilled, and in Denmark local authorities play a much more active role in directing C&DW to re-use or final disposal than in the UK. All three countries have high rates of landfill tax (DETR, 1999).

The main lesson to be learned from overseas experience, and this is really restricted to increasing the recycling of C&D waste, is that separation of different materials during demolition is crucial. This can be encouraged by the requirement of a written demolition plan prior to the re-development of sites, thereby encouraging developers to think well in advance about how they propose to deal with re-usable and recyclable materials (Symonds Group Ltd 1999).

The different types of information tools such as waste exchanges and standards and specifications address different information barriers so it is likely that a combination will be needed. However without further evaluation the effectiveness of the tools remains unknown.

6. Conclusions

Very little evaluation has been carried out on the environmental benefits arising from information programmes and waste exchanges. There has been a general assumption that they are ‘a good thing’ but little assessment on how well they are used, let alone whether they really lead to an increased use of secondary materials. Any information that leads to a change in attitude to resource use and the environment can be regarded as useful but a more rigorous approach is needed. The increase in the UK of information provision would provide a useful case study to determine if the use of secondary materials for construction increases and which sources of information were the most effective.

It has been seen that a reduction in the disposal of construction and demolition waste to landfill does not necessarily correlate with an increase in the use of secondary materials in the construction industry. However an increase in the recycling of construction waste is a useful indicator. Countries with the highest levels of recycling generally have more enforced Government support backed up by taxes, grants for research and the planning system.

It can be seen therefore that in the long term the introduction of a variety of information providers is crucial in changing attitudes and increasing market efficiency. In the short term, however, the only way to dramatically increase the use of secondary materials in the construction sector is to combine these changes with a strong regulatory approach such as the banning of landfill and the introduction of demolition plans.

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Session 4

THE DESIGN OF SUSTAINABLE BUILDING POLICIES: THE TECHNOLOGICAL AND INFORMATION INTERFACE

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In the long run, the opportunities for a sustainable energy future depend critically on new and emerging technologies. The design of public policies to promote sustainable buildings needs to consider and anticipate the full range of these technological possibilities. Some of these technological advances require considerable research and development before they can become commercially feasible. Others are only concepts that may require decades for translation into workable options for the built environment.

The commercial success of such technologies could enable an energy future that is both good for world economies and is good for the environment. This essay provides a sampling of some of the major advances in technologies for buildings that could occur with a vigorous commitment to R&D and with supporting policies to accelerate their market introduction. Many of these examples are drawn from a recent report completed by five U.S. Department of Energy national Laboratories, entitled *Scenarios for a Clean Energy Future* (Interlaboratory Working Group, 2000). The discussion is divided into four parts: equipment and appliances, building envelope, intelligent buildings, and distributed energy resources.

Equipment and Appliances

By definition, the energy used in buildings is consumed by equipment that transforms fuel or electricity into end-uses, such as delivered heat or cooling, light, fresh air, vertical transport, information management, and entertainment. The overall efficiency of this transformation depends largely on the efficiency of the equipment itself.

Numerous opportunities exist to develop equipment that is much more efficient than that currently available.

- It may be possible to virtually eliminate space heating in many climates by means of building shells with very high resistance to heat loss or gain involving high insulation walls, ceilings, and floors and triple pane windows with transparent heat-reflecting films; wide use of passive designs; and mass-produced components (walls, ceilings) with very low infiltration rates.

- Microtechnology could greatly increase heat and mass transfer rates, with highly efficient applications to chemical and thermal systems. One potential buildings application, microheat pumps and compact heat exchangers, could be distributed throughout the building as part of the walls or window (Figure 1). This distributed approach would allow selected rooms or even parts of rooms to be heated or cooled as needed.

Figure 1. Compact Heat Exchangers

- Multi-functional equipment and integrated systems offer the opportunity for a significant increase in efficiency improvement. For example, an integrated water heating/space cooling system that uses heat pumping to meet space heating, air conditioning, and water heating needs could be 70% more efficient than the combined efficiencies of systems in use today.

- Advanced lamp technology integrated with sunlight collectors and daylight distribution systems could be combined with control technologies to reduce lighting energy requirements to a fraction of today's levels. Figure 2 portrays a solar lighting and power system of the future. The concept separates and uses different portions of sunlight for two different uses, interior lighting and distributed power generation. The design takes advantage of two facts. First, the luminous efficacy of the visible part of the spectrum is more than double that of electric lamps. Second, photovoltaic cells, especially thermo-photovoltaic cells, are very efficient in converting the infrared portion of the spectrum to electricity.

- Dramatic declines in the energy consumed by supermarket refrigeration systems could be achieved with distributed system designs. Such systems of the future would locate compressors close to display cabinets thereby avoiding the loss of refrigerant charge. Use of the waste heat by heat pumps for space conditioning would lead to further efficiency gains.

Figure 2. A Solar Lighting and Power System

- As energy conversion technologies evolve, many buildings could become net producers of energy as roofs incorporate photovoltaic panels and fuel cells and microturbines generate more power than is required on site. In addition, fuel cells and microturbines produce waste heat that can be employed to serve building thermal loads. These power technologies could transform the entire demand and supply chain in terms of energy generation, distribution, and end-use.

- Building control systems of the future will likely incorporate smart technology to closely match energy and water supply and ambient conditions with the needs of building occupants. Building loads and central plants supplying the loads will be more integrated and optimized to enhance the efficient use of the energy streams into and out of the building.

The Building Envelope

The building envelope provides fundamental thermal load control for a building. Walls, roofs, and floors block or delay the flow of heat between a building's interior and exterior. Windows can also block heat flow, provide daylight, transmit solar energy, and provide a view of the outside. High-capacitance internal walls, ceilings, and floors can provide thermal storage that reduces energy use by storing solar energy and reduces peak loads by balancing energy use over a 24-hour period. Improvements in the energy performance of these building elements reduce energy use in buildings and thereby reduce greenhouse gas emissions.

Decreasing the building thermal load reduces the need for heating and cooling energy. These emerging building envelope technologies will significantly reduce building energy use:

- super insulation, based on vacuum principles
- new-formula high-efficiency foam insulation that uses no chlorofluorocarbons or hydrochlorofluorocarbons
- advanced gas-filled, multiple-glazing, low-emittance windows and electrochromic glazing
- roof systems that promote self drying, thereby preventing moisture from degrading the performance of attic insulation
- passive solar components
- durable high-reflectance coatings
- advanced thermal storage materials

Intelligent Building Systems

The process of designing, constructing, starting up, controlling, and maintaining building systems is very complex. If it is done properly, the final product delivers comfort, safety, and a healthy environment and operates efficiently at reasonable cost. If any part of this process breaks down, the product fails to deliver these benefits. The lost health and productivity in office environments alone costs U.S. businesses hundreds of billions of dollars each year. In addition, operating these “broken” systems is estimated to cost at least 30% of commercial building energy use (more than $45 billion).

The key to designing and operating buildings efficiently is the ability to manage information, deliver it in a timely manner to the proper audience, and use it effectively for building design and operation. More intelligently designed and operated buildings use energy more efficiently and thus reduce greenhouse emissions.

Inexpensive sensors that monitor combustion, moisture, occupancy, thermal loads and other characteristics of a building and its equipment and envelope are critical enablers of smart information management (Figure 3). In the intelligent building systems concept, data from the design of the building, together with sensed data, will be used to automatically configure controls and commission (i.e., start up and check out) and operate buildings. Control systems will use advanced, robust techniques based on smaller, cheaper, and more abundant sensors than are in use today, including chemistry labs on a chip. Intelligent devices will use this wealth of data to ensure optimal building performance by continuously controlling and recommissioning building systems using automated tools that detect and diagnose performance anomalies and degradation. Such systems will optimize operation across building systems, inform and implement energy purchasing, guide maintenance activities, and report building performance while ensuring that occupant needs for comfort, health, and safety are met at the lowest possible cost.

Figure 3. Inexpensive Combustion Sensors and Chemistry Labs on a Chip

Many different types of software tools will be required to optimise the use of such data. *EnergyPlus* represents one such type: a building design tool (Figure 4). EnergyPlus is a new generation building energy simulation program designed for modeling buildings with associated heating, cooling, lighting, ventilating, and other energy flows. It builds on the most popular features and capabilities of BLAST and DOE-2 but includes many innovative simulation capabilities including time steps of less than an hour and modular systems simulation modules that are integrated with a heat balance-based zone simulation. Other planned simulation capabilities include solar thermal, multizone air flow, and electric power simulation including photovoltaic systems and fuel cells (http://gundog.lbl.gov/).

Tools for diagnosing the energy performance of existing buildings are also needed. One such tool just recently developed is the *Whole Building Diagnostician* (http://www.buildings.pnl.gov:2080/wbd/intro.htm). This tool is a modular diagnostic software system that provides detection and diagnosis of common problems associated with the operation of heating, ventilating, and air-conditioning (HVAC) systems and equipment in buildings. It:

– Detects changes in energy consumption of whole buildings and major building systems

– Identifies and diagnoses operating problems with outside-air ventilation and economizer control

– Estimates impacts on energy costs (Figure 5).

Third-Party User Interfaces

Figure 4. EnergyPlus: A Building Energy Simulation Tool

While significant energy-efficiency improvements are expected from advancements of energy end-use technology in the demand sectors, additional energy-efficiency improvements are likely to emerge as the delineation between the energy demand and supply sectors vanishes. New competitive market structures are likely to provide energy solutions that seek global optima, in which benefits for both the demand and supply sectors are maximized.

For instance, with the advancements of fuel cell vehicles and their likely market adoption within this decade, it is a possible that residential and small commercial building customers could use their vehicles to produce electricity for their own use or become a net supplier of electric power into the distribution grid. By generating electric power at the location of use transmission and distribution losses can be avoided.

With an advanced information technology infrastructure, distributed generation and load management technologies are likely to become part of the generation mix of the future supply sector. It will then be feasible to trade-off a megawatt hour (MWh) of electric generation with a megawatt hour of load reduction. With such an information technology infrastructure in place, optimal dispatch of generation capacity could be extended to include load management assets at many commercial and industrial customers' sites.

Under such a scenario, it is likely that the utilization of less energy-efficient peak power plants could be significantly reduced, while distributed energy resources will increase.

Figure 5. The Whole Building Diagnostician Distributed Energy Resources

Distributed energy resources are small power generation or storage systems located close to the point of use. They offer significant potential for reduced transmission and distribution costs, higher efficiencies through cogeneration, fuel flexibility, reduced emissions of carbon and local air pollutants, enhanced power quality and reliability, and more end user control. Many believe that these potential advantages will bring about a "paradigm shift" in the energy industry, away from central power generation to distributed generation (Figure 6).

With generation located near loads, transmission and distribution costs could be reduced by (1) deferring upgrades to substations and other transmission and distribution facilities; (2) providing black start capability, spinning reserves, and voltage support; and (3) reducing reactive power losses. Some distributed generation technologies, like renewable energy and fuel cells, can generate electricity with no, or at least fewer, emissions than central station fossil-fired power plants. Total emissions can also be reduced through distributed generation using fuel cells, microturbines and internal combustion engines if the waste heat generated is usefully employed on site to improve overall system efficiency. Finally, as the electric industry restructures, distributed generation could also provide increased reliability as reserve margins shrink, independent system operators become effective in their operation, and market volatility is tamed (NRECA, 2000).

Figure 6. The Transition to Distributed Energy Resources

Today's distributed generation market in the United States is largely limited to backup generation. Customers are hospitals, industrial plants, Internet server hubs, and other businesses that have high costs associated with power outages. Smaller niche markets are growing, where distributed energy resources are used as a stand-alone power source for remote sites, to reduce costs associated with on-peak electricity charges and price spikes, and to take advantage of cogeneration efficiencies. Distributed generation could be particularly advantageous in developing countries by requiring less infrastructure investment, reducing transmission line requirements, and being more responsive to rapidly growing demand for power. It is likely that this increased demand will continue, and possibly accelerate, well into the future as small-scale modular units improve in performance and decrease in cost, interconnection and other barriers are tackled, the demand for electricity continues to grow, and the worldwide digital economy explodes.

A recent report commissioned by E Source describes a visioning process based on the assumption that the demand for ultra-reliable power service will increase far more rapidly than the demand for electricity itself (Geraghty, 1999). Many futurists foresee more and more digital information being created, processed, and transported faster and faster by power-sensitive equipment. Power densities of micro-processors and routers are increasing, as are the requirements for heat dissipation associated with this equipment.

This growth could mean an increase in the cost of power outages and a growing demand for power reliability. This indicates a rapidly growing demand for ultra-reliable power services, which could be met by distributed energy resources. Research is ongoing now on distributed generation technologies and their interconnection to the grid. For distributed generation to enhance system-level efficiency, improvements would be needed in the performance of power-producing equipment such as advanced turbines and microturbines, natural gas engines, fuel cells, cooling heating and power systems, and renewable and hybrid systems. A next generation of power electronics, energy storage, and sensors and controls would also be required. With successful RD&D, the United States (and much of the rest of the world) could realize a paradigm shift to ultra-high efficiency, ultra-low emission, fuel-flexible, and cost-competitive distributed generation technologies easily interconnected into the Nation's energy infrastructure and operated in an optimized manner to maximize value to users and energy suppliers, while protecting the environment.

Conclusions

A consideration of the longer term makes clear the tremendous variety of possibilities that exist for energy futures. The discussion of energy technologies under development gives a sense of the many different technological opportunities that could alter these futures. These technologies could significantly influence the environmental impacts of energy production, transmission, and distribution, avoiding future stresses on the energy system by much higher efficiency of energy end-use and reducing direct economic as well as environmental and social costs of energy use. These possibilities need to be considered in the design of sustainable building policies.

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Session 5

REDUCING CARBON EMISSIONS FROM THE BUILDING SECTOR - A REVIEW OF TECHNICAL POTENTIAL, BARRIERS TO CHANGE AND POLICY INSTRUMENTS

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ABSTRACT

The starting point for this paper is a discussion, based on a small number of exemplar buildings, of the technical potential for the construction of buildings with very low carbon emissions. This is followed by an analysis of the features of the construction industry that appear to account for the wide gap between the performance of buildings at the cutting edge, and the actual performance of existing and typical new buildings. This leads on to a discussion of some of the policy instruments - including regulation, carbon taxation and other market-based measures, RD&D programmes and innovation strategies - that are available for extending international best practice throughout the buildings sectors of industrialised countries. The paper's two central insights are that the instruments discussed are synergistic and mutually reinforcing, but that they are unlikely to succeed, singly or in combination, in the absence of an acceptance at the highest political levels, of the need to achieve large reductions in carbon emissions from industrial economies.

INTRODUCTION

The purpose of this paper is to offer thoughts on and possible insights into a range of issues related to the problem of how to reduce carbon emissions from the Buildings Sector of industrialised countries. These thoughts and insights are offered from the perspective of an academic, with a background in physics, who has spent almost a quarter of a century developing, evaluating and attempting to implement technical options for reducing energy use and carbon emissions, mainly in the building sector.

This paper begins with a brief discussion of climatic goals and argues for the development and implementation of low energy and carbon technologies in the built environment of OECD countries, in parallel with and, if necessary, in advance of the development of the global political agenda. It reviews the technical evidence for the contention that very large reductions in energy use and carbon emissions are possible in the built environment and then goes on to discuss the barriers to the extension of international best practice throughout the construction industries of the industrialised countries. This leads on to a discussion of policy instruments that are available at the national and international level for speeding a transition towards sustainability in this crucial sector of OECD economies.

GOALS

At the global level there is deep ambivalence, and in some quarters, outright hostility, to the notion that deep cuts in carbon emissions from industrialised countries would be unavoidable as part of any realistic and equitable global strategy to mitigate climate change. The central achievement of Kyoto was an agreement that, if ratified and implemented, would achieve little beyond preventing the global situation getting worse significantly quicker. Even this, it now seems, is unlikely to be ratified.

Despite this, there is an increasing consensus within the scientific and technology policy communities, particularly but not exclusively in Europe, on the need to achieve such cuts. One can point to the ground-breaking study by the Enquete Kommission of the German Bundestag (Deutsche Bundestag 1991), to the work of the Danish Ministry of Energy and Environment (1997) and in the last year, to the report of the Royal Commission on Environmental Pollution in the UK (Blundell 2000). Among non-governmental organisations, one can point to the work of IPSEP (Krause et al 1989, and at the highest level one can point to the work of the IPCC itself (Houghton et al 1990). The basic conclusion has changed little since proposals first mooted at the Toronto Conference in 1988. It is that global carbon emissions from the combustion of fossil fuels need to be reduced, in absolute terms, by of the order of 50% within a few decades and declining thereafter towards zero, with the bulk of the initial reductions coming from industrialised countries.

