UNEP-SBCI TASK FORCE ON GREENING THE BUILDINGS SUPPLY CHAIN

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UNEP-SBCI Task Force on Greening the Building Supply Chain
Noel Morrin, SKANSKA (Co-Chair)
Arab Hoballah, Chief- Sustainable Consumption and Production, UNEP (Co-Chair)
Martha Delgado, Secretariat-Global Cities Covenant on Climate
Pascal Eveillard, Saint-Gobain
Peter Graham, Global Buildings Performance Network
Jane Henley, World Green Building Council
Chris Jofeh, ARUP
Torsten Kleiss, Siemens
Rodney Milford, Construction Industry Development Board- South Africa
Maria Salette, Brazil Ministry of Cities
Kevin Stelzer, B+H Architects
John Tracey-White, Royal Institution for Chartered Surveyors
Constant Van Aerschot, Business Council for Sustainable Development Singapore
Ike Van Der Putte, FIDIC
Xudong Yang, Tsinghua University
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EXECUTIVE SUMMARY

It is well understood that the building sector causes major environmental impacts and that reducing these is an imperative for sustainable development. Unfortunately the building sector is highly fragmented, and the supply chains that form to facilitate building activity often consist of many parties with differing objectives. The buildings sector supply chain is a complex network of manufacturers, suppliers, vendors and users through which our built environment is constructed, maintained, renovated and demolished. Rarely can any one of these actors take direct responsibility for environmental protection, resource efficiency, minimising life-cycle costs and overall supply chain efficiency. As such, the supply chain is responsible for high levels of energy consumption, carbon emissions, water use and waste generation. There are many benefits to be derived from greening the elements of the supply chain and there are many best practice cases showing there is considerable potential for improving its overall environmental performance.

There are several potential intervention points to green the supply chain, leading to greater resource efficiency and better environmental performance. Appropriate interventions can lead to significant reductions in energy consumption, carbon emissions, water use and waste generation, as well as improvements of co-benefits through more sustainable patterns of consumption and production.

Motivated by the unrealised resource efficiency potential within the building supply chain, the UNEP- Sustainable Buildings Climate Initiative (UNEP-SBCI) established a special Task Force with the main objective to identify initial opportunities for achieving greater resource efficiency in the building sector supply chain and provide recommendations to UNEP-SBCI in relation to developing this topic in more depth in future UNEP-SBCI activities. More broadly, the recommendations could support the Sustainable Buildings and Construction Programme being developed under the 10-Year Framework of Programmes on Sustainable Consumption and Production, adopted by member states at the 0212 UN Conference on Sustainable Development in Rio de Janiero (Rio+20).

This report from the Task Force provides recommendations for developing a work programme under the auspices of UNEP-SBCI to green the building sector supply chain by focussing on five key criteria: energy, carbon, water, materials and waste. The report addresses environmental performance measurement, and barriers and opportunities to enhance supply chain operation, as well as identifying best practices using international case studies.

There is the need for better information and understanding of the building supply chain and factors that influence its environmental performance. There are a lack of proven models available to assist with understanding and documenting opportunities to green the overall supply chain. While the opportunities exist, there is a lack of awareness of the benefits from greening the supply chain amongst the key stakeholders. The key recommendations from the Task Force for future project work that could be undertaken by the UNEP-SBCI to embark on the next phase of work are therefore to:

- Develop more specific information and documentation on mapping the buildings sector supply chain;
- Measure and document the impact of a green building and construction supply chain;
- Develop business models and recommendations for incentives for ambitious service level agreements and documentation of performance for actual facilities;
- Educate and build the capacity that would enable and empower professionals within the industry to green supply chains according to long-term goals;
- Develop more specific information and documentation on mapping the supply chain for different building types in different regions and identify the key leverage points. i.e. where in the supply chain greening efforts can be made and influenced by the right policies and programmes (e.g. eco labelling of materials);
- Support government through information sharing and advice to develop policies that drive or influence supply chain efficiency with planning, regulations, codes, standards and targets;
- Develop key indicators on the impact (economic, social and environmental) of a green building and construction supply chain;
- Following the developing of the indicators, measure and document the impact (economic, social and environmental) of a green building and construction supply chain;
- Carry out more research on how building developers/contractors can promote Energy Management Systems and other techniques to improve efficiency within the supply chain companies themselves; and
- Support the scale-up or adoption of policy or market mechanisms such as eco labelling and incentives that would convince building developers/contractors to buy products and material from more sustainable manufacturers and suppliers¹.

**Background**

The United Nations Environmental Programme – Sustainable Buildings Climate Initiative (UNEP-SBCI) wants to achieve greater energy and resource efficiency in the building sector, including throughout its supply chain. This work is part of UNEP’s effort to promote a green economy. UNEP defines a green economy as one that results in “improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.”²

UNEP-SBCI has focused on promoting policies and practices for sustainable buildings since its inception in 2006, with clear goals to reduce energy consumption and greenhouse gas (GHG) emissions from buildings. The work has resulted in numerous publications, including baseline emissions reports as well as the provision of tools. The latter include the ‘Quick Scan Policy Tool’ to help governments assess existing policies and identifying gaps, and the Common Carbon Metric (CCM), a tool and protocol to measure energy consumption and report GHG emissions from building operations.

**Objectives of Report**

This report summarises the work of the Task Force on Greening the Building Supply Chain. The Task Force members come both from within UNEP-SBCI and from organizations that are involved in different aspects of the buildings construction industry. The objectives of this report are to provide insights from task-force members on how to green the buildings sector supply chain. It considers the recent literature together with case studies and building sector analysis relating to the supply chain for building construction; to better understand current issues, such as resource use, and construction and demolition waste; to consider performance measurement, and barriers and opportunities to enhance supply chain operation; to identify best practices using comparative international case studies. This report considers five key green criteria: energy, carbon, water, materials and waste. For these criteria the focus for this report will be restricted to environmental concerns.

The report is intended to highlight gaps in knowledge and information availability, and propose a possible work programme that would provide more targeted and accurate information.

The main sources of information sources of information for this report are:

- Information and data contributed by the Task Force members. This material also included case study summaries;
- A Literature review investigating current research and activities in greening the building sector supply chain. This study researched the broader topic of greening supply chains and investigated sub-topics such as, green procurement of building materials and products, sustainability and supply chain principles, greening the commercial building sector and materials and waste in the building construction industry.