It follows from this by a fairly short chain of argument, that both the existing built environment and the current product of construction industries in most industrialised countries is environmentally obsolete and that a policy of no-change is unsustainable. It is unfortunate that the clarity of this conclusion tends to be obscured by a tendency for global fora to be dominated by discussion of problems relating to the allocation of carbon emission rights, accounting conventions and carbon trading mechanisms at the expense of discussion of the technical means for their reduction. The present author takes the view that these, necessarily difficult but essentially procedural, global discussions, should be supplemented by a parallel process which, wherever consensus can be established, takes the environmental goal as given and seeks to begin the actual process of constructing low- or post-carbon infrastructures within industrialised countries.

In parallel with the problem of mitigation of climate change, there is also the need to consider adaptation strategies. The need to adapt has been recognised at the international and national levels (Watson et al. 1996, Graves & Phillipson 2000). Both adaptation and mitigation require significant changes in the way the built environment is designed, built, operated and managed. There are potentially powerful synergisms between mitigation and adaptation strategies. As the author has noted elsewhere (Lowe 2001), a strategy built around highly insulated and airtight thermal envelopes, carefully considered glazing and built-form, with carbon-efficient building services, information technology and appliances, simultaneously achieves up to a 90% reduction in carbon emissions from new buildings under current climatic conditions, and:

- minimises peak summertime temperatures and future cooling requirements under central assumptions;
- eliminates fuel poverty[1] now, and guards against the future risk of higher energy prices;
- minimises the risks from both expected and unexpected changes in climate – e.g. the possibility of much lower winter temperatures in Northwestern Europe that may arise from the reduction or disappearance of the Gulf Stream.

1. Fuel poverty is a term used in the UK to describe the situation of low-income families, living in the poorly insulated, inefficiently heated dwellings. The result is discomfort together with increased morbidity and mortality.

Unfortunately, synergy is not inevitable. As an extreme example, a policy of driving down electricity prices and subsidising air conditioning systems would be an effective adaptation to a warmer climate, but would significantly increase carbon emissions. The main problem addressed by this paper is the mitigation of climate change through measures affecting the built environment. But it is clear from this brief discussion that such action needs to be undertaken in the context of an integrated approach in which the objectives of a combined adaptation and mitigation strategy are used to drive long-term innovation.

TECHNICAL SCOPE FOR REDUCING ENERGY USE AND CARBON EMISSIONS

It only becomes rational to locate responsibility for reducing carbon emissions within the built environment to the extent that decisions made in this sector of the economy are in principle capable of reducing carbon emissions. If this were not the case then it would be necessary to look elsewhere for savings, either to the energy supply systems that lie upstream of the built environment[2] or to other sectors.

It is worth noting here, that in typical industrialised countries, the energy used to operate the current stock of buildings exceeds by a factor of 5 or more the energy embodied in current new construction, including both manufacture and transport. In the case of the UK, building operation accounts for roughly half of all energy use, and the production and transport of building materials for about 5% each. The implication of this is that the problem of how to reduce the total environmental impact of buildings is, and is likely to remain for many decades, dominated by operational energy use[3]. The discussion that follows will reflect this observation.

It is therefore necessary to review the evidence for the feasibility of reducing energy use and carbon emissions through actions within the built environment. As the author has noted elsewhere, prototype buildings exist in a number of countries that demonstrate reductions in energy use and carbon emissions by 10-fold or more compared with corresponding stock averages. Figures 1 and 2 show carbon emission data for exemplar commercial buildings and dwellings respectively, compared with data representing typical levels of performance.

Analysis at the level of whole buildings clearly demonstrates the possibility of producing very low energy buildings, but a brief review of how these savings have been achieved provides additional insight and confidence in what can be achieved, in the built environment, with currently available technology. This review is not intended to be exhaustive. But it captures the key features of buildings that currently represent international best practice and provides essential background for the rest of the paper.

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2. The options for looking downstream consist of direct and indirect sequestration. The former, involving the capture of carbon dioxide emissions at the scale of the individual building, is unlikely to be feasible for the forseeable future. A variety of indirect sequestration options is in principle available, but none has the combination of simplicity, elegance and freedom from adverse side effects that is characteristic of measures to reduce demand for energy.

3. Buildings are complex products that essentially average across large parts of the economy and across all of the main physical categories of energy use. Falls in the average energy/carbon intensity of OECD countries would therefore result in falls in embodied energy/carbon content of building materials and components, which would in turn offset the increased material use brought about by the need to reduce operational energy use in buildings.

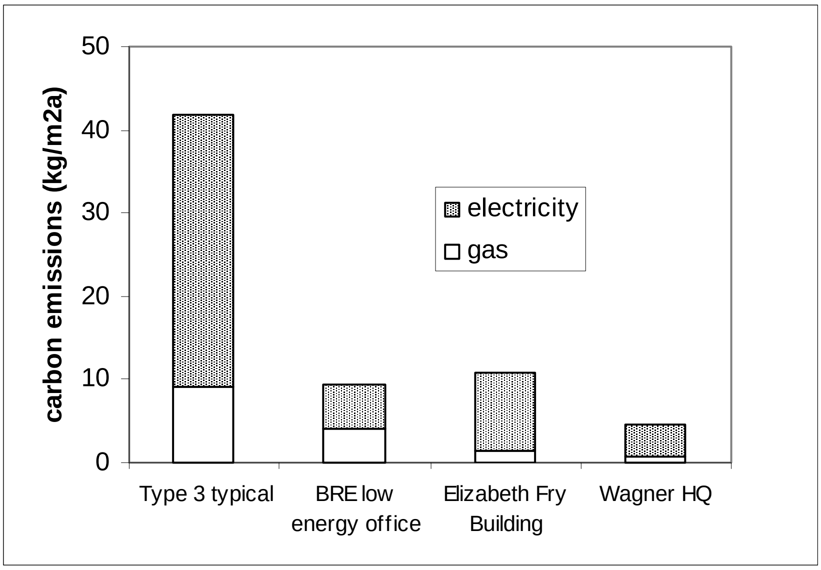

Figure 1. Carbon emissions from office buildings – current UK new-build and selected exemplars (Olivier 2001, Olivier 1997, Crisp et al. 1984, Energy Efficiency Office 2000, Wagner & Co 1999).

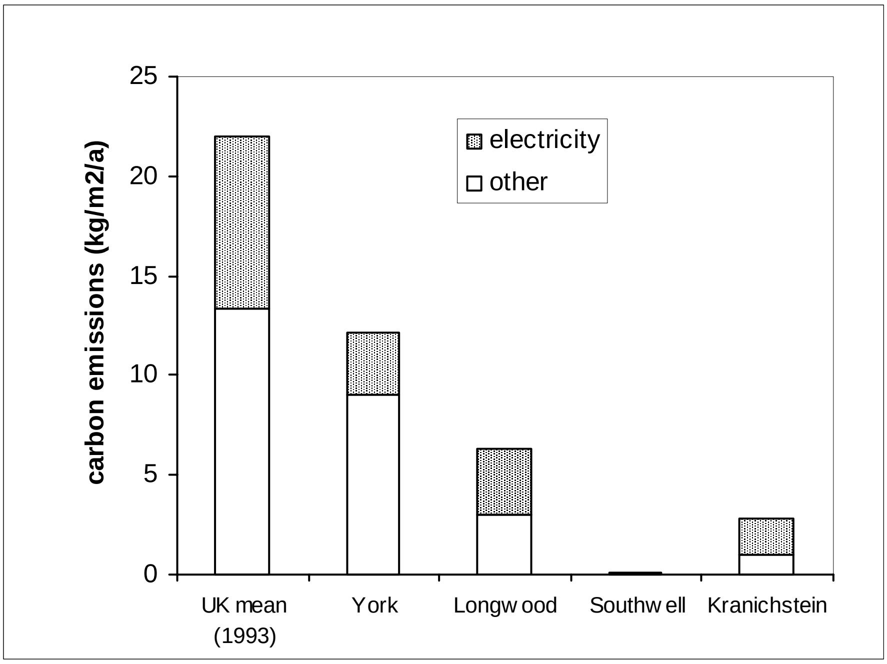

Figure 2. Carbon emissions from dwellings (Vale 1996, Feist 1994, Olivier & Willoughby 1996, Bell & Lowe 1998, DOE 1993, DTI 1994).

Thermal envelope

The most obvious features of buildings constituting international best practice are their highly insulated and airtight thermal envelopes. Such buildings typically have 2-3 times the local regulatory minimum thickness of thermal insulation, minimal thermal bridging and air leakage rates of 3 m/h or less. In temperate climates, these measures reduce space heating requirements currently in excess of 100 kWh/m^2a (delivered energy) for new buildings, and twice that in the existing stock, to below 15 kWh/m^2a. This approach also significantly reduces cooling consumption, particularly if associated with measures to control solar and internal heat gains.

Envelope performance is not a sufficient condition for low or zero annual space heating and cooling. Inattention to other aspects of building design and operation can still lead to high energy use. But without high envelope performance, state-of-the-art overall performance is not possible. The scope for increased thermal insulation in buildings depends on the very significant differences between current levels of thermal insulation and energy- or carbon-optimised insulation levels. The latter, determined by comparison of embodied and operating energy, are typically many times thicker than the former. Carbon-optimal thicknesses of wall insulation in Northern Europe are, for example, between 3 and 5 times regulatory minima (Lowe et al. 1997). For typical load bearing masonry construction, incremental embodied energy to achieve zero space heating is approximately 25% of total embodied energy of buildings built to current standards. Feist (1996) reports that the simple payback time for thermal insulation incorporated into the prototype Passivhaus was less than 2 years.

Furthermore, current building construction is not optimised with respect to embodied or lifetime energy cost. In some unfortunately widespread cases, current constructions have a higher embodied energy content than their superinsulated equivalents. In such cases, the incremental embodied energy cost of achieving superinsulated envelope performance, in the context of a general re-optimisation of construction, may be negative.[4]

Building services systems and IT

In addition to high performance envelopes, buildings representing international best practice are characterised by highly efficient buildings services and IT systems. Energy use for mass transport (fans and water pumps), water heating, auxiliary cooling, lighting and IT in such buildings are all reduced, in most cases dramatically, compared with current typical practice.

Energy efficient design of ventilation systems most powerfully exemplifies some of the key principles at work. Ventilation systems consist of chains of sub-systems, the performance of each of which can be improved. The performance of the overall system is the product of the sub-system performances. The implication of this is that specific fan power – the energy used to deliver one litre of air per second to the building – can be reduced significantly by modest improvements in each sub-system. Overall improvements by a factor of 4 or more compared with current practice are thereby possible (Energy Efficiency Office 2000). Finally, the rate at which air needs to be supplied to the building can itself be reduced by reducing heat gains (through fabric insulation and reduction in IT loads), reducing or

4. Much UK dwelling construction makes use of load bearing cavity walls, insulated with expanded polystyrene foam. Such a construction, with 50 mm of expanded polystyrene, has an embodied energy cost *slightly greater* than that of a similar construction with a 250 mm cavity fully-filled with mineral fibre. The former just meets current UK Building Regulations requirements for U value. Dwellings built to this standard require typically more than 100 kWh/m^2a of space heat. The latter is sufficient to deliver a space heating demand of less than 10 kWh/m^2a in most of the EU.

eliminating space heating loads (through fabric insulation and airtightness) and eliminating or reducing sources of indoor air contamination. The overall environmental impact of air handling systems is determined by the product of intrinsic efficiency and level of demand. If both are improved, the overall reduction in energy use can be very large. As has been observed by others (Nørgård et al 1983, von Wiezsäcker et al.1999), careful whole-system integration and optimisation can reduce the amount of energy used to move air by a factor of 10 or more.

Energy efficient design of IT equipment shares many of the features of ventilation systems (in addition to being synergistically linked to ventilation system design). Energy use for IT depends on the intrinsic efficiency of devices and on their control systems. IT systems in most categories display at least a 5:1 range of intrinsic energy intensity (electrical power per unit of functionality). The most frequently cited example is that of the PC itself - the earliest reference the author can find is Norford et al. (1989). The intrinsic power demand for PCs ranges from 100-200 W for a desktop machine to 10-20 W for a laptop. Differences in functionality and ergonomics between the two classes of machine are not connected to their energy intensity – there is nothing to stop manufacturers from marketing desktop machines with a power demand close to that of laptops. The fact that the overwhelming majority of such machines have a power consumption up to 10 times higher than necessary, demonstrates a large untapped capacity for demand reduction. This is particularly significant, given the high rate of turnover of IT equipment in buildings.

The importance of control arises because most IT equipment spends much or most of its time idle. Taking full advantage of this fact requires, at a technical level, a control system that progressively shuts each particular sub-system down during a period of inactivity, coupled with power supply and related systems with high part load efficiency. Given these, very large savings are possible, a fact that has been recognised by the US Department of Environment (DOE) through the introduction of its Energy Star programmes. Energy Star is exemplary in both positive and negative senses. It demonstrates the ability of governments to remove inefficient equipment from the market by measures short of outright bans - it is now almost impossible to obtain a PC that does not claim to be Energy Star compliant. And it also demonstrates how such programmes can fail through technical timidity and user resistance. The Energy Star standard emphasises control measures rather than measures to improve the intrinsic efficiency of PCs. As a result, the gulf between laptop and desktop technologies has stayed as wide as when first identified in the late 1980s, while equipment that in reality offers only a modest improvement in intrinsic efficiency is identified by the world’s largest energy agency as “efficient”. Anecdotal evidence from a range of institutions suggests that the impact of the Energy Star programme is further reduced because:

- institutional IT managers are hostile to Energy Star features;
- Energy Star features may be disabled or inaccessible when running under certain operating systems[5];
- even when Energy Star features are not disabled by operating systems, manufacturers routinely supply PCs with Energy Star features turned off;
- very few are ever turned on again.

It is said that the difference between a pessimist and an optimist is that one perceives the glass to be half empty while the other perceives it to be half full. The obvious pessimistic conclusion from the above is that Energy Star, and programmes like it, make at best a rather modest impact on energy use of appliances. A

5. In the author’s own experience, Energy Star features cannot be accessed by Hewlett Packard PCs running Windows NT.

more optimistic view is that the manifest deficiencies of Energy Star mean that very large savings in energy use by IT in buildings are still to be made.

BARRIERS

The main conclusion from the above brief discussion is that energy use in all end-use categories can be reduced dramatically and that sustainable levels energy use are technically achievable in buildings in all OECD countries. There is nevertheless a widespread perception that:

- energy use and CO_2 emissions from both new and existing buildings in many OECD countries is either static or growing;
- the gap between what is demonstrably technically achievable and current typical practice has widened, over the last two decades, from around a factor of 3 in the early 1980s to a factor of 10 now, as international best practice has continued to improve.

This section of the paper attempts to determine what it is about the construction industry that makes it so apparently resistant to change. Based on the resulting understanding of the nature and dynamics of the industry, the author then begins to describe a series of measures that in combination would be likely to achieve significant change.

Information processing and innovation

Of all of the factors of production - labour, capital, availability of materials - the one that most powerfully constrains innovation is the ability of human beings to process information. The key scarce resource throughout the construction industry is attention. This fact has been more generally recognised by economists for decades[6]. Nevertheless, its many implications are not widely understood. Scarcity of attention leads to the development of a series of strategies for reducing the number and complexity of decisions that need to be made, both at the individual level and at the level of the firm. These include:

- the development of codes of practice, simplified models and sets of default assumptions to minimise the need to think about what is really going on in any given situation;
- the emergence of the “forgetting curve” which has the effect of eliminating information that may be out of date[7] and thus of reducing the amount of information that needs to be considered in the making of any given decision, but also, of eliminating information about possibly pivotal demonstration projects that occurred more than perhaps five years before the present;

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6. Much of the earliest work was done by Simon, who introduced the theory of bounded rationality. (Simon 1960).

7. This concept was originated by Amory Lovins, albeit in a different context. The author’s most recent experience with the forgetting curve arose in the context of a project to evaluate higher energy performance standards in housing in the UK. The author mentioned to another participant in the project, a senior manager in major a UK-based construction company, that this company had been responsible for the construction of the UK’s and possibly the world’s first superinsulated masonry house, at Machynlleth in North Wales in the late 1970s. The individual in question had never heard of it.

- the development of strategies for prioritisation of matters for consideration, based on a mix of individual and corporate interest;

- reliance on what has been shown to work in the past.

Strategies for dealing with limits to information processing combine with the impacts of economies of scale to produce an industry that is characterised by powerful network effects, and in which the dynamics of technological change are characterised by hysteresis and discontinuity (Almeida 1998). Where change does occur, it tends to be in directions that impact directly on the bottom line of companies involved, or that reduce uncertainty in the period leading up to the completion and handover of buildings, regardless of, and in some cases despite, the resulting impacts on long term performance[8].

As noted above, prioritisation and rationing of attention are direct consequences of the limits on individual and collective information processing capability. Issues that are deemed to have an importance less than a certain threshold receive no attention at all. In economics, the term used to describe the degree to which any particular issue stands out above the background of the taken-for-granted is "salience", but the term "signal-to-noise ratio" may be more helpful. Unfortunately, for most companies and for most individuals working in the construction industry, the signal-to-noise ratio of energy and environmental performance in buildings is low and, due to falling energy prices and rising income, declining.

Access to technology

Even where a company adopts a positive stance toward environmental issues, progress may not be made. The company may lack anybody who understands the relative importance of the different aspects of environmental impact, it may not know what level of performance it needs to aim for to make a significant difference and it may be unclear about how such performance can be delivered. Such problems lead to:

- an exaggerated interest in matters that are of second-order importance (e.g. embodied energy content of building materials) while avoiding matters of primary importance (most importantly, operational energy use);

- the design and construction of buildings that set out to reduce energy use only modestly;

- the development of technical solutions for which expectations are high but that ultimately do not deliver.

One of the consequences of minimising the need to think about what is really going on in buildings (see above) is a shortage of people in the construction industry who are capable of doing so. This, coupled with the emphasis of the architectural profession on the visual environment, leads to the specification of visually obvious but poorly understood technical features as part of energy and environmental strategies[9]. In the last

8. Examples include the development of dry lining as a replacement for wet plastering of load-bearing masonry construction in the UK (Lowe 2000), and the development of self-levelling screeds and ventilated crawl spaces in Sweden (Samuelson 1997).

9. Examples abound. Bordass et al (2001) quote the example of the Portland Building at the University of Portsmouth in the UK, which has solar-powered ventilation turrets to express the building's environmental strategy, but non-condensing boilers in its plant rooms. The Inland Revenue Building at Nottingham in the UK has hydraulically operated roofs on its stair towers, which were intended to provide stack ventilation to the adjacent offices. But the stack ventilation strategy is largely non-functional while the roofs of the offices barely meet regulatory minimum insulation levels.

two decades, such features have included double envelopes, atria, stack ventilation and turf roofs. The impact of these features on building design is often profound and great effort is needed on the part of the whole design team to integrate them successfully into workable buildings. But the analytical and empirical evidence supporting their adoption ranges from muddy to absent and their impact on energy use and environmental impact ranges has ranged in practice from obscure to clearly negative. Meanwhile, the attention of everybody involved in the procurement of buildings - clients, architects, engineers - is drawn away from those measures, such as air tightness, thermal insulation and well designed ventilation systems, which are analytically well understood and for whose efficacy there is, if one knows where to look, overwhelming empirical evidence. Individuals who are capable of an analytical understanding of environmental goals and the means of meeting them, thus find that their time and energies are diverted into coping with the consequences of decisions made by other professionals who are not.

Lack of feedback

Feedback is essential to the healthy development of any system[10]. However, feedback on energy use and environmental impact in the built environment is weak and often absent. In the UK for example, systematic measurements of internal temperatures, air leakage rates and energy use in new construction are not made. It is therefore not possible to know for certain whether performance is improving or worsening and, therefore, whether changes in regulation are effective or not.

Feedback requires that the output of each system or sub-system is measured and not simply speculated about. It requires the existence of a reliable and robust interpretive framework for making sense of the measured data. It requires measurements and interpretation to be presented back to those actors who initiated the sequences of actions that gave rise to the properties of the systems that are being measured. Finally, it requires those actors to have a stake and an interest in the consequences of their decisions and actions.

Poverty of aspiration

Given the large gap that exists between the requirements of containing climate change and the performance of existing building stocks and construction industries, poverty of aspiration is one of the most insidious obstacles to the development of sustainable construction industries in OECD countries. This operates at all levels, from the pronouncements of governments, to objectives of research councils and research programmes, to the goals of industry associations and individual companies. It is also structurally embedded in energy rating and environmental performance assessment methods in the form of closed measurement scales, and linguistically embedded through the use of terms like "Best Practice" to describe performance representing only modest improvements on typical practice[11].

The UK Standard Assessment Procedure for Energy Use in Housing (SAP) is a classic example of a system that uses a closed scale - in this case performance is assessed on a scale arbitrarily capped at 100, corresponding to carbon emissions for space and water heating of around half that achieved by the current Building Regulations. This has unfortunately led many individuals within the industry to conclude that

10. Amory Lovins put it somewhat less delicately – "any system without feedback is stupid".

11. The UK's Best Practice Programme exemplifies this problem. Readers may find Benjamin Lee Whorf's discussion of the impact of misleading labels on human behaviour to be salutory in this context (Whorf 1941).

performance better than 100 is not possible[12] - the capped rating scale has effectively capped debate about higher performance in the domestic sector over a period of more than a decade.

POSSIBLE POLICY RESPONSES

Building consensus for long term radical change

The rest of this paper will be a discussion of possible policy responses to the problem of Climate Change. This discussion is heavily influenced by a comparison of the situations in the UK, Germany and Denmark and does not claim to be exhaustive. It nevertheless appears that a prerequisite for the success of any realistic Climate Change Mitigation strategy is the acceptance, at the highest political levels, of the need for deep cuts in carbon emissions from industrialised countries. This acceptance needs to be followed by measures to construct broad social and political consensus around long term, national or regional plans to achieve these cuts.

It is possible to conceive of and, in some cases, to observe directly, a number of obstacles to such a development. These include:

- an unwillingness to give away bargaining chips in global negotiations over the control of Climate Change;

- an unwillingness to cause domestic political anxiety;

- an unwillingness to threaten or undermine competitiveness of domestic industry;

- an ignorance among the policy making community of the technical scope for reducing carbon emissions from the economy as a whole and from the building sector in particular, leading to a timidity in setting political goals.

Nevertheless, a number of countries including Denmark (Danish Ministry of Energy 1990, Danish Ministry of Energy and Environment 1997) and Germany (Deutsche Bundestag 1991) have begun the process of constructing such a consensus. The importance of constructing or beginning to construct such a consensus becomes clear as one begins to consider other categories of policy response.

Role of regulation

Regulation has historically been the main method by which governments have sought to control energy use in the Built Environment. The greatest strides have arguably been made in those countries with the clearest perception of their own vulnerability and the strategic importance of energy performance. In Europe, Denmark and Sweden reacted most strongly to the oil crisis of the early 1970s, and produced the groundbreaking SBN-80 and BR77.

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12. SAP, which is a linearised logarithmic function of the financial cost to householders of providing space and water heating, also suffers badly from opacity. It is likely that the next revision of the building regulations will replace the closed SAP scale with an open Carbon Index scale - though the problem of opacity is likely to remain. The Energy Performance Coefficient, the Dutch equivalent of SAP, is a good example of an open, physically-based performance scale, whose relatively simple structure indicates clearly to the user that the ultimate goal of the construction industry must be zero environmental impact.

Some of the prerequisites for effective regulation appear to be:

- a clear regulatory goal - in the context of this paper, this would be provided by long term, national or regional plans to achieve environmentally significant reductions in carbon emissions from the built environment;
- a good empirical understanding of energy use in the built environment, and of the physical, technical, and social factors that determine it;
- a willingness to indicate the long term development of the regulatory framework up to 10 years from the present, to provide the whole of the construction industry with a firm basis for business planning;
- a system of measuring the impacts of successive revisions to regulation on the empirical performance of statistically significant samples of buildings;
- a willingness to set minimum standards of performance at a level that drives, rather than simply responds to innovation in the construction industry;
- a willingness to support the long-term development of the regulatory environment with appropriate research, development and demonstration programmes.

To summarise, regulation should be part of a clearly stated climate change mitigation strategy and should be challenging, evidence-based and supported by research. Regulatory systems that lack the prerequisites outlined above, run the risk of acting as a brake upon, rather than a stimulus to, innovation[13].

Market-based approaches to carbon emission reduction

Regulatory minimum energy performance standards and building control systems are capable of further development in all countries. There are nevertheless fairly clear limitations to what can be achieved by this approach - as the author has concluded elsewhere:

> "[…] traditional regulatory systems are able to exert imperfect control over perhaps one third of the energy and environmental impact of modern buildings that arises from space heating, and little or none over the rest." (Lowe 2000)

Market-based interventions in principle operate at a much more fine-grained level than regulation. The simplest and most transparent market-based intervention is the carbon tax, which is capable of engaging the full spectrum of mechanisms by which emissions can be reduced (shifts in mix of consumption, fuel substitution including moves to renewable energy, and technical innovation in all sectors of the economy). There are also powerful synergisms between carbon taxation and other policy interventions. For example, carbon taxation:

13. This paper has already suggested that the Energy Star system now acts in this way, by labelling almost all commercially available PCs "Energy Star Compliant", with the implication that they are energy efficient. In the UK, where the perceived goal of the building regulatory system from the late 70s to mid 90s was to avoid challenging the construction industry, one finds elemental errors of design and construction to be justified by individuals across the construction industry, with the response that the buildings in question met the requirements of the Building Regulations.

- helps to legitimise stringent regulatory requirements;
- reduces the incentive to subvert regulatory intent;
- provides an incentive to improve practice beyond the levels prescribed by regulation;
- rewards energy efficiency in those areas where regulation is difficult or impossible to implement.

The concept of carbon taxation has been under discussion since the early 1990s (von Weizsäcker & Jesinghaus 1992, Blundell et al 2000, OECD 2001). Governments have nevertheless found it difficult to introduce in practice. Problems with carbon taxation include:

- in most societies, energy and carbon taxation would be regressive;
- carbon taxation at a significant level would be accommodated by shifts in the balance of imports and exports of energy-intensive goods and services, and by the relocation of industries away from the countries that introduced it - a phenomenon known as "leakage";
- carbon taxation would be an inefficient way of raising energy performance because of the low price elasticity of demand for energy;
- taxation in general, and taxes on energy in particular, are unpopular.

There are a variety of responses to these problems. The regressive nature of taxes on energy can be addressed by an integrated approach to taxation and benefit structures. While the problem of leakage can no longer be addressed by the imposition of tariff barriers, it can be addressed by the harmonisation of taxation policies across trading blocks. Moreover, the built environment is affected less than any other sector of the economy by leakage[14]. The problems posed by attempting to introduce ecological tax reform in one country have also been exacerbated by the fact that the political consensus necessary to introduce such policies has hitherto only been present in the smaller countries of Europe.

The problem of elasticity of energy demand is only a problem in the short term - detailed engineering analysis suggests strongly that the price elasticity of demand for space heating should be in the region of 0.5, based on re-optimisation of the building envelope alone (Lowe et al. 1997). Detailed economic arguments suggest that long run price elasticities may approach unity in many systems. Much of the conceptual difficulty in this area arises from the long time constants associated with the built environment and the construction industry. These range from a decade or more for the replacement of building services systems, to several decades for major refurbishment of building envelope components, to a century of more for replacement of whole buildings[15]. Development of the full response to a rise in prices in this sector requires the construction industry, systems suppliers and the public to believe that such a rise will be sustained for a period not substantially shorter than the life of typical buildings. Where the construction industry and its markets do not expect them to be sustained, price rises are likely to excite only short term coping behaviour - transfer of expenditure for those individuals and organisations that can afford it and

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14. It is therefore ironic that in most economies, much higher taxes are levied on energy used by the road transport sector than on energy used in buildings.

15. An excellent general discussion of the problems of time lags in energy using infrastructure may be found in Grubb (1997). The fact that it is impossible in principle to extract the long term impact of energy price on demand from econometric data for the last two or three decades, has not stopped economists from attempting to do so, and concluding, erroneously, that the impact is small.

increased hardship for those that cannot. This in turn implies that the key to maximising the impact of carbon taxation, is the construction of a credible social and political consensus behind the policy.

The problem of unpopularity of taxes on energy points, once again, to the absolute necessity of constructing broad political consensus around policies to reduce carbon emissions. Conversely, the failure to justify such taxes in environmental terms may make it impossible to sustain them politically[16].

The political difficulties associated with carbon taxation has led to the development of a range of alternatives. These include levies, tradable emissions permits and so on. The impact of such measures will be reduced to the extent that they:

- apply only to final consumers and not to upstream energy supply sectors;
- incorporate avoidance mechanisms based on the application of particular technologies;
- are simply not applied to the most energy intensive parts of the economy.

Systems that include some or all of these features have been applied in, among other countries, the UK and Denmark (Svendsen 1998). Compared to a carbon tax, such measures tend to be complex, opaque, bureaucratic and expensive to administer.

RD&D

Research, development and demonstration programmes have a number of crucial roles to play in the process of shifting the construction industry and the built environment towards sustainability. These include:

- re-establishing the limits of the possible: there is a dialectical relationship between RD&D and the political process - innovative RD&D programmes need, at the very least, the tacit “permission” of government, but at the same time they expand the domain within which political consensus can be achieved;
- re-contextualising existing practice and re-defining labels such as “best practice”;
- defining new performance standards;
- identifying and addressing social, political, technical, economic, procedural and perceptual barriers to change.

In order to perform these roles, RD&D programmes need to be weakly constrained by short-term commercial realities, but strongly constrained by the demands of long-term, environmentally realistic

16. One of the more effective innovations made by the last Conservative Government of the UK, with the explicit purpose of controlling carbon emissions from road vehicles, was the introduction of the “fuel price escalator”. Under this system, taxation on road vehicle fuel was to increase, first by 3 and then by 5% per annum indefinitely. When the system came under political attack in the Autumn of 2000, the Labour Government made no attempt to justify it in environmental terms, despite the simultaneous occurrence of the worst floods for several centuries. It has now been abandoned. The lack of understanding on the part of senior members of the cabinet was underlined by the apparently honest bafflement of the chancellor when told that his proposal to reduce the price of low sulphur petrol and diesel would lead to an increase in carbon emissions.

performance targets. Such programmes need to be built around progressively lower carbon emission targets, reflecting the continued advance of the underlying technology. There is a need for RD&D to be layered, from projects working at the cutting edge (the Götzberger Autonomous House, Voss et al. 1993) in a number of intermediate steps (the Passivhaus, the Niedrigenergiehaus) back to projects in support of current practice (e.g. the UK's Best Practice Programme). Cutting edge projects need to be at least 10 years ahead of widespread deployment (the third "D"), and perhaps 15 years ahead of incorporation into building regulations[17]. It is crucial to recognise the limits to what can be achieved by programmes that are jointly funded by government and industry, and to accept that state funding has a dominant role to play in defining the medium to long term. Cutting edge projects cannot be funded under regimes that insist on 50+% industrial co-funding and 2-5 year pay-offs - conditions that apply to a variety of funding programmes run by the UK DETR and by the EU. While a partnership approach can have many advantages when one is attempting to explore the implications of technological developments for the construction industry, it is the author's experience that industry will not bear the major cost of any research project that is not clearly in its own short term interest. Much of what needs to be done to support a transition to low carbon economies simply does not fall into this category.

One of the most important functions of RD&D is to provide a steady stream of exemplars - facts-on-the-ground. Good exemplars function in many ways: from enabling cutting edge teams of practitioners to develop and refine approaches to low carbon building, through the cognitive dissonance they induce in the rest of the construction industry, to the powerful impact that they can have in the process of educating tomorrow's building professionals. These exemplars need to be sufficiently closely spaced in time to sustain viable and vibrant research communities and to stay ahead of the "forgetting curve". In societies and industries that are dominated by a philosophy of seeing-is-believing, exemplars need to be geographically closely spaced - Wolfgang Feist of the Passivhausinstitut has suggested that no German citizen should live more than 10 km from a Passivhaus.

Related to the provision of exemplars is a need for the systematic collection, analysis and interpretation of performance data from a wide range of buildings of all types, spanning the whole spectrum of performance. While methodologies and systems for undertaking this task have been developed - one of the most successful being PROBE (Cohen et al. 2001) - they have yet to be applied extensively. For understandable reasons, many players in the construction industry are reluctant to allow their own work to be exposed to such searching enquiry - indeed, it has been impossible to obtain public funding in the UK for the widespread application of PROBE. Such work is nevertheless essential to provide the feedback (see above) needed by all involved in the maintenance and production of the built environment.

Developing environmentally-driven innovation strategies

The nature of innovation in the construction industry is closely related to RD&D. The change that is needed to fit today's building stocks and construction industries for a low carbon future by the middle of the century is a very significant one. To achieve it will require that environmental considerations - in particular the need to adapt to and mitigate climate change - should constitute the defining theme for innovation in the construction industry over at least the next twenty years.

17. One of the best examples of such a strategy is provided by the history of the development of the Low Energy House (NEH = Niedrigenergiehaus) and Passivhaus concepts in Germany. The first demonstrations of the NEH concept took place in the late 1980s (Feist & Werner 1988). The technology demonstrated by these projects was developed and codified by the Hessian Environment Ministry, which also, in 1989, provided financial support for the prototype Passivhäuser at Kranichstein (Feist 1997). The NEH concept, though not formally part of the regulatory minimum standard, was referred to explicitly in the 1994 German Building Regulations (Bundesministerium für Wirtschaft 1994), signalling a clear intention to move in this direction.