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¹ Similar studies have been done on Sustainable Public Procurement (e.g. Perera et al. 2007, and ICLEI, 2007
² Ibid, p.16.
INTRODUCTION

Growing global concern about the rapid rate of consumption of natural resources, and the impact of waste on the planet’s ecosystems, has led the drive to more careful use of all resources. There is growing awareness for the need for a more comprehensive approach to resource efficiency. Yet the trend is not encouraging. The tremendous growth in technology and increasing wealth in the OECD countries and the rapid rise of Brazil, India and China have also led to the unsustainable exploitation and degradation of the resources and ecosystems upon which all species, including human, depend. Globally, we are consuming resources, both renewable and non-renewable at unsustainable levels.

The buildings sector is a key area for attention because it is a highly resource intensive industry. The facts are:

- The buildings sector is responsible for more than a third of global resource consumption annually (considering all resource inputs);
- The buildings sector is responsible for more than a third of global energy consumption;
- The buildings sector is responsible for 12% of all fresh water use;
- The manufacture of buildings materials consumes about 10% of global energy supply; and
- Buildings construction and demolition waste contribute about 40% of solid waste streams in developed countries.3

Lowering these impacts is a major challenge that must be addressed.

To date, considerable attention has focused on the energy and environmental performance of buildings during their operation. However, the concern should be broadened to consider the entire supply chain because the pre-construction, construction and demolition phases of the building life cycle also offer significant opportunities to improve performance. Embedding greater resource efficiency throughout the entire construction industry supply chain can result in considerable reductions in resource use as well as environmental impacts.

The building sector supply chain is structurally complex involving many actors. The actions of owners and buyers, architects, contractors, materials producers and providers, procurement requirements, transport logistics, and many others influence overall environmental performance. The UNEP Green Economy Report states that the building value chain “includes the manufacturing of material supplies, the construction process, building operation and maintenance as well as the disposal, recycling, or reuse of building, operations, construction, and demolition waste.”4 They represent a wide range of suppliers providing many different services throughout the supply chain including materials, labour, and equipment such as heating and cooling systems, controls and lighting. There are also other areas including landscaping, plants, access roads, transport, etc.

There are several intervention points in the chain, which could be brought to bear to affect greater resource efficiency and fewer adverse impacts. The chain and intervention points are shown in the figure2 on page 10. It is possible to achieve significant reductions in energy consumption, GHG emissions, water use and waste generation by making appropriate decisions at each of these intervention points.

A GREEN STRATEGY IN THE BUILDING SUPPLY CHAIN

This initiative focuses on the supply chain responsible for constructing, maintaining, renovating and demolishing buildings. It therefore focuses less on the static features of a building and more on the design of its production system or supply chain. The UNEP SBCI Task-Force’s objective is to identify strategies for reducing the total environmental impact

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4 Ibid. p. 353.
of the building supply chain and identify significant opportunities for improving resource efficiency. Common aims such as minimising the use of non-renewable materials, improving recycling rates, and use of materials with greater recycled content are often cited as important goals for green building, but when tackling these issues from a supply chain perspective, trade-offs between various options and stakeholders need to be considered. Integrated supply chain management is therefore necessary.

Supply Chain Management (SCM) initiatives have been common in the building sector for more than thirty years and have been applied to reduce the environmental impact of construction through the concept of “lean construction”. Lean construction aims to redesign production systems to minimise the environmental harm caused by building activity while improving time internal and external efficiency, removing adversarial purchaser-supplier relationships and add value across the entire supply chain. Lean construction emphasises eliminating process and material wastes, and thus complements life-cycle approaches to building and building product design.

Many organisations are already introducing sustainability criteria into part or all of their supply chain management processes and there is a high level of awareness of the commercial opportunities. For example, a recent survey of more than 700 members of the United Nations Global Compact on sustainable business practices found 96% of CEOs thought that sustainability should be integrated into all aspects of strategy and operations and 88% of them singled out the supply chain as an area of specific importance. This highlights the growing awareness of the need for establishing initiatives to reduce the significant environmental impacts of the construction industry through supply chain management.

**Green Criteria**

A focus on the supply chain not only has potential environmental benefits, but also helps to integrate environmental consideration into core business decision-making. However, given the complexity of the building sector the Task Force recommends that UNEP focus on five key environmental performance criteria: energy, carbon, water, materials and waste. These have been selected because they not only represent the main impact categories for the environmental performance of buildings, they align well with the criteria used in popular environmental performance rating schemes (many of which are used as proxy standards in building procurement).

**Energy, GHG emissions and Water**

The requirements for energy, carbon and water in the sector are high. The buildings sector is responsible for more than one-third of global energy consumption and about 30% of global energy-related GHG emissions. This is direct energy consumption and would be higher if the entire supply chain were included, in part through the inclusion of embodied energy in materials and equipment. The energy embodied in building materials is equivalent to about ten years of operational energy. Recurring embodied energy, the energy embodied in materials that are added to the building through maintenance and refurbishment over its life cycle can also be significant. An Australian study of the life cycle embodied energy of a Melbourne office building found that, over a projected 40-year period, embodied energy accounted for 60% of the building’s total energy requirements due to retrofitting and maintenance.

Buildings are responsible for between eight and 16 per cent of global freshwater consumption and in urban areas, they generate approximately 20 per cent of wastewater production. Most calculations exclude water required for electricity production and manufacturing building materials. Freshwater use in buildings is in turn responsible for two to three per cent of world energy consumption, predominantly for pumping and treatment.

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5 Ahuja 2013
7 The Emissions Gap Report 2012 – Bridging the Emissions Gap, UNEP p32
Building-related water use is estimated at 12 per cent in Mexico, the United States and Canada. However, there are significant regional variations depending on the level of urbanization in a country and the size of its agricultural and industrial base. Building-related water use in Singapore, for example, has been estimated at 53 per cent. Most Indian cities rely heavily on groundwater for use in buildings where ground-water levels are projected to drop well below the international benchmark for water stress of 1700m³/person/year by 2030.

**Materials and Waste**

Building materials represent about half of all types of materials used for all purposes, and about 40% the solid waste generated worldwide. Building materials have important environmental impacts, including the potential to increase air and water pollution across the production chain (i.e. extraction, processing, transportation and installation).