It is, however, unlikely that industry will move in this direction of its own accord. Experience in the UK suggests that the construction industry's own agendas for change have much more to do with cutting first cost, reducing construction times and reducing the need for litigation, than they do with reducing the environmental impact of the sector (Construction Task Force 1998). It is clear that the state has a key role to play establishing an exogenous agenda for change that transcends the short-to-medium term, bottom-line perspectives of the construction industry.

Scope and need for international cooperation

International cooperation is likely to be of use in a number of areas, including:

- the development of overall targets for carbon emissions in industrialised countries;
- the introduction of energy and carbon taxation at a scale that is likely to minimise problems such as leakage (see above);
- the introduction of minimum performance standards for building services systems, appliances and IT;
- the sharing of regulatory experience;
- the creation of trans-national systems of standards - e.g. CEN and ISO;
- the identification and sharing of international best practice in construction;
- the direct transfer of technology;
- the development of international cutting edge projects - examples include IEA Tasks 13 & 28.

There are a number of areas in which the pursuit of international co-operation may in fact hinder the pursuit of environmental goals. For example, while exchange of experiences related to the development of national consensus on the need to control Climate Change may assist many countries, the pursuit of joint policies, either at the level of the trading block or at the level of global negotiations, tends to be constrained by the least willing participant in such exercises. There appears to be considerable value in the diversity that exists between the policy goals and implementation strategies of different countries and regions. As the author has argued earlier, there is a need to take the environmental goal as given and, wherever consensus can be reached, to seek to begin the actual process of constructing low- or post-carbon infrastructures within industrialised countries, in parallel with the negotiation of global agreements.

Correspondingly, there are areas where international co-operation is likely to be the key to success. These include the establishment of energy performance standards for IT and domestic appliances, and the development of policies on energy pricing and carbon taxation. In the case of all of these measures, there is tension and potential conflict between the need to implement radical strategies for reducing carbon emissions and the requirements of regional and global trading environments overseen by the EU, NAFTA and ultimately by WTO.

CONCLUSIONS

The first part of this paper argues that the problem of containing Climate Change can be addressed, in the built environment, by extending international best practice throughout the sector. The actual problems that need to be solved to achieve this are not complex. At a concrete level, they amount to ensuring that:

- buildings are airtight and thermally insulated;
- internal sources of heat gain are minimised;
- solar heat gains are controlled;
- building services systems are intrinsically efficient and operated only when needed.

Put this way the problem seems tractable. But experience of the last quarter century shows that achieving radical change in a technical infrastructure that is characterised by longer physical life and slower response than any other sector of the economy is not trivial. A number of potential interventions have been set out in this paper. But it is crucial that the interdependencies and synergies between them are recognised. Failures to move practice forward have tended to occur where policies have been implemented in isolation and in the absence of any overarching goal. Such successes as there have been, have occurred where it has been possible to develop integrated frameworks of intervention in the context of a consensus about the overall objective. It remains to be seen whether this insight is a sufficient basis for wider progress in the future.

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Session 5

THE ROLE OF POLICY IN CREATING A SUSTAINABLE BUILDING SUPPLY CHAIN

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INTRODUCTION

Many of the generally acknowledged global environmental problems (greenhouse warming, ozone depletion, soil erosion, acid rain, eutrophication, to name a few) are directly or indirectly caused by the creation, operation, or disposal of the built environment. For instance, 30% of all primary energy in the U.S. is consumed by the built environment and on the order of 40% in many other OECD countries. Consequently much of the impact of energy (coal, oil, natural gas, uranium) extraction and processing, power plant construction and operation, associated transmission lines, and transportation (trucks, trains, barges, and ships) can be attributed to building operation. Much of the impact of automobile manufacture, operation, and disposal is tied to the distribution of the built environment on the landscape. Consequently the impacts of buildings extend far beyond the physical boundaries of the structures and infrastructure themselves. For policy instruments to be effective, they must comprehensively and holistically address the wide range of activities directly or indirectly connected to the built environment. Clearly this is an enormous undertaking and an appropriate scope must be selected to address these problems in a reasonable manner. Among the many global environmental crises facing humankind, mass materials movement associated with construction is probably the most underrated when compared to its impacts. This paper will concentrate on the materials used directly in the construction of the built environment, the materials industries supporting construction, and the policy instruments that may prove effective in redirecting this complex array of actors onto a path of sustainability. To further narrow the scope appropriately, construction industry and its associated materials movements in the U.S. will be covered. The initial discussion will be about materials issues with respect to sustainability and ways to address more appropriate materials use that could be driven by policy instruments. This will be followed by a review to the concept of industrial ecology and how it informs the decision making process with respect to the building materials supply chain.

MATERIALS AND SUSTAINABILITY

Sustainability is affected by anthropogenic materials use due to (1) environmental effects of mass materials movement during extraction, (2) depletion of high quality mineral stocks for industrial use, and (3) dissipation of concentrated materials resulting from wear and emissions. Mass materials movements and their negative environmental impacts are a recently identified phenomenon. As humans deplete the relatively accessible and valuable stocks of minerals, there are fewer of these resources available for future generations and the energy needed to extract more dilute stocks and the distances to them will both undoubtedly increase. The dissipation of artifacts is the thermodynamic equivalent of increasing entropy or conversion from useful to useless (Georgescu-Roegen 1971; Ayres 1993).

The earth, along with its biosphere, is essentially a closed-system with respect to materials and materials flux. Organizations studying materials cycles are producing convincing arguments that the environmental damage caused by extraction of primary materials is exceeding the capacity of natural systems to cope with the damage being caused by the mass material movements accompanying their extraction. Almost 30 years ago, Harrison Brown (1970) suggested that humankind had already become a major geologic force. He noted the need for increased recycling efficiency and a lowered demand on extraction as the source for metals to both protect the environment and address the worldwide disparity in resource availability between rich and poor nations. Roger Hooke (1994) examined this issue and found that in terms of moving rock and soil, humans were shifting the surface of the planet on a par with nature (Table 1). Estimates by the Wuppertal Institute are that the materials flux of human processes is twice the flux caused by all natural forces and systems combined, including hurricanes, earthquakes, tornadoes, and volcanoes, excluding sea floor spreading and continental subduction (Schmidt-Bleek 1994). Accompanying the Wuppertal Institute scenario is the hypothesis that sustainability requires that the human induced materials flux should be no greater than the natural flux. Parallel to the enormous quantities of matter being moved by humankind is the co-option of on the order of 40% of all terrestial and aquatic biomass by humans for their own uses at the expense of all other species (Vitousek et al. 1986). Additionally, humans are also co-opting over 50% of all accessible water run-off worldwide, which is expected to increase to 70% in the next 3 decades (Postel et al. 1996). One-third to one-half of the earth's surface has been transformed by human activities and more nitrogen is fixed by humans than by all natural sources combined (Vitousek et al. 1997). The introduction of tens of thousands of synthetic chemicals, many of them hazardous, into the global environment is another factor that is causing documented illnesses and disturbances to the reproductive systems of animals, including humans, throughout the world. The net effect of all these human disturbances is not clearly understood but, if these trends continue, the result can only be catastrophic, especially if synergism and positive feedback loops amplify these negative effects.

With regard to materials, the Wuppertal Institute suggests that the materials intensity per service unit

	Billion Metric Tons (BMT)
Wind erosion	1.0
Glaciers	4.3
Mountain Building	14.0
Oceanic Volcanoes	30.0
Humankind	42.0
Water	53.0

Table 1 Average annual transport of rock and soil (Hooke 1994 as tabulated by McNeill 2000)

(MIPS) must be reduced by a factor of 10 to move into a regime that could be considered sustainable (von Weizsäcker et al. 1997). Alternatively it could be said that resource efficiency must be increased by a factor of 10 to achieve the same end. The Factor 10 Club founded by Friederich Schmidt-Bleek, formerly of the Wuppertal Institute, is laying the groundwork for an international effort that originated with the Cournoules Statement in 1994, calling on industry and governments to transform their policies to effectively dematerialize their countries' economies. Dematerialization is the reduction of the quantities of materials needed to serve economic functions (Wernick 1994) or the decline over time in the weight of materials used in industrial end products (Wernick et al. 1996). It should be noted that this proposal for dematerialization does not distinguish between virgin and recycled or reused resources. Closing materials loops could produce, in effect, a factor 10 reduction in human-induced materials flux from the earth, with a far smaller reduction in aggregate materials throughput.

In addressing dematerialization, Stephen Bunker (1996) notes that instead of being an environmental or sustainable development response, dematerialization is not much more than an attempt to increase profitability, that it is not a new idea because industry always strives to lower the unit costs of production. The intensity of use (IOU) index measures materials mass per unit of Gross Domestic Product and for all industrialized countries, IOU indices have been generally falling for many decades, indicating, by this metric, a steady dematerialization of their economies. In fact, industries compete to offer ever more lines of products, increase labor productivity, and in effect, increase demand and the consumption of materials. In housing, for example, over the past 30 years the average American home has steadily increased in size from 170 to 220 square meters while the number of occupants has fallen from 3.5 to 2.5. Aggregate materials use or throughput, in contrast to IOU indices, is steadily increasing and environmental damage is climbing proportionately. Also neglected in discussions of dematerialization are the toxic by-products associated with extraction and processing of, for example, metals such as copper, zinc, platinum, and titanium. Part of the problem with clearly assessing dematerialization is the substitution of lighter weight materials for heavier ones. In what is a classic scenario in materials use, high technology polymers and carbon composites are rapidly replacing metals in many applications (Williams et al. 1987). Although dematerialization in an IOU sense is occurring by shifting to these alternatives, the environmental damage caused by the production of these materials and their general non-recyclability can make the benefits of dematerialization questionable.

True dematerialization must focus on virgin resource extraction rather than just on intensity of use and the environmental impacts of the technologies and substitutions creating dematerialization need to be carefully scrutinized. Dematerialization must also focus on a shift to reuse, recycling, and remanufacturing, all important aspects of closing materials loops. Additionally, deenergization, decarbonization, and detoxification of the industrial system should accompany dematerialization if significant resource and ecological benefits are to be achieved. It must also be kept in mind that although human ingenuity can perhaps effectively dematerialize the global economy, Robert Ayres (1993) notes:

“There are no plausible technological substitutes ….for soil fertility, clean fresh water, unspoiled landscapes, climatic stability, biological diversity, biological nutrient recycling and environmental waste assimilative capacity. The irreversible loss of species and ecosystems, and the build-up of greenhouse gases in the atmosphere, and of toxic metals and chemicals in the topsoil, groundwater and in the silt of lake-bottoms and estuaries, are not reversible by any plausible technology that could appear in the next few decades. Finally, the great nutrient cycles of the natural world - carbon, oxygen, nitrogen, sulfur, and phosphorous - require constant stocks in each environmental compartment and balanced inflows and outflows. These conditions have already been violated by large-scale and unsustainable human intervention.”

Finally, Denis Hayes (1978) suggested that a sustainable world would be one in which “Material well-being would almost certainly be indexed by the quality of the existing inventory of goods, rather than by the rate of physical turnover. Planned obsolescence would be eliminated. Excessive consumption and waste would become causes of embarrassment, rather than symbols of prestige.”

MATERIALS IMPACTS OF CONSTRUCTION

Materials consumption by construction industry dominates worldwide materials consumption. About 40% of all materials extracted annually in the U.S. end up in the built environment (Wernick and Ausubel 1995). Because construction activity amounts to about 8% of U.S. GDP, the materials impacts of construction far outweigh its relative size in the economy. In 1993, over 2.1 billion metric tons (BMT) of materials were incorporated into buildings and built environment infrastructure. In 1999, cement consumption in the U.S. was 105 million metric tons (MMT). It has been estimated that over 90% of all the materials ever extracted in the U.S. are in today's built environment. Consequently policy must address this enormous, burgeoning stock of materials to insure that it becomes, to the greatest degree possible, a resource for future generations rather than an enormous waste disposal problem.

Waste from construction activities is enormous. At present in the U.S., over 145 MMT of construction and demolition waste are created annually. This compares to a municipal solid waste (MSW) stream of about 280 MMT, meaning that construction and demolition waste comprises about one-third of the total materials being landfilled. Of the total construction and demolition waste stream, about 92% is attributed to demolition activities and 8% is waste from construction activities, either new buildings or renovation of existing structures. Waste from new construction amounts to 27 Kg/m^2 while from renovation activities in typical commercial buildings, the quantity of waste can be as much as 320 Kg/m^2.

Of possibly greater consequence is the Ecological Rucksack of construction or the total quantity of material that must be extracted to obtain a unit of pure material. For example, for iron ore extraction, the Ecological Rucksack can be expressed as the ratio 14:1, that is, 14 metric tons of waste in the form of tailings or mine waste is the result of producing 1 metric ton of iron. For rarer materials, such as gold and platinum, the ratio can range up to 350,000:1. For the most massive quantities of materials used in the built environment, sand, gravel, and stone, the Rucksack is not so unfortunate with a ratio of 1:0.86 for gravel and 1:1.2 for natural stone. Coal extraction's ratio is 1:5 while that for petroleum is 1:0.1. In addition to the Ecological Rucksacks , the relative scales of extraction need to be considered. For the materials mentioned here, 10 BMT of sand and gravel, 5 BMT of stone, 5 BMT of coal, 5 BMT of petroleum, 0.5 BMT of iron,

Material	Ecological Rucksack	Scale (BMT)
Oil	1:0.1	5
Sand/Gravel	1:0.86	10
Natural Stone	1:1.2	5
Coal	1:5	5
Gold	1:350 000	0.0001

Table 2 Ecological Rucksack and scale of selected materials

and 0.0001 BMT of gold were extracted worldwide in 1994 (see Table 2).

Building Specific Materials Issues

Buildings, the most significant components of the built environment, are complex systems that are perhaps the most significant embodiment of human culture, often lasting over time measured in centuries. Architecture can be a form of high art and great buildings receive much the same attention and adoration as sculpture and painting. Their designers are revered and criticized in much the same manner as artists. This character of buildings as more than mere industrial products differentiates them from most other artifacts. Their ecology and metabolism is marked by a long lifetime, with large quantities of resources expended in their creation and significant resources consumed over their operational lives.

The main purpose of the built environment is to separate humans from natural systems by providing protection from the elements and from physical danger. Modern buildings have increased the sense of separation from the natural climatic processes and have made the underlying biological and chemical processes of nature irrelevant for their occupants. Until humans achieved space travel, the extraction and conversion of materials for building construction has been the highest expression of dominance over the constraints of natural bio-climatic and material constraints. This “constructed” ecology has in turn created an ecological illiteracy and had profound psychological and human health impacts (Orr 1994). Concentrations of buildings effect micro-climate (heat islands), hydrology (runoff), soils and plants (suffocation and compression), and create false natural habitats (nests on buildings). This increasing separation of ecological feedback loops inherent in the design, construction and use of buildings since the Industrial Revolution has brought many architects back to an era of reconsideration of this de-evolutionary and unsustainable path. The construction industry is extremely conservative and subject to slow rates of change due to regulatory, liability, and limited technology transfer from other sectors of society. The extended chain of responsibility and the separation of responsibilities for manufacturing materials, design and construction, operations and maintenance, and eventual adaptation or disposal, have resulted in a breakdown of feedback loops among the parties involved in creating and operating the built environment. Modern buildings, although products of industrial societies, are perhaps unique among modern technologies in terms of the diversity of components, unlimited forms and content, waste during the production process, land requirements, and long term environmental impacts.

The built environment interacts with the natural environment at a variety of scales, from individual structures affecting their local environment to cities impacting the regional environment, affecting weather by changing the Earth’s albedo (Wernick and Ausubel 1995) and other surface characteristics, altering natural hydrological cycles, and degrading air, water, and land via the emissions of its energy systems and due to the behavior of its inhabitants.

Buildings can be distinguished from other artifacts by their individuality and the wide variety of constituent parts. Buildings are assembled from a wide array of components that can be generally divided into 5 general categories:

1. Manufactured, site-installed commodity products, systems, and components with little or no site processing (boilers, valves, electrical transformers, doors, windows, lighting, bricks);
2. Engineered, off-site fabricated, site-assembled components (structural steel, precast concrete elements, glulam beams, engineered wood products, wood or metal trusses);
3. Off-site processed, site-finished products (cast-in-place concrete, asphalt, aggregates, soil);
4. Manufactured, site-processed products (dimensional lumber, drywall, plywood, electrical wiring, insulation, metal and plastic piping, ductwork);
5. Manufactured, site-installed, low mass products (paints, sealers, varnishes, glues, mastics).