Construction waste consists of unused material produced directly or incidentally by the construction phase itself or from the industries producing the construction materials. Construction and demolition waste constitutes a significant proportion of solid waste streams in many countries. For example, in Australia C & D waste constitutes up to 40% of the urban solid waste stream disposed at landfill sites while in Singapore it comprises between 10% and 20%, and in the US around 33%. The construction and demolition sector is responsible for about one-third of all waste in the UK – 120 million tonnes of waste every year. The UK Government’s 2008 Strategy for Sustainable Construction found that over 25 million tonnes of construction, demolition and excavation waste ends up in landfill every year. Although considerable variability of waste exists amongst construction sites, there is much opportunity for reducing this waste. The building industry can therefore play a major role in trying to reduce solid waste and reduce the need to take up space for landfills.

Solid waste is generated both during building construction and demolition. The highest proportion of solid waste by weight is normally made up of materials such as bricks and concrete, while by volume packaging and timber are major components. In many markets there is a high rate of recycling for ferrous and non-ferrous metals and these are typically diverted from land-fill.

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12 (CEC, 2007)
13 U.S. Department of Commerce (2000) National Trade Data Bank, November
17 http://www.ukgbc.org/content/waste
Supply chain
A supply chain is a system of organisations, people, activities, information, and resources involved in moving a product or service from supplier to customer. This includes all the materials needed for the buildings sector. Greening the supply chain includes interventions at all points along that chain. The different green supply chain initiatives are a means to achieving energy savings and GHG reductions, among a number of disparate businesses, in some or all parts of the supply chain.

Construction is a complex, multi-organisation process typically involving the client/owner, designer, contractor, supplier, consultants and other stakeholders. It is also a multi-stage process, which includes conceptual activities design, construction, maintenance, replacement, and even decommissioning. The following two diagrams provide the relationships in the buildings supply chain (Figure 1 & 2).

![Diagram of Supply Chain](image)

**Figure 1: Players and Practices in the Buildings Market**
Source: WBCSD, Energy Efficiency in Buildings, Facts & Trends, p. 32

The required interventions points, elements to be considered at each stage and the green criteria can be illustrated in the form of the flow diagram below which looks at the supply chain somewhat differently than Figure 1 above.

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Figure 2 identifies the potential intervention points within the building project life cycle and material supply, and which can be addressed against the five criteria used throughout this report and described in the previous section: energy, carbon, materials, water and waste. The diagram helps to better understand where the potential barriers and challenges at a policy level are and to provide a framework for the Task Force to further develop its work in this area.

The three first interventions – Inception, Design/contract and Specifications – impact on the entire supply chain and thus are key to its greening. During the construction phase the objective is to minimise the impact of construction and carry out the “green” design. It is at the construction phase that materials play a key role. The last interventions include Site Management, Operations and Maintenance and Demolition aim at improving the environmental performance over time. These interventions will be looked in greater detail to better understand the potential green interventions to the building supply chain.

The information/services flow is illustrated in the horizontal axis as the building project Life Cycle. The material/resources flow is represented as the vertical axis, known as the material supply chain; both intersecting at the point of site, essentially creating a building as an end product. Both information and material flows would, in fact, continue to extend beyond the first point of intersection signifying the post-construction phases of the building life cycle.

Demolition waste includes much solid waste and it is an important phase where green interventions could take place. Planning for the eventual demolition can bring many benefits although it also entails complexity and additional costs.
Designing for adaptability and disassembly offers the possibility for building owners – particularly of commercial buildings, since they are often demolished sooner – to act as stock materials for future construction and minimise the loss of materials during renovations and disassembly. In Figure 2, the arrow that goes from the demolition phase to material extraction represents the link between these two phases and how the building supply chain could be considered as a closed cycle.

**Points of influence in the building life cycle**

- **Inception**
  The main stakeholders involved in this stage often include developers, financiers and investors, and government authorities. At the inception stage decisions are taken over what the function is, where it should be located and how it is to be financed. Performance requirements are to be considered at this early stage following the minimum requirements of building codes. Goal setting should include sustainability criteria.

- **Preliminary Design and Design Specifications**
  The concept of Integrated Design Process, essential for achieving standards of sustainability and energy efficiency in architecture, suggests that the process should evolve from a traditional model where the architect takes all the key decisions to a model where many professionals are involved from the very beginning of the project and work collaboratively.\(^\text{19}\)

  The Integrated Design Process is the implementation of a methodology or a decision making process that would help to achieve sustainable buildings. It integrates innovative processes and eco-efficiency by using sustainable design tools, principles of economy of resources and human and ecological design principles. In parallel, it also considers the life-cycle cost of the project and will use a tool to forecast the required investment.

  From the inception and preliminary design stages, a clear picture of what is required in terms of green criteria, or the green design specifications, can be developed. Initial plans can be written out and discussed with professionals. At this stage, main stakeholders can advance towards a finalised plan. Requirements for planning permission and the local planning authority building control regulations should be applied as well as the full preparation of a cost plan and appropriate discussions with tenders or financial advisers. Financial institutions can also play a role by including environmental performance requirements in loan approval criteria or developing products that promote integration of green development.

  In choosing the materials to be used for the construction, the design team should consider the potential environmental impacts that start at the point of resource extraction. The environmental impact varies with the materials used. Green building design can reduce the use of resources and extend the useful life of a building. Similarly, the use of disassembly techniques can provide future flexibility and options to meet other functions or respond to a change of application.

  Resources must be used more effectively throughout the entire life cycle of the building. The design team, when selecting materials, should also consider the potential environmental impacts generated during the manufacture and operation related to the transformation of raw materials to a building material where toxic waste, by-products and emissions can occur.

- **Construction & Site Management**
  Designers or developers will usually put projects out to tender to undertake the construction. Many green criteria should be taken into account during the tender process. Pre-construction planning should integrate the green criteria into the plans for scheduling, labour needs, co-ordination of all actors, supervision, etc. During the actual construction, there is a need to ensure that the green criteria are integrated into this phase. Also, during construction much can be done to minimise waste through careful attention to waste and ensuring good quality construction.

\(^{19}\) The Aesthetics Committee of the World Buildings Design Guide of the National Institute of Building Sciences states: “The design of buildings requires the integration of many kinds of information into a synthetic whole. An integrated process, or “whole building” design process, includes the active and continuing participation of users, code officials, building technologies, cost consultants, civil engineers, mechanical and electrical engineers, structural engineers, specifications specialists, and consultants from many specialized fields. The best buildings result from active, consistent, organized collaboration among all players.” For more information, see http://www.wbdg.org/design/aesthetics.php.
After completion the contractors hand over the building to the developer or owner. Often a “defects liability period” is written in the contract, with the contractor remaining liable for repairs for a specified period. Finally, the building is put into its planned use. These defects can include green criteria, depending on how the contract following the tender process was prepared.

- **Operations & Maintenance**

Although out of the scope of this specific report, operations and maintenance can contribute a large proportion of a building’s overall life-cycle impacts due to their long life-span. The resource efficiency of a building can be improved greatly through the application of adaptable design principles, which have been neatly summarised as designing for ‘long-life’ and ‘loose-fit’. This recognizes that different layers of buildings are refurbished or replaced at different rated over their service life. The key is to optimise the design of layers of the building to best suit the intended functions. Structural layers of buildings for example, need to be designed and constructed to last a long time, whereas relatively short life-span interior layers (such as ceilings, non-structural walls, floor coverings etc.) should be designed to be able to be replaced without causing damage to longer lasting layers. Green procurement guidelines also need to be implemented during this phase to ensure purchase of environmentally beneficial services and equipment. Occupants of the building also have a big influence on the environmental performance of the building. Induction and training, environmental management systems, are all important in achieving environmental performance goals.

**Building Demolition & Re-use**

Design for adaptability, durability and disassembly actions should be taken at the early stages of the project in order to design a building that eliminates (or minimises) the loss of materials during the renovations and disassembly. As mentioned above if buildings are designed for ‘long-life & loose-fit’, waste associated with demolition or retrofitting can be avoided. Buildings can also be designed for deconstruction – requiring the use of durable materials and connection methods that enable disassembly for re-use.

**Main stakeholders**

The building supply chain consists of a broad range of actors with functional specialisations involved over a number of separate process phases. Some of the key buildings and construction supply chain actors are shown in Figure 4. Notice that the developers play the key role, interacting with virtually all stakeholders.

![Figure 4: Relationships in the Buildings Value Chain](source: WBCSD, Energy Efficiency in Buildings, Facts & Trends, p. 31.)

**Essential Relationships**

There are various links and patterns of flows along the project life cycle and supply chain, complex interactions between both horizontal and vertical supply chains in the form of pre-construction and post-construction two-way influences. The
legal frameworks and contracts affect all of the steps and are very important in the relationship between stakeholders and in each intervention process.

The construction process can be thought of as a cyclic process of interdependent phases. This process follows a sequence of decisions made by suppliers and customers linked together by their contribution to the finalisation of the building project, which is often referred to as the project life-cycle. Within this life-cycle strategies for greening the supply chain can be seen as a chain of information that facilitates meeting customer demand while achieving the following environmental objectives:

- **Optimising the environmental outcomes (Feasibility & Concept Design and Detailed Design):** From an economic point of view, the customer need can become an “effective demand”, which leads to the feasibility and concept design (including specifications). These bring together different sub-phase operations, including design, financial contracts, licenses, permits, etc. The Detailed Design is an important phase because it is at this phase in the design of a building that materials are specified. During this process life-cycle assessment tools, green materials guidelines, on-line data-bases and regulatory instruments such as product eco-labels become important.

- **Minimising the impact of construction (Construction):** The implementation or construction phase includes purchases or procurement of materials and equipment, service development, etc. with the design requirements in mind. All actions taken at this stage depends on the decisions from the early stages and main objectives are environmental management and construction waste minimisation; and

- **Realising the environmental performance over time (Use, Demolition/Re-use):** The phase of construction management, commissioning operations and maintenance depend also on the decisions taken in the inception phase. The use and demolition/reuse phases are where strategies on reuse and recycling of resources are taken.
POTENTIAL ENVIRONMENTAL INTERVENTIONS

There are three objectives for environmental interventions that have sufficient potential to warrant further exploration and development. The three related objectives are:

- Optimise the environmental outcomes
- Minimise the impact of construction
- Realise the environmental performance over time.

These are discussed below from the intervention points from inception through to demolition as described above in Figure 2.

Goal 1 (Inception Phase) – Optimise environmental outcomes

Actively undertaking steps to optimise the environmental outcome at all stages of the building chain is fundamental. However, it is well understood that the largest environmental improvements are most cost-effectively achieved when implemented at the inception of a building project.

Inception Phase

Stakeholders: As shown in Figure 4, the developer plays the key role with local authorities, capital providers, agents, owners and users.

The priority green interventions at the inception stage are given below. These interventions focus on engaging the relevant stakeholders at the earliest stage possible in the construction process in terms of both green requirements and supports to ensure there is a systematic application of green interventions throughout the subsequent construction process.

1. **More progressive national building and utility policies and incentives schemes (permitting/tax) including consistency of policies and incentives**

Building codes do not often establish environmental performance requirements for building projects. However, some jurisdictions, municipalities and companies adopt voluntary standards such as green building rating schemes, or bespoke requirements, and apply these to their development approvals processes. It is also often the case that policies and supports are not consistently applied throughout the identified construction process thereby resulting in missed opportunities to achieve green interventions at an early stage in the process. Targeted and timely obligations and incentives to achieve a greener construction process by directing and assisting the key stakeholders at an early stage in the construction process are necessary.

2. **Organizational environment policies** (Developer/Investor/owner-occupier/tenants)

In addition to government policy development it is also key to look towards the progression of in-house company policy that has a focus on a green approach. External requirements, guidance, supports, etc., will always only have limited success if the company itself does not adapt an in-house commitment to achieving greener targets and processes. Achieving senior management buy-in is an important first step in this and once in place will ensure a more successful acceptance of green requirements as well as uptake of incentives and supports.

3. **Decision-making tools & methodologies**

If both external and in-house policy structures are in place it is important to also have technical assistance at hand to enable implementation of such policies. To this end the availability of tools and methodologies that guide and assist an organisation through the process of greening its processes is key. Many relevant tools and methodologies already exist, developed by a variety of both NGO’s and government agencies, and have been proven to work successfully. Availing of such existing resources is an essential element to achieving implementation of policies. Examples are provided in the following sections arranged by procurement phase.