Each of these categories of building components has an influence on the potential for reuse or recycling at the end of the building’s useful life and the quantity of waste generated during site assembly. Category 1 components, because they are manufactured as complete systems, can be more easily designed for remanufacturing, reuse, and disassembly, and thus have a excellent potential for being placed into a closed materials loop. Category 2 products also have this potential although engineered wood products, a relatively new technology, have not been scrutinized as to their fate. Concrete products fit into the first 3 categories and the extraction of aggregates for further use is technically and, in many cases, economically feasible. Category 4 products are in some cases more difficult to reuse or recycle, although metals in general are recycled at a very high rate in most countries. Category 5 products are virtually impossible to recycle and in many cases are sources of contamination for other categories of products, making their recycling very difficult.

Buildings as artifacts of human society are also distinguished to a large extent by their relatively large land requirements and the environmental effects of the cooption of this valuable ecological resource. The built environment significantly modifies natural hydrologic cycles, contributes enormously to global environmental change, has tremendous effects on biodiversity, contributes to soil erosion, has major negative effects on water and air quality, and, as noted above, is the source of major quantities of solid waste. In the U.S., as noted earlier, construction and demolition waste is the major source of industrial waste, amounting to perhaps 500 Kg per capita or on the order of 145 MMT annually. In the U.S. the reuse and recycling rates of this waste is not well known but is probably under 20% of the total mass and probably closer to 10%. Only concrete recycled for its aggregates and metals are recycled at high rates because of their relatively high economic value.

Construction industry also differs from other industrial sectors in that the end products, buildings, are not factory produced with high tolerances, but are generally once-off products designed to relatively low tolerances by widely varying teams of architects and engineers, and assembled at the site using significant quantities of labor from a wide array of subcontractors and craftspeople. The end products or buildings are generally not subject to extensive quality checks and testing and they are not generally identified with their producers, unlike, for example, automobiles or refrigerators. Unlike the implementation of Extended Producer Responsibility (EPR) in the German automobile industry which is resulting in near closed loop behavior for that industry, buildings are far less likely to have their components returned to their original producers for take-back at the end of their life cycle. Arguably EPR could be applied to components that are routinely replaced during the building life cycle and that are readily able to be decoupled from the building structure (chillers, plumbing fixtures, elevators). The bulk of a building’s mass is not easily disassembled and at present there is little thought given in the design process to the fate of building materials at the end of the structure’s useful life.

Most industrial products have an associated lifetime that is a function of their design, the materials comprising them, and the character of their service life. The design life of buildings in the developed world is typically specified in the range of 30 to 100 years. However, the service lives of buildings are unpredictable because the major component parts of the built environment wear out at different rates, complicating replacement and repair schedules. Stewart Brand (1994) describes these variable decay rates as “shearing layers of change” that create a constant temporal tension in buildings. Brand adapted O’Neill’s (1986) hierarchical model of ecosystems to illustrate the issue of temporal hierarchy in buildings that can be related to the spatial decoupling of components (See Figure 1). Faster cycling components such as Space Plan elements are in conflict with slower materials such as Structure and Site. Management of a building’s temporal tension might be achieved with more efficient use of materials through spatial decoupling of slow and fast components. Components with faster replacement cycles would be more readily accessible. This hierarchy is also a hierarchy of control, i.e. the slower components will control the faster components. However, when the physical or technical degradation of faster components surpasses critical thresholds, they begin to drive changes to the slower components such that dynamic structural change can occur. For example, in a typical office building, electrical and electronic components wear out or become obsolete at a fairly high rate compared to the long-lived building structure. At some critical threshold the motivation to maintain the overall building ebbs and the building rapidly falls into disuse and disrepair due simply to the degradation of the faster, more technology dependent components. H.T. Odum (1983) developed the concept of EMERGY, the energy embodied in the creation and maintenance of a factor or process, as a means to quantify the relative contributions of different components to the operation of a hierarchy. Odum’s theory predicts that the control of faster components by slower components is reflected in the latter’s higher EMERGY transformity values. Transformity values are efficiency ratios of total EMERGY to actual energy, normalized in solar equivalent joules, that enumerate a process’s relative capacity to influence system behavior. Using EMERGY to more carefully distinguish between slower and faster components and processes would allow designers to more rationally couple buildings to external processes of manufacture, reuse, and recycling. As such this theory provides a quantitative framework for relating building design to its material components based on their relative contributions to the functions of an 'ecosystem' that includes the built environment and the materials and processes that sustain it.

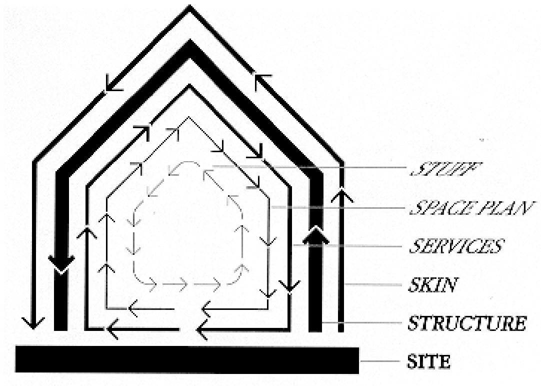

Figure 1. Temporal hierarchy of building components. Thicker lines correspond to longer lived components (Brand 1994)

BACKGROUND TO A POLICY STRATEGY

General Approaches

There are a number of potential approaches for creating a system of sustainable materials reuse. Several recent attempts have been made to articulate principles or rules that can help direct not only sustainability, but ultimately policy. Several of these are described in the following paragraphs.

Golden Rules of Eco-Design

Stefan Bringezu (2001) of the Wuppertal Institute suggests what he terms the Golden Rules of Eco-Design:

1. Potential impacts to the environment should be considered on a life cycle-wide basis.

2. Intensity of use of processes, products and services should be maximized.

3. Intensity of resource use (material, energy, and land) should be minimized.

4. Hazardous substances should be eliminated.

5. Resource inputs should be shifted towards renewables.

These rules are based on several management rules for sustainability. First, the use of renewable resources should not exceed their regeneration rate. Second, non-renewable resources should only be used if physical and function equivalents are provided such as investing in solar-derived energy from the profits of fossil fuel consumption. Third, the quantity of waste released must not exceed the absorptive capacity of nature. Finally there must ultimately be a balance between materials inflows and outflows to/from the economy because physical development cannot continue indefinitely and without bound.

Bringezu also suggests that there are four basic construction activities that must be kept in mind to examine materials impacts on a life cycle basis: (1) Design of construction products and buildings; (2) Materials management; (3) Planning of infrastructure; and (4) Product, facility, and building management.

General Rules of the Production-Consumption System

James Kay, an ecologist at the University of Waterloo in Ontario, Canada, suggests that the human means of producing artifacts for use or 'consumption', should respect a set of rules that recognize the capacity and limits of natural systems (Kay 2001). A brief description of these rules is as follows:

1. The interface between man-made systems and natural ecosystems should address the limited ability of natural ecosystems to provide energy and absorb waste before their survival potential is significantly altered. Additionally, the survival potential of natural ecosystems must be maintained. This is referred to as the problem of *interfacing*.

2. The behaviour and structure of large scale man-made systems should be as similar as possible to those exhibited by natural ecosystems. This is referred to, after (Papanek 1970), as the *principle of bionics*.

3. Whenever feasible the function of a component of a man-made system should be carried out by a subsystem of the natural biosphere. This is referred to as *using appropriate biotechnology*.

4. Non-renewable resources be used only as capital expenditures to bring renewable resources on line.

Industrial Ecology Viewpoint

Industrial Ecology can be defined as the application of ecological theory to industrial systems or the ecological restructuring of industry (Rejeski 1997). In its implementation it addresses materials, institutional barriers, and regional strategies and experiments (Table 3)(Wernick and Ausubel 1997). Industrial Metabolism is the flow of materials and energy through the industrial system and is directed at understanding the flows of materials and energy from human activities and the interaction of these flows with global biogeochemical cycles (Erkman 1997).

1. The Material Basis -Choosing the material -Designing the Product -Recovering the Product	3. Regional Strategies and Experiments - Geographic, economic, political - Industrial symbioses
2. Institutional Barriers and Incentives -Market and Institutional -Business and Financial -Regulatory	

Table 3 Issues confronting the implementation of Industrial Ecology

As noted by Graedel and Allenby (1995), the rejection of the concept of 'waste' is one of the most important outcomes of Industrial Ecology. In an ideal industrial system, nonrenewable materials would be utilized in a closed loop to minimize the input of virgin resources. Products degraded by age or service would be designed to be reverse-distributed back to industry for recycling or remanufacturing. The processes creating the loops would be designed for zero solid waste to include zero emissions to water and air. Renewable resources would also be used in a closed loop manner to the maximum extent possible and follow the same zero waste rules as for nonrenewables. Renewable resources, being biological in origin, could be recycled by natural processes as simple biomass which could serve as nourishment for biological growth.

According to Deanna Richards and Robert Frosch (1997), "..industrial ecology views environmental quality in terms of the interactions among and between units of production and consumption and their economic and natural environments, and it does so with a special focus on materials flows and energy use." They also go on to note that the integration of environmental factors can occur at three scales:

- microlevel (the industrial plant);
- mesolevel (corporation or group operating as a system);
- macrolevel (nation, region, world).

It is interesting to note that these three levels are identical to the levels at which natural systems are studied for their function.

Industrial Ecology has evolved in several major directions since it became well-known in the late 1980's. The first direction is the evolution of the concept of eco-industrial parks (EIP) in which waste and by-products from a group of companies are shared as resources. Sometimes referred to as 'industrial symbiosis,' the grouping of industries with compatible energy and materials waste and needs helps minimize the emissions of the industrial cluster. Extending the concept of waste energy/materials sharing to regional scale can hypothetically result in 'islands of sustainability.' The Kalundborg EIP in Denmark is the most frequently cited success story of industrial symbiosis but detailed knowledge of the materials, energy, economic, environmental, and social effects of this industry cluster are not well-known (Richards and Frosch 1997).

The second major direction of Industrial Ecology is the optimization of materials flows by increasing resource productivity or dematerialization. The notion of a service economy which sells services instead of the actual material products is considered the sine qua non of this strategy, alternatively referred to as 'systemic dematerialization.' One of the questions facing Industrial Ecology is whether corporations can profit more from closing materials loops and behaving environmentally responsibly or through built-in obsolescence and open materials cycles (Erkman 1997).

Fritz Balkau (2001) suggest that industrial ecology can be used as a framework for developing appropriate policies with respect to sustainable materials use. He focuses on implementing and operationalizing industrial ecology through management and policy instruments. In reviewing the concept of Industrial Ecology, he suggests that it might be defined as the study of materials and energy flows, population dynamics, and the operational rules and interrelationships of the entire production system. The challenges in implementing this strategy are insuring the Industrial Ecology concept is complete so that it addresses all policy areas and that an effective combination of management instruments is available for applying the concept in real situations. The main elements of Industrial Ecology that have been suggested are industrial metabolism, industrial ecosystems or associations, materials cycles in nature and industry, and the evolution of industrial technologies. These in turn have resulted in a number of concepts for operationalizing sustainability: the precautionary principles, the prevention principle (cleaner production and eco-efficiency) life-cycle management, the zero emissions concept, dematerialization (the factor 10 concept), and integrated environmental management systems. He suggests that we have not yet seen a mature industrial ecosystem where management systems have evolved sufficiently to produce a true artificial ecology. However a number of management elements have appeared which give us hints at how these management systems may eventually appear. Among the existing dynamic management elements are corporate decisions on sustainability; the adoption of environmental management systems (EMS); the practice of supply chain management; central infrastructure management; cooperative environmental programs; and government industrial development policy. The challenge is to combine these management instruments in an intelligent and systematic fashion.

Balkau suggests that the construction sector also needs to stay abreast of emerging environmental problems and adapt the design, operation, and disposal of the built environment to address new issues. The construction industry also needs to be more aware of the secondary impacts of its activities, that is, the damage done during the extraction of the resources needed for creating the products that comprise buildings and infrastructure. Quality of life as affected by construction also needs to be included in the array of issues for industry awareness and possible action. For example, congested transportation systems, increased noise, and increased municipal solid waste are also outcomes of construction activity. He concludes by suggesting a management framework for Construction Ecology. A wide variety of instruments from environmental standards to building codes and financial criteria can be applied to Construction Ecology and assist its implementation. However the primary prerequisite for creating a framework of management instruments is the definition of environmental goals. To accomplish this, construction industry itself must come up with a common view of its environmental agenda to include parameters such as energy efficiency.

The final lesson provided by the Industrial Ecologists is that implementation of both Industrial Ecology and Construction Ecology must be carried out using the appropriate policy instruments by a variety of entities to include government, corporations, and developers. An environmental agenda that construction industry can agree to is particularly important as it would set the parameters for behavior of the many actors in the construction process. Coordination in the application of policy instruments such as building codes and standards for building products would help orchestrate a steady march toward a system of creating the built environment that pays careful attention to resource and environmental issues. Coherent action is important to be able to produce change and the establishment of an agenda to integrate policy and technical issues is needed to create this coherency.

POLICY INSTRUMENTS FOR THE BUILDING SUPPLY CHAIN

The Working Party on National Environmental Policy of the OECD produced a recent report, Policy Instruments for Environmentally Sustainable Buildings that laid the groundwork for considering policy for all aspects of buildings (OECD 2001). The report made several key observations with respect to materials that are worth noting prior to delving into specific policy issues. Among these observations are (1) the long-lived nature of the products; (2) the extended supply chain; and (3) the spatially fixed nature of products and production processes and the heterogeneity of buildings. Commentary on each of these aspects is contained in the following sections.

Long-Lived Nature of Products

Although the report notes the long life of buildings, buildings are in effect subjected to the shearing layers of change described above. With the general exception of the shell, building components are replaced at intervals, some of which are not notably different from other consumer products such as automobiles. Building services (mechanical, electrical, plumbing, fire protection, security, data) are subject to replacement at intervals on the order of 5-25 years depending on the component and technology pressures. The building space plan (walls, doors, finishes) is also subject to fairly rapid changes, as the needs and tastes of the occupants change. The furnishing and appliances of the built environment are also subject to frequent changes, 5 to 20 years being typical time spans. The roofs of most contemporary buildings have 10-30 year lives and even doors and windows are likely to be replaced in this time frame. Only the structure of the building is unlikely to be changed over a nominal lifetime of 50 years. Although the frequent turnover of building components can cause waste problems, there are also opportunities to upgrade energy systems, both active and passive types, to reduce energy consumption.

Extended Supply Chain

The supply chain of the built environment has been described as being different than that of other industries in that a large, diverse industry produces the components of construction, the buildings are assembled from custom designs on a site, they are maintained and altered over a lifetime from 30 to 100 years, and demolished by specialized contractors at the end of their lifetime. In fact however, many of these efforts of construction are not dissimilar from other industries, most notably the automobile industry. This industry has a large range of suppliers and automobiles are largely customizable though not to the extent of buildings. They are maintained and modified over a lifetime from 10-20 years and processed by specialized automobile yards at the end of their life. There are similarities and differences in materials, products, and technology. Buildings contain large quantities of steel, plastics, and copper wiring. Buildings also are likely to contain significant percentages of concrete, clay and cement block, wood, and drywall. Thus buildings do contain significant quantities of materials that are difficult to recycle into product or materials of equal quality. This is largely an economic issue due to the large mass of materials required to produce even relatively small structures.

Spatially Fixed Nature of Products and Production Processes, and Heterogeneity of Buildings

Unlike other products or artifacts of human industry, buildings are almost all custom designed by architects and have historically had a significant place in culture. The low level of standardization is due to the desire to make buildings unique but also due to the sheer scale of buildings compared to other artifacts. The large size of and investment in many buildings makes it likely that owners will want them to be different from other buildings. This is a phenomenon that occurs in other sectors at the top of the line. The more expensive an automobile, the more the likelihood is that the owner will put their own personal stamp on it in some way or another. With respect to scale, ships are perhaps the only other artifacts of comparable scale and these are also each relatively unique. Aircraft, many of which are as costly as a major building, are also subject to fairly heavy customization in terms of appearance as well as in their interiors and avionics when major airlines are the buyers. Like aircraft, ships, and automobiles, the basic components of buildings are bought from catalogs. Consequently I would argue that the fixed nature of buildings and the production process has little to do with their heterogeneity. It is the scale and cost of the building compared to other artifacts that is likely to make them more heavily customized by their owners.

CASE STUDY - THE U.S. CARPET TILE INDUSTRY

Perhaps the industry most approaching the ideals of a true ecology of construction in the U.S. is the carpet tile industry. Carpet tiles are semi-rigid squares (typically 450 mm per side) of carpet that are used in commercial and industrial applications. The advantage of this carpeting system is that areas of carpet that become worn out due to heavy traffic or damage can be simply removed and replaced with new carpet tiles. For a variety of reasons several major manufacturers of carpet tiles are competing for market share based at least partially on the recyclability of their products. Among these manufacturers are Interface, Collins & Aikman, and Milliken. Each of these manufacturers has evolved a different strategy for competing in this age of emerging awareness of greening issues.