Examples of best practices
The **Building and Construction Authority (BCA) Green Mark Scheme** was launched in January 2005 as an initiative to drive Singapore's construction industry towards more environmentally responsible buildings and to incentivise those who go beyond the standard. It is intended to promote sustainability in the built environment and raise environmental awareness among developers, designers and builders when they start project conceptualisation and design, as well as during construction. It is a benchmarking scheme that incorporates internationally recognised best practices in environmental design and performance.

Preliminary Design Stage

**Stakeholders:** Owner-occupier, Design Team and Municipal authorities and regulators

The priority Green interventions at the Preliminary Design are:

1. **Green specifications – adopt ‘green’ target and criteria**

   Early stage intervention, as in the inception phase, is most important in ensuring a systematic approach to greening the construction process. Following the intervention at the inception phase where effectively the project owner has accepted and understood the requirement for a green building, the next step is to ensure that these requirements are translated into the preliminary design stage, i.e. that initial design concepts have as their basis green specifications and that these are not neglected for insertion as an afterthought at a later stage.

2. **Sustainable Design and design for adaptability (aesthetics & functionality)**

   Designing a project with environmental requirements need not interfere functionality and aesthetics if they are integrated at an early stage. Ensuring that environmental performance is considered at preliminary design stage results in an integrated design that addresses all requirements to deliver the final building without the need to adapt or change the design through later “afterthought” types of green interventions.

   As greening a building can require innovative methods and/or materials, it is of interest that the initial design concept is developed in such a way that it can be adapted depending on potentially new and previously unknown green solutions being made available later in the construction process. Such a move allows for flexibility in materials or product choice at the contracting stage with suppliers.

*Examples of best practices*

**DuboCalc** is a tool which has been provided by the Netherlands Government, Ministry of Infrastructure (2011) to measure the sustainability of a project at the design stage in an objective and standardised manner. The tool is spreadsheet based and can be used with the Prorail CO₂ Performance Ladder.

**CH₂ (Melbourne, Australia)** is designed to be greenhouse gas neutral and improve overall employee wellbeing. Different strategies were used when doing this but an important one to mention is the charrette process. This was run over 2 weeks, with the consultants and project team sitting together every day to discuss the future project. This process ensured that in a short period, around 80% of all the building design and systems were resolved in an integrated holistic fashion. All the consultants understood the systems and why they were in place. This focus on collaboration was critical to the achievement of an integrated design concept for CH₂. The CH₂ design and development process is well documented to enable others to learn from the experiences.

**Multiplex and Stadium Australia** used Life Cycle Assessment (LCA) in the original design optimisation of the Olympic Stadium for the Sydney 2000 Olympics. The LCA was carried out using a software tool by the New South Wales Department of Public Works and Services based around the Boustead 3 model, but using Australian data. The use of LCA led to an improved design,
resulting in annual primary energy savings of 30%. Added to this, the use of gas cogeneration led to a 37% reduction in GHG emissions when compared with conventional design. There was a 13% reduction in water use with 77% of water used being sourced either from onsite recycling or onsite water collection. Further, the LCA aided in the selection of materials, and the prioritisation and evaluation of initiatives. Finally it allowed compliance with the ESD requirements placed on the project.

CEN/TC 350, the European Committee for Standardization/Technical Committee – Sustainability of construction works supports the construction of sustainable works and preparing standards for the measurement of embodied and operational impacts for whole buildings across the lifecycle.

Design Specifications

Stakeholders: Owner-occupier, developers and building contractors and/or design consultants and facility management

The priority Green interventions at the Design Specifications are:

1. **Green criteria in prequalification and selection of key contractors, subcontractors and suppliers and supply chain audits**

   Suppliers should demonstrate that they have systems in place to reduce the environmental performance of their processes and that products and materials supplied comply with environmental performance standards. Several standards exist to improve energy-related performance and energy efficiency continuously and to identify energy reduction opportunities. Consistent energy management standards such as EnMS (ISO50001) can help to realize untapped energy efficiency continuously. With the release of the ISO50001 is expected that the equivalent European energy management EN16001 will be withdrawn.

2. **Green specifications for optimum material use**

   Green specifications provides guidance on how to make the best environmental choices when selecting construction materials and components. They often provide guidelines and life-cycle performance criteria for materials and products within a product class (eg. Structural, non-structural etc) or by function (e.g. cladding, floor covering, windows etc). They may also include qualitative information on suppliers, such as whether manufacturing plants use recycling and waste minimisation systems. They may also refer to eco-labels and regulatory compliance.

   **Examples of best practices**

   **Ecospecifier** is an Australian database of environmentally responsible materials and products and there are many such directories available, usually on a pay-for-service basis.

   **GreenTag** is the world’s first BIM-based product rating and certification system, a holistic sustainability rating system based on Building Information Management (BIM) and LCA. A Green Tag Certified logo exhibiting a PLUS means the manufacturer data and factory have been fully audited in accordance with the standard.

   **Environmental Product Declarations (EPDs)** are a form of eco-labels that are rigorously prepared under ISO 14025 standards and independently verified.

**Farringdon Station, London**

In close conjunction with the City of London and the London Borough of Islington, a vision for the regeneration of this key area of London has been developed.

The project demonstrates how sustainable development can have both an environmental and economic benefit. For example, the team diverted 100% of the demolition waste from landfill that saved £365,000 ($545,000) in landfill.

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20 GreenTag is a product certification administered by EcoSpecifer in Australia see: www.ecospecifier.com.au/certifications/green-tag-certification.aspx
tax, while reusing the rubble from the demolition removed the need for approximately 850 truck movements that saved 30 tonnes of carbon dioxide emissions and approximately £70,000 ($105,000) on the cost of additional materials. For the new ticket hall, instead of using what would have amounted to 500 tonnes of steel, the team used an eco-reinforced alternative that was 95% recycled and responsibly sourced.