Interface recently released information about a new product called Solenium which is a hybrid carpet-resilient flooring material. Although it is a composite of several different layers of materials (PTT face fiber, fiberglass and carbite adhesive, polyurethane cushion, and polypropylene secondary backing), it is designed for disassembly. At about 190^{o}C, the adhesive bonding between the face fiber and urethane cushion dissociates, allowing the materials to be peeled apart for recycling. The secondary backing can be manually peeled away from the urethane cushion (EBN 1999a). Although the new product does require some virgin materials for its manufacture, the bulk of the materials can be recycled into new product. Interface also offers materials such as Solenium as “Products of Service,” meaning that they can be leased from Interface who then takes on the responsibility for maintaining, removing worn sections, and recycling the used materials into new products.

Backing materials are one of the most important components of carpeting because they come into contact with the underlying surface and must have adequate toughness, strength, and durability to withstand the wide variety of loads to which they will be subjected. Collins & Aikman created a new backing material which they refer to as Powerbond ER3 and which contains up to 50% post-consumer waste in the form of old carpet from its competitors. The remainder of the ER3 product is internal production waste and post-industrial automotive waste. The manufacturer claims that the ER3 backing may in fact be superior to backing it manufactures made of 100% virgin materials.

Milliken’s approach to effective materials use is to remanufacture used carpeting by deep cleaning, retexturing the surface and overprinting a new pattern on top of the old color. As part of their marketing strategy, Milliken is planning on selling a product called “Precycle” which indicates the carpet tiles are designed for remanufacture and with an eye to potential color schemes for future generations of remanufactured product. Remanufactured carpeting also carries a significant financial incentive-the cost of the remanufactured version is half that of the new carpet tiles (EBN 1997).

Raw materials manufacturers such as Dupont, AlliedSignal, BASF, and DSM Chemicals are also participating in related closed loop materials ventures. In a new venture called Evergreen Nylon Recycling, AlliedSignal and DSM are building a facility which recycles a variety of nylon called *nylon 6*, which is highly recyclable. In effect the recycled polymer is identical to the virgin polymer and thus 100% recyclable. A process known as *selective pyrolysis* uses heat and steam to separate the constituent products of the nylon carpet, and *caprolactam*, the building block of *nylon 6*, rises to the top of the vat during processing. To assist with identifying carpet containing *nylon 6* and to prevent contamination from other types of nylon carpeting, AlliedSignal developed a hand-held infrared device to assist contractors in the collection of the appropriate used carpeting in the field (EBN 199b).

These actions and strategic moves by carpet tile manufacturers and raw materials producers for the carpet industry are perhaps the most comprehensive example of the evolution of a construction ecology that has similarities to its natural system counterpart. For the first time, manufacturers are actually competing not only on the function and cost of their products, but also on the ability of the materials to be kept in a closed loop system of manufacture-use-recovery-manufacture. The question that emerges from this observation of this one segment of construction materials is: when can we expect to see similar progress in other product segments, for example wall panels or acoustical tiles? The carpet tile industry is providing ample evidence that systems approaching the ideals of construction ecology are both achievable and profitable.

The flooring industry is an anomaly in that the industry has moved towards waste minimization of its own volition without regulatory incentive. However, in other industries, the voluntary adoption of life cycle analysis is unlikely to occur without some regulation and incentives. Therefore, in order to use the lessons learned from the carpet and flooring industry regarding the possible innovation in life cycle approaches to products that result in waste minimization, a framework has been designed using Hasegawa's scheme for classifying policy instruments (OECD 2001) (See Table 4). Note that in Table 4 the label "consumer" refers to the actor that procures the product from the producer. In the case of carpet tiles, the consumer would be the carpet subcontractor who purchases and installs the tiles. The following paragraphs address the various policy instrument possibilities by phase of the built environment.

Design and Construction

Producers could be required by regulation to take life cycle responsibility for their products, thus designing them for recycling, using Design for the Environment principles, or to use recyclable materials in their products. This could include a scheme similar to Extended Producer Responsibility (EPR) in which the producer is required to take back both used and waste products they had manufactured. For the consumer or builder, a requirement that buildings must contain a certain minimum percentage of recycled content and recyclable materials would be in order. Producers could also be required to use specific materials for specific products if technical data indicated that these materials were in fact recyclable where the alternatives were not. Economic incentives for improved materials use behavior could include taxes on virgin materials and subsidies for using recycled materials. It is important to pair incentives and disincentives together across the life cycle of a specific product to ensure waste minimization across the board for existing products as well as new products. To assist the impacts of regulatory and economic instruments, Eco-Labeling and Certification schemes could assist in providing information about products that meet the highest standards with respect to materials recycling and recyclability.

Use and Refurbishment

Carpet tiles are one of the shorter lived products of the built environment, requiring replacement in as little as 5 years in heavily trafficked areas such as corridors. It could well occur that carpet tiles are replaced 8 to 10 times over the life cycle of a 50 year building. Consequently carpet tiles must be designed for easy removal and replacement to minimize their impacts. Keeping carpet tile waste out of landfills has to be a primary objective of policy instruments at this stage of the building cycle. The general rules would be for contractors to be required to extract used carpet tiles and return them to the manufacturer or in fact any manufacturer for refurbishment and/or recycling. When replacing materials, the same incentives and disincentives that exist at the construction stage would occur once again. Closing materials loops must also include incentives to set up the logistics of moving materials from tens of thousands of building sites back to the manufacturer. In the case of Interface, their strategy is to create products of service, for example through their EverGreen Lease program in which they retain ownership of the carpet tiles while leasing the service of the carpet tiles to the user. A similar strategy could be employed for many building components, with the manufacturers retaining both ownership and responsibility for building products. This type of activity could be encouraged via economic instruments that would provide tax credits for products of service utilized in buildings.

Demolition/End Use

Demolition waste comprises the bulk of the construction and demolition waste stream from construction. In the U.S., of the approximately 145 MMT of construction and demolition waste, 92% of this waste stream is connected to demolition activities. For products to be returned to their manufacturers for use as raw materials for new products, it is necessary to insure that the removed materials are as clean as possible in order to maximize the ‘recycling potential’ of the waste materials. This generally implies an orderly process of buildings disassembly, that is a process of ‘deconstruction’ rather than demolition in which the materials of the former building are all commingled. Consequently policy instruments that require deliberate disassembly of buildings are needed to insure materials are removed in as high quality a condition as possible. With respect to regulatory instruments, the primary instruments would require two actions: (1) the storage of disassembly information in the building and (2) the provision of adequate time in the permitting process to allow building disassembly. The latter could be implemented by requiring delay times after application for a building demolition permit. Economic instruments for this phase would include increasing the cost of disposal of demolition waste and providing incentives, perhaps in the form of subsidies, for entities that set up deconstruction, recycling, and/or materials reuse businesses. Information instruments could include Eco-Labeling schemes that have as one of their criteria the ability to disassemble products into recyclable materials.

Table 4 Application of Policy Instruments to carpet tile manufacture, use, and disposal

	Design and Construction		**Use and Refurbishment**		**Demolition/End Use**	
	Consumers	Producers	Consumers	Producers	Consumers	Producers
Regulatory Instruments	*Require builders to use a minimum level of recyclable and recycled content materials	*Life cycle responsibility for producers, for example, Interface's "Solenium", *Technical standards, equiring that carpet tiles be manufactured from highly recyclable nylon 6	* Require contractors collect carpet tiles and return them to producers *Landfill ban *Require contractors to use materials that are recyclable	*Require producers to take back used product and waste product and recycle it	* Require contractors to collect carpet tiles and return them to producers *Landfill ban *Require contractors to use materials that are recyclable	* Require producers to take back used product and waste product and recycle it
Economic Instruments	*Tax credit /reduced building permit fees for builders who use recyclable flooring *For owner possible property tax credits	*Tax on use of virgin material *Incentive for use of post-consumer waste * Subsidies for take-back scheme	*Reduced permit fees for used recyclable and recycled content materials *For owner possible property tax credits	*Landfill tax *Reduced fees for contractors who recycle existing materials	*Incentives for using post-consumer materials in product ex. Collins & Aikman's Powebond ER3	* Landfill tax
Information Instruments	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certification scheme	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certification scheme	*Eco-labeling *Information campaign to explain certification and labeling schemes	*Certificati on scheme

SUMMARY AND CONCLUSIONS

In summary, waste minimization and resource conservation can be achieved by designing policy instruments that will help industries develop life cycle approaches to their products both in design for reuse, recycling, refurbishment and deconstruction. The carpet and flooring industry is a good example of how companies can design for the environment and be economically successful simultaneously, by reducing their consumption of virgin materials while developing technology to reuse their products. When designing policy instruments, utilizing the industrial ecology model will enable governing bodies to encourage that existing products will be diverted from the waste stream and become resources while new products will be designed to contain post-consumer materials as well as to be reused and recycled into new products in the future. Of course, policy instruments must target both the producer and consumer groups to ensure that all stakeholders are similarly motivated to make a material choice that will minimize waste and reduce resource consumption.

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Session 5

BUILDING PRODUCT SELECTION

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ABSTRACT

This paper is intended to provide a framework for discussion in *Workshop session 5*, and so responds to the OECD/IEA 'brief' fairly literally. This is quoted in eight parts, each of which are followed by a short comment, and then one or more diagrammatic explorations, focussing on building product selection.

Accordingly the paper begins with an exploration of the building product supply chain, and suggests that it is longer than the usual designer-supplier sequence. Next, the types of policy measures available are characterised and one of the measures – information – explored in a bit more detail.

Two stages of intervention are examined – the 'availability' and 'permitted' stages – for their impact on building product selection, and the opportunities for government intervention.

Then three actors in the process are considered from the same points of view – the public, contracts authors, and the standards/conformance infrastructure.

The problem of integration, or rather dis-integration, is examined from a couple of view points – building codes and levels of government, and a case study on PVC.

Finally, the 'what' and the 'how' of intervention are explored in some detail against the three themes of the workshop – energy, indoor air quality, and materials efficiency/waste. A common diagrammatic structure is used for each theme.

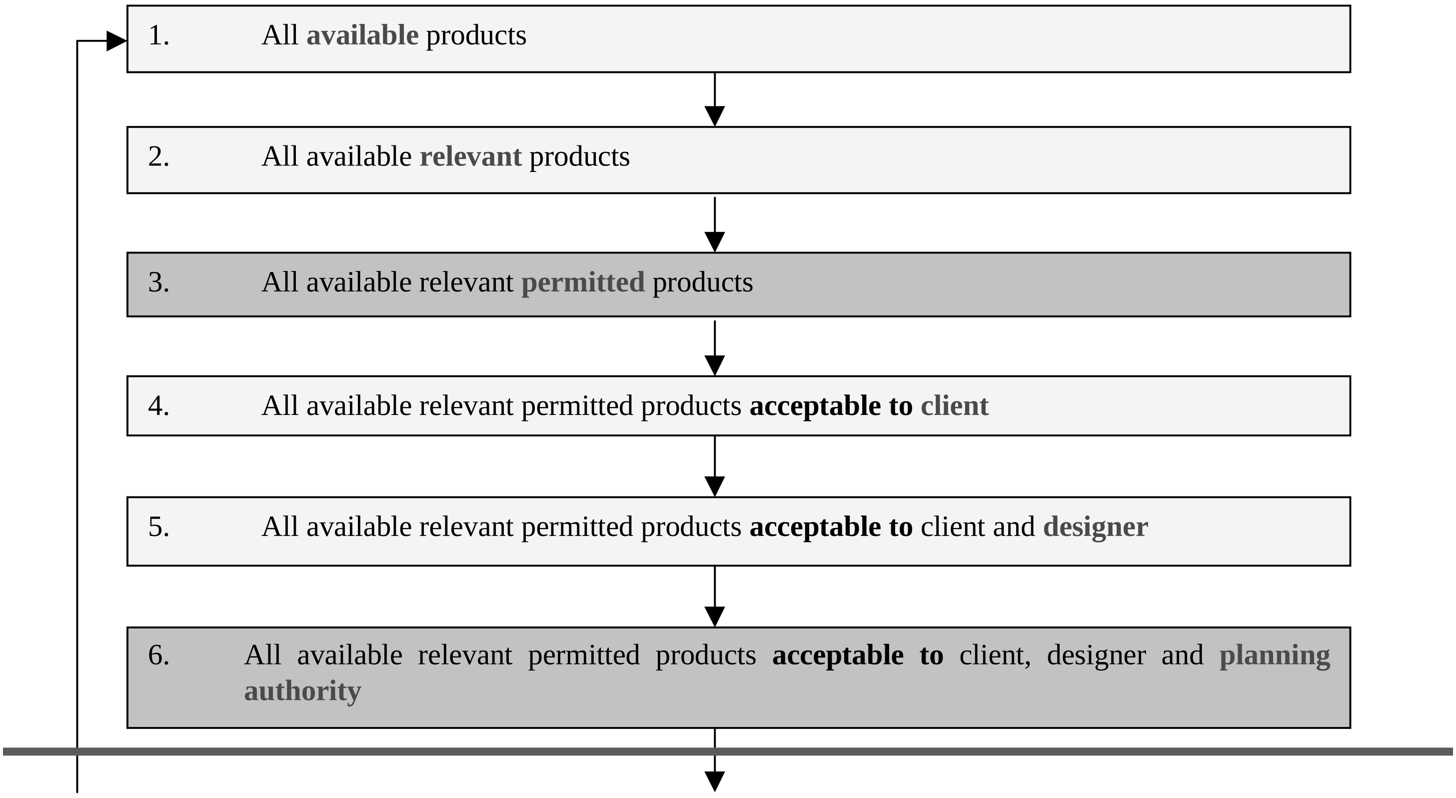
The building supply chain is long, taking in a variety of firms and users with very different characteristics.

The chain for selecting building products begins long before the project itself, with the manufacturers …

… and it ends with the occupants who, in this scheme of things, include facility managers, fitout contractors, demolition contractors - all those who have to work with the products selected.

There are two main phases - the public, and the private.

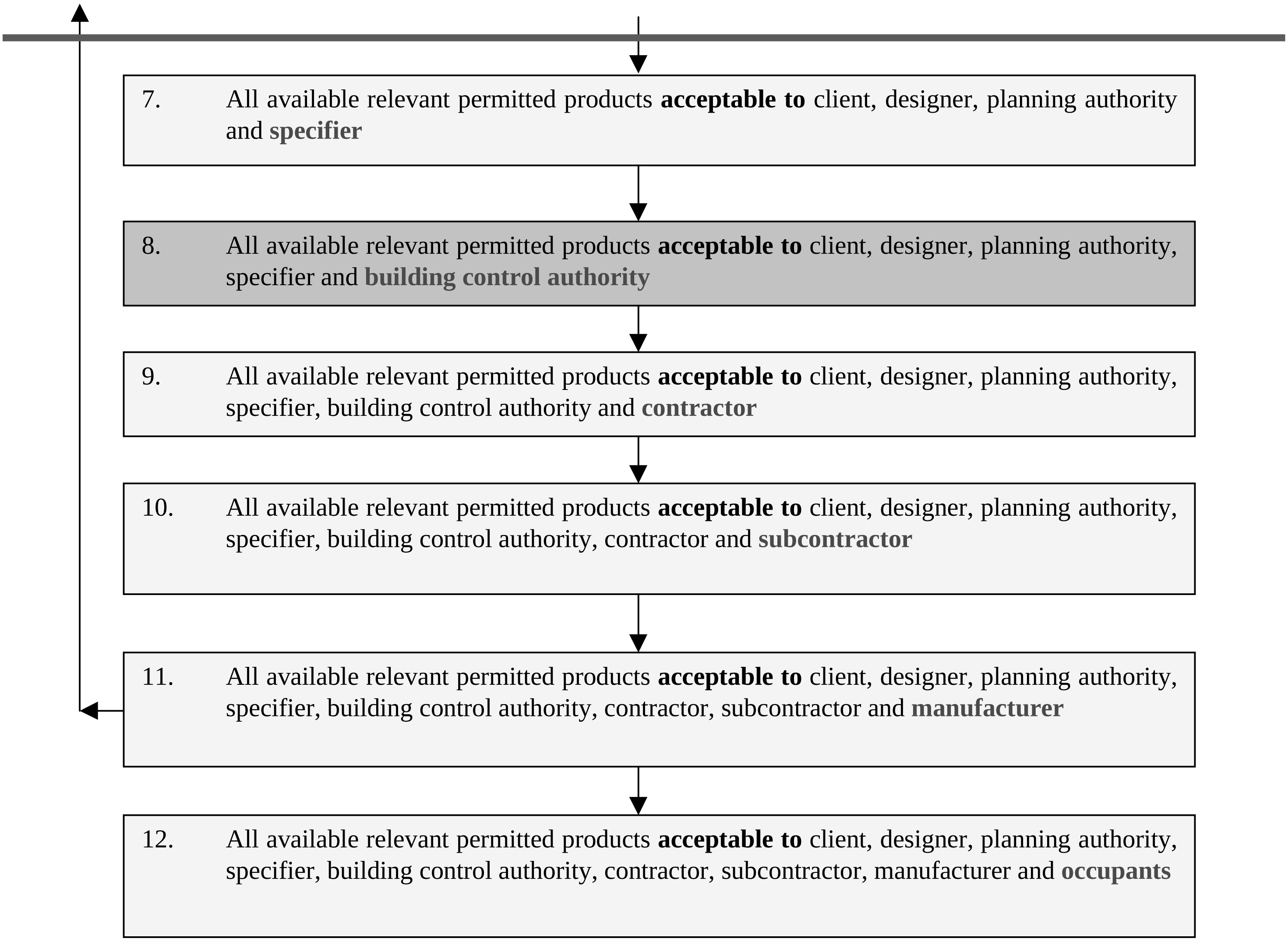
Figure 1. BUILDING PRODUCT SUPPLY CHAIN: PUBLIC PHASES



Source: Gelder, John, 1997a,. See also: Department of the Environment, Transport and the Regions, 2000.