**Goal 2 – Minimise the impact of construction**

During the construction phase the contractor must implement environmental design strategies and implement environmental quality management, green procurement and waste minimisation. Construction firms should build teams with environmental credentials by:

- Ensuring potential sub-contractors have track record on green building construction;
- Ensuring the appropriate controls and require the use of environmental standards (ISO 14000);
- Performance based contracting.

**Construction (Contracting)**

**Stakeholders:** Developer, building contractors and subcontractors and key materials & equipment suppliers

The priority environmental interventions at the Construction (Contracting) are:

1. **Apply Environmental Management Systems and Standards**

Because of the many different stakeholders, professions and trades involved in a building project and managing building operations over its service life, adopting common environmental policies for a project is critical. Agreeing on the application of standards such as the ISO14000 (environmental management) and 14040 (Life-cycle Assessment) can provide useful management frameworks. Green building rating schemes also offer a platform for providing projects with a common definition and set of performance goals for a building project. Where sub-contractors and suppliers do not have their own environmental performance policies or guidelines, contract clauses and sub-contract agreements can be used to enforce compliance with the requirements of head-contractor or development companies. Similarly, tender conditions and procurement policies can require potential contractors to demonstrate their track-record in applying and/or complying with environmental performance requirements on previous projects.

2. **Preference Contractors with Environmental Credentials not only by Price**

To help ensure that contractor and supply chain organisations are incentivised to pursue a environmental process in their bid for contract a specific structure can be applied to the design specifications that rewards green measures and approaches., put in place by the relevant bidding organisations. Such incentives could include ranking tender bids based on environmental track record and documentation as well as price.

3. **Embed Environmental Performance Clauses (mandatory) in Main & Sub-contract models**

Ensure that environmental performance requirements are addressed in tender documents, forms of contract and sub-contract agreements.; It may not be enough to simply refer to product standards or green specifications during tender and contract documentation. Consideration should also be given to establishing environmental KPIs and reporting requirements. This is a intervention that can be very targeted to specific trades and materials.

**Examples of best practices**

**Seattle School Skanska Living Building Challenge (LBC).** A programme of the International Living Future Institute, the Living Building Challenge (LBC) is widely considered the world’s most rigorous building performance standard. A Living Building generates all of its own energy through clean, renewable resources; captures and treats its own water; incorporates only non-toxic, appropriately sourced materials; and operates efficiently and for maximum beauty. A building must perform as designed for one full year of occupancy and pass a third-party audit before receiving certification as “Living.” The Seattle School certified as world’s forth Living Building was built by Skanska and its green building team navigated the strict material requirements to source building
products that do not contain any of the materials or chemicals on the LBC Red List of harmful products. One of the greatest challenges in this effort was finding local manufacturers and vendors who were fully transparent about the chemical makeup of their products. The use of healthy materials promotes better indoor air quality, as well as further transparency in the building materials industry.

The London Olympics established a target to cut the carbon footprint by 100,000 tonnes of carbon emissions in the procurement of materials and venue construction. All venues have followed a sustainability process and they took special attention on the procurement of contractors and designers and the result was that the main stadium was constructed using a range of innovative techniques, including recycled materials. As an example, the circular frame around the stadium consists of old, abandoned gas pipes instead of using the traditional virgin steel and two-thirds from the steel used in the entire roof is recycled. The velodrome used sustainably sourced timber and natural light and ventilation. But the aquatics centre is all concrete and steel and just passed sustainability standards.

The Prorail CO2 Performance Ladder operates in the Netherlands and is primarily a procurement tool. Suppliers to Prorail are companies tendering for infrastructure projects such as construction and maintenance of dams, waterworks and roads, but could also be used for buildings. Participating suppliers obtain independent verification of their carbon management, scored on a 1-5 scale against a number of set criteria. A score of 5 gains an equivalent to a 10% discount on the price of their bid in the tender evaluation process. Lesser scores receive smaller discounts. A company scoring Level 5 has a CO2 emissions inventory of its most important suppliers (scope 1 and 2). Supply chain sectors targeted include iron and steel, non-ferrous metals, non-metallic minerals and cement.

The EU’s Green Procurement Policy approach for public-financed buildings is to encourage architects and engineers to include green procurement criteria in building design and for contractors to apply appropriate environmental management measures connected with the construction process. Green procurement criteria might include minimum energy performance standards or specify low VOC interior products or low embodied energy materials, for example. Additional points might be awarded to tenders for submissions that perform beyond minimum standards.

The UK’s Building Research Establishment (BRE) launched a framework standard for the responsible sourcing of construction products in 2008. An important objective was to secure the adoption of good practices throughout the supply chain and was thought to be particularly relevant for companies undertaking work for the 2012 Olympic Games. The standard deals with issues such as where a material comes from, how the workers producing it are treated and what the material’s overall impact on the environment.

Goal 3 – Realise the Environmental Performance Over Time

Site Management
Stakeholders: Municipal authorities and regulators, developers and building contractors and Subcontractors and (key) material & equipment suppliers

The priority environmental interventions at the Site Management are:

1. Green procurement

Sustainable procurement involves a high degree of collaboration and engagement on green issues amongst all parties in the supply chain. UNEP (2012) has introduced guidelines for a 4-step implementation of its procurement guidelines. They have been tested in seven countries. Although they were prepared for governments to implement for public procurement, they are just as applicable to large private construction companies. The UNEP (2012) document also introduces the Electronic Product Environmental Assessment Tool (EPEAT) that is primarily for equipment fit-out of an office or commercial building. It is an electronics rating system that has brought significant reduction in the use of primary materials including toxic metals and hazardous waste. Since an EPEAT requirement is that it meets ENERGY STAR specifications, products purchased with the tool use significantly less energy and produce fewer emissions, including GHG emissions, than conventional products.

2. Production, transport and distribution of resulting products
With a green approach for the construction project’s supply chain it is important to not neglect the delivery and handling of the supply chain’s produced materials and products. Co-ordination and management of the process between materials and product production and their actual utilisation is also very important. Correct handling of goods, whether it is the managed transport to site or subsequent distribution on-site, can result in a reduction of transport emissions as well as excessive production.

3. **Waste minimisation**

An important component of reducing the environmental impact of the construction phase is taking actions on-site that minimise construction and demolition waste. Many strategies available to construction managers are interdependent with good general site management such as maintaining clean and safe working conditions, planning space on sites for material salvage, recycling bins, ensuring all workers have up-to-date plans and specifications, that materials are stored properly and handled appropriately. Including responsibilities for maintaining a healthy working environment, minimising waste and helping to achieve the projects environmental goals in site inductions and providing training to workers are also important.

The **Nedband South Africa Office Building** is one of South Africa’s first star-rated buildings, having a highly commendable range of “green” features. It is a good example of waste minimisation, with good energy and water efficiency initiatives and using materials with recycled content and construction waste recycling. It included a site-based Environmental Management Plan, developed and implemented by the contractor for day-to-day site work and construction (voluntary initiative, not a mandatory requirement). The contractor tracked all waste streams and completed quarterly reports on waste generation, recycling and re-use.

**Operations & Maintenance Stage**

**Stakeholders:** Tenant/owner-occupier, investor and facility management

The priority Green interventions at the Operation & Maintenance Stage are:

1. **Green criteria in prequalification and selection of Facility Management and include contractual incentives and criteria for green improvements**

   In a similar fashion to the design specification stage, the selection of a facility manager can also be approached on the basis of green requirements and incentives. It is important that the environmental performance goals of building design are achieved during building operations. In commercial, public and large residential buildings, this responsibility normally falls on a Facility Manager. It is therefore important that the Facility Manager has appropriate qualifications and a good track-record in environmental management of building operations.

2. **Benchmarking & Performance Management**

   Obviously no environmental benefit is achieved unless the performance objectives of the project are met. Knowing that they are met requires monitoring and reporting of actual building performance across key performance indicators. However, comprehensive post-occupancy evaluation of energy consumption, and other important issues of environmental performance such as water, waste and indoor environmental quality is not yet common practice. This is not to say that tools and methods for performance evaluation, reporting and benchmarking do not exist. In jurisdictions such as Sydney, Australia and New York, NY USA, monitoring and reporting the actual energy performance of commercial buildings is mandatory. In the European Union requires member states are required to assess and label the energy consumption and greenhouse gas emissions of homes. More can be done however, and monitoring and reporting of environmental performance should be implemented in green supply chain initiatives,
Example of Best Practices

**Woolworths, South Africa**
Woolworths’ comprehensive governance system ensures that its sustainable business practices are implemented and targets achieved. Corporate decisions are relatively easy to implement since they are chiefly directed to the retail chain over which they have complete control. The directive applies to energy saving features, rainwater harvesting and waterless urinals amongst other water saving devices. The example illustrates how one organisation can act as the change agent in a network of over 200 stores.

Product and Service Suppliers
For the energy metric the key interventions identified are EnMS and technology retrofits. ISO50001 is indicated as the main standard as typically used by larger industry while for SMEs there are often simpler buyer endorsed or government incentivised solutions applied such as simplified energy audits\(^{21}\), capital incentive programmes, and energy performance monitoring, rating and labelling. Reducing the life-cycle environmental impacts of products over their entire life-cycle may be enhanced with extended supplier responsibility. Service contracts that enable product suppliers and/or manufacturers to retrieve and recycle product that has reached the end of its service life should be considered.

Example of Best Practices

**Supplier Self-Assessment Questionnaire (SAQ)**
The Global e-Sustainability Initiative (GeSI) is a joint initiative of an international group of Information and Communications Technology service providers and suppliers, with the support of UNEP and the International Telecommunication Union. They have created an integrated Supplier Self-Assessment Questionnaire (SAQ), which replaces questionnaires focussing on one aspect of sustainability only. It will be useful for companies seeking to strengthen supply chain engagement. Drawing on leading practices in the field, and addressing environmental, social, and governance issues, the SAQ is a “conversation starter” for companies to use with their suppliers as they begin to assess the sustainability risks in their supply chains. The goal is to help companies be more competitive and build resiliency in their supply chains.

**The Project Sustainability Logbook**
The Project Sustainability Logbook aims to accompany built assets through all stages of its life by means of benchmarks that are updated regularly. The version available is the non-commercial draft version circulated at the last International Federation of Consulting Engineers (FIDIC) World Engineering Conference in Seoul, September 2012.

**Eco Reinforcement Scheme : CELSA GROUP-CELSA STEEL SERVICE, UK**
Eco-Reinforcement is a third-party certification scheme developed by the reinforcing steel industry to comply with BRE Global’s BES 6001 Framework Standard for the Responsible Sourcing of Construction Products. Eco-Reinforcement provides a means for construction clients, specifiers and contractors to be able to purchase reinforcing steel from a supply chain that is pro-actively addressing issues of sustainability. The Eco-Reinforcement Scheme Council provides a forum for stakeholders to work together to continually improve performance within the reinforcing steel industry. Information is available at [http://www.celsa-steelserviceuk.com/Company.mvc/Eco](http://www.celsa-steelserviceuk.com/Company.mvc/Eco) and [www.eco-reinforcement.org](http://www.eco-reinforcement.org)

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BARRIERS TO GREENING THE SUPPLY CHAIN

With the complexity and the number of points of interventions, there are many barriers that affect the greening of the building supply chain. The following is a short summary of the main barriers that have been identified by the Task Force.

No dominant buyer/player to drive the process
There is a need for innovation and vision in order to drive the process. To achieve that, there is a need for leadership from within supply chain to drive the process forward in order to cope with increasing complexities and through appropriate green strategies. Setting a common goal and sharing visions with all the stakeholders is required but is also essential for strategic communication in supply chains to drive the process. The situation can progress positively with a handful of very large firms and a predominance of SMEs players serving niche markets.

Undefined and often fragmented responsibilities
The building sector is relatively fragmented, with few dominant players in most sectors. The effect of this high level of fragmentation can be that the project delivery process is considered highly inefficient in comparison with other industry sectors. This can lead to:
- Lack of co-ordination and awareness amongst the main stakeholders in the construction process, such as between product/system suppliers, builders, designers, architects, contractors and engineers;
- Poor communication at the inception phase, which leads to poor eco-design and planning throughout the entire process; and
- Lack of building construction local regulations that could clarify the role of each key stakeholder.

Lack of awareness, information, knowledge about benefits
There is a lack of knowledge and technical resources at many stages of the construction and supply chain process in relation to green solutions and energy efficient potential. Without an awareness of environmental and commercial benefits of green and energy efficient solutions amongst both suppliers and construction project stakeholders, there is little incentive to lead the way in this area.