The public can participate, and in some cases is expected to participate, in some of these phases. Decision makers at each phase should be cognizant of relevant issues arising at other phases. In particular, clients (in their briefs/programs) and designers should consider occupation and subsequent phases.

Figure 2. BUILDING PRODUCTS SUPPLY CHAIN: PRIVATE PHASES



Source: Gelder, John, 1997a.

Contrary to popular opinion, specifiers do not select or describe every product, nor do they describe every product such that no others can be used. Specifications are often quite open.

Building control authorities (and other regulatory agencies e.g. for fire and electrical systems) usually have at least two bites of the cherry – first when the plans are submitted for approval, second when the building is ready for occupation.

Occupants generally have no direct say in the products used, unless they equate to one of the entities further up the chain. But, their needs should have been considered.

In addition, various public policy measures affect the environmental characteristics of buildings.

The policy measures chosen depend on how strongly the government feels about the issue, and on how much it believes the private sector is ready, willing and able to deal with the issue by itself.

Table 1. GOVERNMENT PRODUCT INTERVENTIONS: INTENSITY VS TYPE

Intensity	Legal	Economic	Information	
			Active	Passive
Mandate-ban	● ● ● ●	Penalties		●
Encourage-discourage	Controls-limits	● ●	● ●	●
Leave to market				● ● ●

Product mandates/bans clearly rely on legal provisions, backed up by penalties for non-compliance, and making the Acts/regulations available. At the other extreme, leaving sustainability to the (responsible) market implies that, at most, government will provide passive information to assist the market make its decisions.

Accordingly, there is a wide variety of choices of policy instruments in terms not only of types of instruments (e.g. regulatory tools, economic instruments, etc.) …

Information is one of those instruments, and comes in many forms. What we do counts for at least as much as what we say.

Table 2. GOVERNMENT INFORMATION

Active information			Passive information
Information generation	Information application	Information dissemination	Information dissemination
Research and development. Think tanks.	Demonstration projects with industry e.g. M4I in the UK. Leading by example (do as I do) – green government projects.	Awards to projects, products. Awards to people. Advertising campaigns. Media releases. TV programs. Education.	Websites e.g. policies, links, legislation, advice, background information. Publications [ditto].

*The **acts** of passing sustainability laws, penalising polluters, rewarding good works, funding research in the private sector, and simply making information available, also serve as 'information'. Announcing these (media releases) is important.*

This characterisation of information, and of policies generally, could equally well be applied to other players in the construction sector e.g. professional institutes. The RIBA, for example, is proposing to 'green' its HQ at Portland Place.

See also: BRE Construction Insight, 2000; Ecocycle Council for the Building Sector, 1997; Gelder, John, 1998a GEN 23.

… but also in terms of stages of intervention (e.g. design and construction, use and refurbishment and demolition) …

The next example suggests possible government interventions at the ‘availability’ stage. Followed by a short list of building products controlled by legislation, at the ‘permitted’ stage.

Table 3. GREEN PRODUCT AVAILABILITY

Time of widespread use		**Place of manufacture**	
Past	**Future**	**There**	**Here**
Hemp	Alternatives to peat	Linoleum in Europe	But not in USA
Natural rubber	Safe refrigerants	Stainless steel in USA/Japan	But not in Australia
Natural turpentine	Plastics with renewable precursors	Bricks throughout Australia	But not in NT
Shellac	Arachnid fibres	Livos (etc) paints in Europe	But not in Australia
Lime mortar	Sea gel	TermiMesh in Australia	But not (much) in USA
Organic dyes	Safe gas flooding systems	Thatch in UK	But not in Australia

Interestingly, hemp pops up again later, under controlled substances. Many governments do not seem to believe that low-THC hemp is a realistic proposition. Some ‘past’ products are scarce in the wild, but could be farmed. Some ‘future’ products are becoming available now.

The inevitable eventual drying up of oil wells requires us to consider non-fossil precursors for many industrials, now. But some governments seem unwilling to see this.

Further information: Benjamin, Yorick et al., 1994; Gelder, John, 1998b PRO 11.

Examples of controlled (but not banned) construction products

antimony or antimony compounds
arsenic
asbestos (brown, blue and white).
barium salts
cadmium or cadmium compounds
calcium chloride admixtures
chlorofluorocarbons (CFCs) and HCFCs
chromates
creosote
formaldehyde
halogenated electrical cable insulation and sheathing
hemp
halons
lead or lead compounds
mahoganies (some)

mercury mildewcides/fungicides
mineral wools
organochlorine insecticides
organophosphate insecticides
peat and other mulches from non-sustainable sources
pentachlorophenol (PCP)
phthalate plasticisers
phosphogypsum
pitch and tar
polychlorinated biphenyls (PCBs)
polyvinyl chloride (PVC)
potting soil
rainforest timber species generally
selenium or selenium compounds
sulfur hexafluoride
tributyltin oxide
vermiculite
vinyl chloride monomer
volatile organic compounds (VOCs)

Source: Gelder, John, 1999.

These products are banned in some jurisdictions, controlled in others, and uncontrolled in others still. The list is of course much larger than this. It is unfortunate that many of the most useful products have turned out to be bad for the environment and/or our health e.g. asbestos, CFCs, organochlorines, halons, lead, mineral wools.

… and their targets (e.g. consumer, designer, material producer etc.).

There are very many entities involved. The following three are among those which are often overlooked - the public, authors of contracts, and developers of the standards and conformance infrastructure. All have an impact on products chosen, as well as other sustainability issues.

Table 4. ASSISTING PUBLIC INTERVENTIONS ON BUILDING PRODUCT SELECTION

Stage	Public interventions	Government contribution
Available	Lobbying manufacturers and their associations e.g. Greenpeace on PVC, led to PACIA's *Responsible Care*. Working with manufacturers to green up their processes e.g. Dow in USA. Disseminating information on available green products e.g. *EcoSpecifier* (Australia), *Batir Sain* (France).	Fund lobby groups. Fund information activities. Financial incentives for manufacturers to work with environmentalists.
Relevant	Disseminating information on applications for green products.	
Permit-ted	Lobbying government e.g. to ban lead, PVC for certain applications. Cost-benefit studies before passing laws e.g. BCA.	Build cost-benefit studies into law. Consult community when developing laws. Respond to lobbying e.g. NSW *Lead Reference Centre*.
Client	Lobbying clients e.g. Greenpeace/SOCOG alliance (Sydney Olympics), and their associations e.g. British Council for Offices' *Materials guide* (British Council for Offices, 2000)	Government as client, working with environmentalists. Financial incentives for clients to work with environmentalists.
Designer	Lobbying designers and their associations. Contributing to green information sources produced for designers e.g. authoring/sponsoring Notes in the BDP *Environment Design Guide* (Australia).	Government as designer, working with environmentalists. Financial incentives for designers to work with environmentalists.
Planning authority	Public consultation. Environmental impact studies. Lobbying government e.g. to include sustainability in planning reviews e.g. follow-on from Sydney Olympics, for Sydney at large.	Build public consultation, EIS into law for all projects over a certain size etc. Respond to lobbying e.g. build sustainability into planning law e.g. Leichhardt, NSW.

Government funding of lobby groups and information activities is a common assistance at al stages.

Table 5. SUSTAINABILITY IN CONSTRUCTION CONTRACTS

Topic	**Example clauses**									
	Dutch	**Sweden**	**UK**		**USA**		**Australia**			
	UAV 89	AB 92	JCT 98	ICE 93	AIA A201 97	EJCDC 90	AS 4000 90	JCC 94	PC-1 98	C21 96
Construction site H&S	6.16 16.1		20.1	18			12		8.16 8.17	24.3
Product default to 'new'					3.5.1	6.5	29.1	6.08.02	9.1	53.2
Waste ownership	19.3 21.1 21.2 21.3	8	16	70.1 70.2				10.04		
Methods	5.2				3.3.1	8.9		6.03		54
Site contaminants	5.8					4.5.1				
Environmental protection	5.8								8.20	25
Property protection			20.2	80.2 81.1	10.2	6.20	12			

Source: Gelder, John, 1999.

Some of these provisions are pro-sustainability (e.g. explicit environmental protection), some are anti (e.g. product default to 'new'). Some vary from contract to contract e.g. waste ownership, health & safety. Some Canadian contracts ban the sale of demolished materials from the building site, interfering with the economic viability of deconstruction. Users of contracts should watch out for these sorts of provisions.

Governments can influence the content of construction contracts in several ways:

laws governing contract content & interpretation;

interpretation of contracts in the courts (admittedly they are independent, but government can challenge non-green interpretations of contracts it is a party to – does property protection include environmental protection, for example);

participation in the drafting of national standard forms of contract (e.g. UAV in the Netherlands, AS 4000 in Australia); and

drafting of forms for the government's own use (which may well be the national standard forms).

Table 6. BUILDING PRODUCT DESCRIPTION AND CONFORMANCE

	Description	Example	Conformance
Product	Proprietary	Exhaust fans: XYZ Brand, model 15F.	Check packaging, labelling, iTags.
	Descriptive	Floor tiles: Linoleum, 600 x 600 mm, lime green.	Observation.
	Performance	Durability (minimum): 50 years.	Test (custom).
	Reference standard	Water efficiency: To ISO 1234-5.	Third party product certification e.g. Kitemark, ecolabel.
	Reference assessment	Partitions: Must have a current Agrement Certificate for this purpose.	Certificate from BBA (against UK building regulations).
Process	Environmental management systems	EMS: To BS EN ISO 14001:1996.	Audit.

Governments are unlikely to use proprietary descriptions in identifying products, either in law or in contracts. However, they might be included in government-sponsored information sources.
Use of EMSs is not going to deal with particular products and their properties. Even the processes described in a company's EMS may not be acceptably sustainable.

The ideal identification method for governments is generic standards, ideally ISO/IEC (to overcome WTO objections). On the environmental side, green considerations should be included in product standards. They rarely are at present. Rather, green issues are dealt with separately e.g. in special standards for water efficiency or energy efficiency. These standards do not usually provide a complete product description.

The more ways a product can be described, the better. Governments should encourage development of standards, particularly those incorporating green considerations. This can be achieved through subsidies to standards-producing agencies (for their secretarial function), financial aid (especially to consumer representatives) for attendance at standards meetings, particularly overseas, through participation in the *standardisation process, and by referencing current standards (too often old versions are cited in regulations).*

The other methods are in the hands of specifiers and manufacturers.

Conformance against standards is nowhere near as well developed as the standards themselves. Governments could do much to encourage take-up of third party product certification, and of ecolabelling in particular.

Moreover, it is widely argued that a more integrated approach is required to address environmental problems in the sector.

Government interventions can easily be dis-integrated across the many levels and agencies of government. In some cases, consistency is perhaps a more realistic goal than integration. Integration is possible, though.

Table 7. LEVEL OF GOVERNMENT: INTEGRATION OF BUILDING CONTROL

Level	Australia	USA	UK
International	Nordic Model	-	Nordic Model
National	Building Code of Australia 1996 – National provisions	International Building Code 2000 – Model code	-
Provincial	State appendices x 8	State codes x 50	Building regulations x 3
Local	Administration & by-laws	Local codes x 30 Administration & by-laws	Administration & by-laws

Australia used to be like the USA, with a national model code, but with compulsion added for adoption by the states, and no local codes to worry about.

Building codes have been a vehicle for protecting human safety and health, but could be extended to cover sustainability issues. Indeed, some do already e.g. energy-in-use (in USA, UK and some Australian states), durability (in NZ), toxicity (in UK).

Interational cooperation can generate models for regulations, such as the Nordic Model for performance-based building codes. OECD/IEA could assist with this sort of thing in the sustainability arena outside building codes.

A problem for OECD members is that building codes are administered at local (city, county) level. This has been tackled in different ways in different jurisdictions.

The USA, with 50 states, a prescriptive model code, non-metric units, and a history of non-cooperation (partly down to the right to freedom-of-speech), will have a problem achieving national (and international) consistency.

The UK, on the other hand, could easily tidy things up domestically, and in cooperation with Eire. In a similar vein, Australia has longterm plans to harmonise with NZ.

Table 8. PVC CASE STUDY: AN EXAMPLE OF DIS-INTEGRATED GOVERNMENT INTERVENTIONS

Decision chain	Examples of government intervention in the PVC life cycle (Australian)
Available	Tariff protection (much reduced) for plastics industry; precautionary principle enshrined in law
Relevant	
Permitted	Ban on use of asbestos (diaphragm process for rock salt electrolysis, floor tiles), industrial H&S and environmental controls for chlorine, ethylene, EDC & PVC manufacture; exposure standards for mercury (amalgam process for rock salt electrolysis), EDC and VCM & phthalates (all imported); residual VCM permitted in products; National Pollutant Inventory
Client	Water-supply authorities pushing for lead-free piping products [?]; supportive of PVC for functional reasons and for weight advantage [NSW Labor Council]
Designer	CSIRO study on PVC [sponsored by PACIA – industry]
Planning authority	OCA (Olympic Coordinating Authority) views on PVC [working with Greenpeace]
Specifier	Product Standards available (government participation on committees); WaterMark regulatory compliance scheme
Building control authority	Fire-resistant cabling (non-PVC) for certain applications (not in Building Code); fire properties generally e.g. spread of flame, smoke generation; Standard for fire performance of cables: PVC-U for light diffusers (UK)
Contractor	Collection service for waste PVC - Victoria only, and not very successful; cable recycling; costing policies for landfill (local government, costs understated); policy on incineration
Sub-contractor	
Manufacturer	Clean-up required at contaminated sites once involved in PVC & precursor manufacture
Occupants	

Source: Gelder, John, 1997b.

Some of these interventions might be characterised as pro-PVC, some as anti.

The purpose of [this session] is to discuss how governments should target the main points of their intervention …

We've looked at who should be targeted, now we look at what should be targeted.

The how is clear enough - encourage the more sustainable, discourage the less sustainable - but sometimes policies run counter to this.

… and co-ordinate policy instruments to establish environmentally effective and economically efficient policy packages.

In the long term, environmental sustainability equals social and economic sustainability. Efficiency should involve application of the Pareto Principle (the 80/20 rule).

Table 9. BUILDING PRODUCTS & ENERGY: 1

Value	**Embodied energy**	**Energy in use**	
		Consumption of energy	**Affect on consumption of energy**
Negative	Not possible	Produces energy e.g. *photovoltaics, solar water heaters, windmills, conservatories*	Reduces consumption e.g. *washing lines, thermal insulation, double glazing, light shelves, openable windows, thermal mass*
Zero	Extremely unlikely e.g. *sun-dried mud bricks use labour, transport*	Neither consumes nor produces i.e. *normal building fabric*	Neither increases nor reduces consumption (*probably few products are completely neutral*)
Positive	All products	Consumes energy e.g. *boilers, space heaters, fans, aircon units, tumble dryers*	Increases consumption e.g. *single glazed curtain walls, west-facing windows, thermal bridging*

Different products may have different values in different climates, in different energy-source (nuclear vs fossil) and transport regimes (canals vs roads), and so on.

A good example of a contrary policy is that of (seemingly) many US jurisdictions, which ban the use of clothes lines – forcing householders to rely on tumble dryers. Untidy windmills and solar water heaters can also be hard to get past the planners in some jurisdictions.

Table 10. BUILDING PRODUCTS & ENERGY: 2

Value	**Energy at end-of-life**	
	Consumption of energy	**Affect on consumption of energy**
Negative	Produces energy e.g. *wood waste & plastics disposed as fuels*	Reduces consumption e.g. *recycled aluminium reduces need for virgin aluminium*
Zero	Unlikely, except as nett	Neither increases nor reduces consumption (*probably few products are completely neutral*)
Positive	Consumes energy – most products i.e. *to demolish, recycle (esp. compound materials), dispose*	Increases consumption e.g. *downcycled concrete requires virgin reinforced concrete to be made*

Table 11. BUILDING PRODUCTS & INDOOR AIR POLLUTION

Value	**Indoor air pollution in use**	
	Production of indoor air pollutants	**Affect on production of indoor air pollutants**
Negative	Consumes/removes pollutants e.g. *exhaust fans, absorptive paints, filters, pot-plants, asbestos-cement encapsulation, bake out, catalytic conversion, natural light, radon sinks*	Reduces production/release e.g. *VOC-free paints & solvents, radiant heaters, timber flooring, CO monitors, controlled combustion heaters, products requiring aqueous cleaning, physical termite barriers, self-finished products*
Zero	Neither produces nor consumes pollutants i.e. *most building fabric*	Neither increases nor reduces production/release
Positive	Produces/releases pollutants e.g. *photocopiers, urea formaldehyde foams, VOC-containing paints & solvents, wood/fossil-burning heaters, mould, plasticised PVC*	Increases production/release e.g. *carpets (dust mites etc), unflued gas fires, dampness, products requiring chemical cleaners or vacuuming*

Indoor air pollution (during use) is only part of the picture. Embodied pollution – pollution (outdoor air, water, soil) generated during product manufacture, transport etc. – could also be considered, as could end-of-life pollution e.g. most products will create pollutants (uncontrolled wastes) in their demolition/reuse/disposal.

Table 12. BUILDING PRODUCTS & RESOURCE EFFICIENCY: 1

Value	**Embodied waste**	**Resource efficiency in construction & use**	
		Waste creation - use	**Affect on waste creation - design**
Negative	Recycled content materials e.g. *stainless steel, glass fibre insulation, some plastics products* Complete use of renewables *e.g. trees - solid timber, compound timber products, fuel*	Uses waste e.g. *composting toilets, reed beds, methane-based power*	Reduces creation of waste e.g. *use of modular design for modular materials, just-right servicing, water-efficient products*
Zero	Unlikely, except as nett	Neither uses nor produces waste e.g. *normal building fabric*	Neither reduces nor increases creation of waste
Positive	Mineral extraction e.g. *materials discarded after metals extraction and processing*	Produces waste e.g. *conventional sanitary services, paper-handling equipment, food-handling equipment*	Increases creation of waste e.g. *avoidance of modular design for modular materials; oversizing of components, oversupply of equipment (built-in waste)*

Embodied waste (extraction, manufacture, transport) varies between localities – for example, some have more advanced recycling e.g. of plastics.

Prescriptive building codes in the US mean that unusual sustainable types of construction (rammed earth, straw bales) can be rejected by conservative authorities. The more adventurous have produced code supplements specifically to allow these constructions.

Oversupply of building services equipment is a common finding of studies into building services in the UK (e.g. PROBE).

Table 13. BUILDING PRODUCTS & RESOURCE EFFICIENCY: 2

Value	**Resource efficiency at end-of-life**	
	Waste creation	**Affect on waste creation**
Negative	Recycling e.g. *steel beams, doors, antique fireplaces* Downcycling e.g. *in situ concrete, PVCs, crushed brick, carpet tiles*	Reduces creation of waste e.g. *screwed/bolted jointing/fastening, lime mortars, dis-assemblable equipment, durable products*
Zero	Neither uses nor produces waste	Neither reduces nor increases creation of waste
Positive	Produces waste e.g. *plasterboard, compound products, old technology equipment, asbestos, CFCs*	Increases creation of waste e.g. *glued/welded jointing/fastening, cement mortars, bonded multi-material products*

Modern masonry codes have required cement mortars for strength. Fortunately, this is now changing.

Houses built using traditional joinery techniques in Japan are often being demolished, rather than deconstructed as intended, for economic reasons. These days, Japan can afford to buy in more wood. For a nation traditionally socially attuned to minimising waste (hence TQM), this sort of change is disconcerting.

Being wealthy can be bad for the environment!

Finis.

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Session 6

SUSTAINABILITY INDICATORS AND POLICY MONITORING

by Pekka **Huovila**

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CRISP (2001) is a EC-funded Thematic Network whose main objective is to create a group dynamic in the field of Construction and City Related Sustainability Indicators. The Network aims to co-ordinate current research work defining and validating such indicators and implementing them to measure the sustainability of construction projects (buildings and built environment) in cities. CRISP, in its objectives, has drawn its inspiration from the international CIBW082 (2001) project "Sustainable development and the future of construction" (Bourdeau et al., 1998). This study concluded: "the next step should be to reach a more consensus vision through a global common model and to set up indicators and policies to translate this vision into reality".

CRISP gathers together the work of a carefully selected set of 24 skilled teams that bring to the Network the results achieved in a wide range of national and international projects in this field from across the breadth of Europe. In each participating country, covering widely the European dimension, the team members are developing and implementing the principles of sustainable development to the city and construction sectors. The CRISP network is led by CSTB and VTT, respectively the French and Finnish building research institutes.

This paper describes the objectives and current status of the Thematic Network collecting and validating urban, building and product level sustainability indicators, and process and strategy indicators. The paper discusses how these indicators can be used for monitoring policies.

Problems to be solved

The Sustainable Construction concept aims at the creation and responsible management of a healthy built environment based on resource efficient and ecological principles. It takes account of environmental and life quality issues, social equity and cultural issues, and economic constraints.

Sustainability indicators constitute one of the bottlenecks in moving towards more sustainable construction and cities. Indicators are needed to precisely define sustainability criteria and to measure the performance of the construction industry and the built environment. Decision-makers and policy-makers need indicators to evaluate economically viable and technically feasible strategies to improve the quality of life, whilst at the same time increasing resource use efficiency. Numerous actors in the construction and development process need tools and guidelines based on indicators to improve current practices and the quality of construction.

Approach

The main activities of the Network are:

- to define a framework and general methodology for construction and city related sustainability indicators,
- to stimulate and co-ordinate the development of such indicators,
- to gather and organise indicators within a database including information on validation, testing, criteria of use…
- and to widely disseminate the results of the research carried out.

Four sub-areas are addressed by four teams or clusters: the product cluster, the building cluster, the urban blocks cluster and the process/strategy cluster. The three first ones deal with different geographic scales and the related actors and concerns. The process/strategy cluster deals with the performance of organisations, environmental management, decision-making processes, policy measures, etc., in brief organisational aspects.

CRISP structure with focused expert clusters

In order to facilitate the use and uptake of these indicators, dissemination will take place through a Newsletter and an active Website developed to be useful to the needs of the end-users. Regular conferences and meetings will conduct discussions with a range of different target groups.

Definitions and examples

An indicator can be presented as a synthetic variable, giving indications, describing or measuring the state of phenomenon or a situation. Indicators reflect cause-to-effect relationship between an action and its consequences. Indicators can also be presented as conceptual tools, expressed in clear and precise terms measuring progress towards the objective, providing a measurement unit through which modelling and monitoring can be conducted.

An indicator must be relevant and effective. Some of them may present an aggregation of sub-indicators. An indicator has to meet requirements such as relevance, sensibility, objectivity, measurability, accessibility or readability. Characteristics of an appropriate and effective indicator include the following: relevant to specific project or program, clear linkage to a goal and objective, understandable for project team and community, focused on a long range view, based on reliable information, measurable by a standard method, based on existing and accessible appropriate data.

Generally, indicators are organised in systems or sets of indicators, like e.g.:

- the United Nations working list of indicators of sustainable development,
- the OECD core set of environmental indicators, applied in numerous countries,
- international frameworks as Green Building Challenge (GBC, led by Canada),
- the European project RESPECT involving communities,
- national environmental assessment tools as BREEAM in UK (developed for different types of buildings, having spread in some other countries),

- indicators linked to various approaches : Life Cycle Analysis, Eco-efficiency, or more generally:

    - public statistics,
    - indicators included in guidelines for sustainable construction or cities,
    - monitoring tools used by ministries or public bodies,
    - consensus-based and promising sets of indicators that contribute to pre-standardisation works,
    - research tools, developing new concepts.

Indicators may be connected to various typologies of indicators, for instance: Pressure - State - Response OECD model, Driving force - Pressure - State - Impact - Response EEA framework (European Environment Agency).

In order to illustrate, population growth is a driving force indicator, release of CO_2 emissions is a pressure indicator, concentration of harmful substances relates to the state of environment, specific governmental measures are responses for a more sustainable development.

CRISP will document in a database both systems of indicators and indicators themselves.

The CRISP Network

The CRISP Network covers 16 countries. CRISP is led by 2 main partners: CSTB (Centre Scientifique et Technique du Bâtiment, France), the Network Co-ordinator, and VTT Building and Transport (Finland).

CRISP Members:

1	**Austria** (2)	Austrian Institute for Applied Ecology, TUW
2	**Belgium** (3)	Centrum Duurzaam Bouwen, CSTC, Energié-Cités
3	**Denmark**	SBI
4	**Finland**	VTT Building and Transport
5	**France** (2)	CSTB, La Calade
6	**Germany**	FhG/IBP
7	**Greece**	Aristotle University of Thessaloniki
8	**Hungary**	EMI
9	**Ireland**	Dublin Institute of Technology
10	**Italy**	Università di Firenze
11	**the Netherlands** (2)	TNO-Bouw, W/E Consultants
12	**Norway**	Byggforsk
13	**Romania**	Urbanproiekt
14	**Spain**	UPC
15	**Sweden** (2)	Chalmers, University of Gävle
16	**United Kingdom** (3)	BRE, BSRIA, University of Salford
	total (24)	

Status of work

The network was kicked off in June 2000 in France. The first task was to exchange information on the on-going projects in that field, to launch the state-of-the-art reporting task and to discuss the indicator framework (the starting point for the indicators framework was taken from the known international classifications or lists).

Then the countries involved submitted state-of-the-art reports and built end-users groups. Until now, we have collected almost 400 names of different types of end-users. A Web site was set up, which will be fed all along the project. Preliminary works and discussions dealt with the framework and methodology for collecting existing indicators and the preparation of the first workshop.

A CRISP indicator data sheet was designed in order to welcome any kind of sustainability indicator. This data sheet has been tested through examples at different scales: product, building, urban area. The present data sheet includes various features, as definition, objectives, implementation method, type, category, users and phase concerned, restrictions precautions of use, references, previous uses, and also CRISP comments. A first version of the CRISP indicator database will be available in the course of the second half of 2001, after a first round of collection of indicators.

CRISP Indicator Data Sheet

Name of Indicator or Index:	
Description:	
Unit(s):	
Method of Measurement:	
SD Category:	☐ environmental ☐ economic ☐ social ☐ institutional
Construction Category:	☐ urban ☐ infrastructure ☐ buildings ☐ products ☐ process
Indicator Type:	☐ performance ☐ efficiency ☐ descriptive
Users:	☐ planners ☐ owners ☐ desigers ☐ contractors ☐ producers ☐ facility managers ☐ users and inhabitants ☐ NGOs ☒ public bodies
Process Phase:	☐ planning ☐ property development ☐ design ☐ construction ☐ operation ☐ demolition ☐ disposal
Objective:	☐ diagnosis ☐ monitoring ☐ assessment ☐ design
Scope:	☐ global ☐ national ☐ regional ☐ local ☐ N/A
System or Set of Indicators:	
References:	

Expected impacts and benefits

CRISP aims to develop and validate harmonised criteria and identify relevant and efficient indicators to measure the sustainability of construction projects particularly within the urban built environment. Through the range of indicators which will be dealt with, the project will contribute to improve the quality of life in urban communities and to promote sustainable development assessed in economical, environmental, social, cultural and institutional terms. Challenges which will be considered through the indicators are for instance linked to the preservation of natural resources, air quality, noise, health and safety, waste, economic competitiveness, employment, deterioration of infrastructure, urban sustainability, environmental loads of construction, socio-cultural aspects etc.

Other impacts include also better co-ordination of the development of sustainability indicators for construction and cities, improved consensus on the indicators available and on the criteria of their use, better understanding and application of these indicators by relevant end-users such as planners, developers, designers, standardisation bodies, authorities, contractors and materials producers ; also in certain cases inhabitants and citizens. These end-users will benefit greatly from an authoritative, relevant and agreed source of information on indicators. It will enable them to develop more appropriate performance targets, tools and standards in order to improve the level of sustainability of the built environment. At the urban or suburban level, it is also a mean to increase governance and local democracy.

The interest and questions of end-users may be very diversified, for instance:

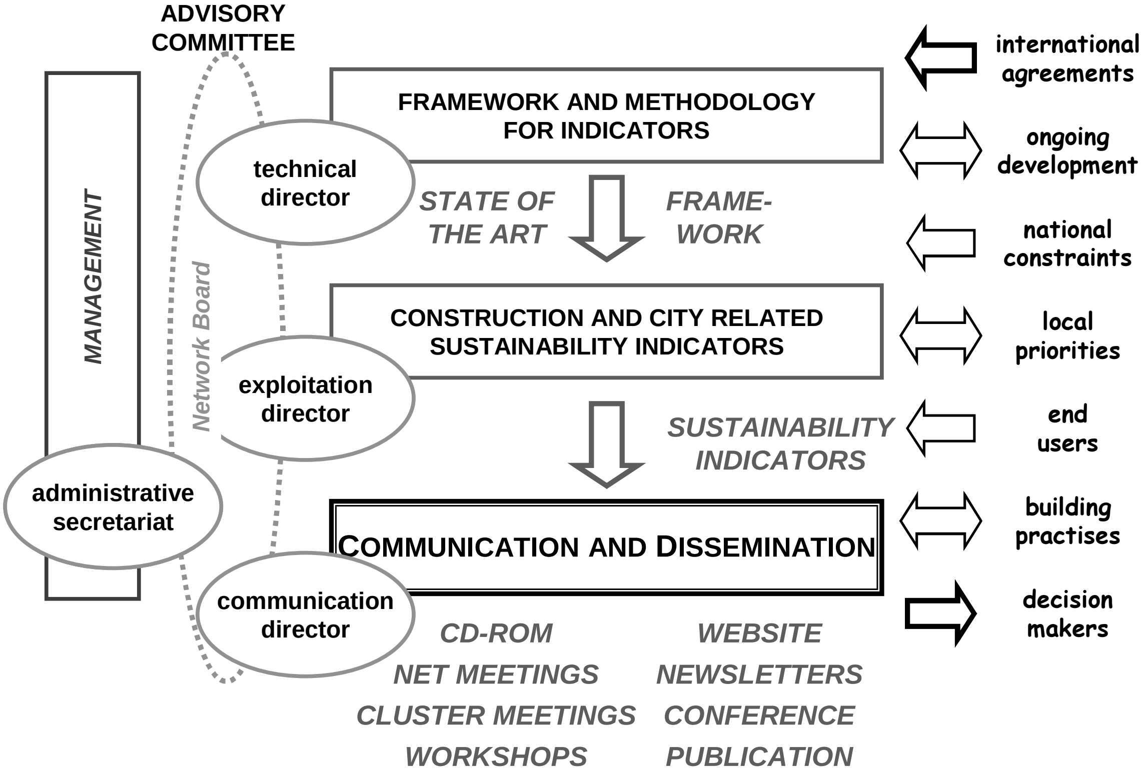
- What are the indicators the most frequently used in Europe, the most consensus-based, internationally recognised, for buildings or cities?
- How to determine if a building product is more or less sustainable than another product or reference (minimum or target)?
- What are the previous uses of such indicator set, its precautions of use, its implementation method?
- What sets of indicators I can use for comparison with other buildings or cities?
- What kind of indicator set can help me in the dilemma "to refurbish or to demolish"?
- How to measure and follow the trends of a neighbourhood in terms of sustainable development criteria, so as to be able to react properly?
- What are the "driving force" indicators (human activities, processes and patterns that influence sustainable development) I need to take account of?
- What are the relevant indicators that enable a company or body to assess its organisation and actions in terms of sustainability performance?

The CRISP deliverables have to meet these various requirements.

The CRISP Organisation

The CRISP Network Board comprises 4 members : the Co-ordinator Luc Bourdeau (CSTB), the Technical Director Tarja Hakkinen (VTT), the Exploitation Director Pekka Huovila (VTT) and the Communication Director Sylviane Nibel (CSTB).

An Advisory Committee, including representatives of other related European Networks and representatives of the main end-users advises the Board about the high level managing issues, the scientific aspects, the contents of the deliverables and more generally all the activities of the Network.



CRISP networking process organisation

In addition, the planned networking process includes active interaction with local end-users taking into account ongoing development, national constraints, local priorities and building practices.

CRISP is developing close links with 2 other major current EU projects dealing with sustainability, PRESCO (practical recommendations for sustainable construction) (http://go.to/presco.net) and SUREURO (sustainable refurbishment in Europe) (http://www.sureuro.com/), through informal contacts, cross participation in different meetings, and more formally through their Advisory or Steering Committees.

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