Risk of using new practices/products
Large energy efficiency product/system suppliers depend on often small and medium-sized installation contractors for these downstream steps in the value chain to reach the end-user market. Therefore there is often a lack of capability and time to adopt innovative new solutions, and therefore a high perceived risk in using new and innovative materials and construction processes.

Lack of incentives
With concern over climate change and a finite supply of natural resources, companies should start to look at its carbon management and this should be the most important incentive for greening the building supply chain. However, for SMEs it is difficult to access all the technological and sustainability knowledge that is often more readily available within large industrial suppliers, research centres and energy efficiency specialist organisations. The lack of funding for sustainable innovation in SMEs is one of the main barriers of the innovation in the building sector.

Difficult to measure the benefits throughout the supply chain
Because the building supply chain is so complex and consisting of such a large variety of stakeholders, more work needs to be done to adapt environmental design tools and indicators to monitor multiple environmental criteria across all stages of the building sector supply chain. The difficulty to measure the different benefits of green supply chain initiatives can lead to a lack of awareness of opportunities. It is also important to note that there are large discrepancies between profit margins available to stakeholders at different stages of the supply chain. The incentives and available funds for taking environmentally sound decisions are therefore not always available. Environmental performance criteria therefore need to be embedded in the project from inception so that any marginal cost increases and risks are more distributed. Fully integrating environmental performance criteria can also create a level playing for sub-contractors and suppliers who work on low margins and often must tender competitively for contracts.
Public Procurement & Forms of Contract

While there are efforts to green public procurement processes, traditional practices remain and lowest cost often the key criterion in procurement decisions. Efforts to incorporate life-cycle costing as part of more comprehensive sustainable procurement procedures are gaining traction in the public sector, but this is not as commonly applied in the private sector. The European Union, for example, has many directives related to public procurement and the efforts to make procurement more ‘green’. UNEP in 2008 called for social and environmental criteria to be included in procurement contracts.\(^2\) Yet, implementation will also rely on reviewing traditional forms of contract – such as lump-sum contracts and investigate the applicability to collaborative and reward sharing (Early Involvement, PPP, PFI, Alliance Contracting performance and service-based contracts. Service and performance contracts can also be used to reduce life-cycle environmental impacts.

RECOMMENDATIONS FOR A FUTURE WORK PROGRAMME

The previous sections were intended to highlight gaps in knowledge and information availability, and summarise where interventions can take place in the buildings industry supply chain to make it more green.

The buildings industry is now facing increasing demands for better and greener performance. Public and private sector clients are increasingly asking for procurement procedures that are at a higher standard than in the past. Unfortunately, existing codes/standards, and in particular rating systems, have had limited penetration to date in the entire life cycle of the materials, products and even buildings themselves.

There has been an increasing focus on optimisation of different components of buildings such as windows and insulation, and in some markets phasing out the use of environmentally and unhealthy products. Still further emphasis has been given to improving the energy performance of buildings during their operational life. However, the adoption of holistic life-cycle approaches to improving the environmental performance of buildings as a system and to the building supply chain remains exceptional. Integrated life-cycle approaches for greening the supply chain and life cycle of buildings need to be made better understood by businesses and the public sector. For example, the European Commission is promoting the basic concept of green public procurement that relies on having clear, verifiable, justifiable and ambitious environmental criteria for products and services, based on a life-cycle approach and scientific evidence base. This needs wider acceptance.

The main outcome of the Task Force to date is to highlight the lack of appropriate information and understanding of environmental performance and energy efficiency in the building sector supply chain. Moreover, there is a lack of models to understand and document possibilities to green the overall supply chain and how this can be influenced by right design process and policies. As a result, the main recommendations being put forward focus heavily on research and collaboration projects to expand the knowledge base as well as documentation of best practice and experience.

As such, this section presents recommendations for priority UNEP SBCI work-streams in greening the building sector supply chain while also contributing to the development and implementation of a Sustainable Building and Construction programme under the UNEP 10-Year Framework of Programmes (10YFP). Key research and strategies for overcoming the main barriers are presented. In order to maximise the impact of the priority green interventions for increasing energy efficiency across the entire building sector value chain, UNEP-SBCI should gather main stakeholders to work together in a cross-sectorial collaboration to:

- Develop business models and recommendations for incentives for long-term ambitious service level agreements and documentation of performance for actual facilities;
- Educate and build the capacity that would enable and empower professionals within the industry to green supply chains according to long-term goals;
- Develop more specific information and documentation on mapping the supply chain for different building types in different regions;
- Support government through information sharing and advice to develop policies that drive or influence supply chain efficiency with planning, regulations, codes, standards and targets;
- Measure and document the impact (economic, social and environmental) of a green building and construction supply chain. This will require the development of key indicators to help the measurement;
- Carry out more research on how building developers/contractors can promote Energy Management Systems and other techniques to improve efficiency within the supply chain companies themselves; and
- Investigate policy or market mechanisms such as Eco labelling and incentives that would convince building developers/contractors to buy products and material from sustainable or energy efficient manufacturers and suppliers.

Such documentation would further be needed for government to provide long term targets, legislation and incentives that can help business to drive invention in more sustainable solutions.

Specifically, within this range of topics, some proposals on recommendations for future project work that could be undertaken by UNEP-SBCI to embark on the next phase of work are described below. Different strategies have been
presented in previous sections with some goals in mind. Following the same structure as in the report, the following recommendations are provided.

Opportunities for cross-sector collaboration (UNEP-SBCI - Industry) to develop more data

Mapping

➢ While there are examples on policies and programmes around the world that are effective in increasing the energy efficiency across the building sector supply chain, more research on good examples of effective collaboration models and more documented examples of effective case studies should be undertaken. This is particularly true in high growth regions globally (including the rapidly advancing countries of Brazil, China, India and Russia), where most of the new construction will take place in upcoming years.

➢ Better documentation of the impact of these policies should be undertaken.

➢ As a second stage, UNEP-SBCI should actively work with developers and contractors to map their supply chain. The mapping should show the dynamics of the supply chain as well as, through the use of pilot projects, show how they design and contract their buildings. The buildings industry should be encouraged to help UNEP-SBCI to develop information and document business models.

Learning from Best Practices

➢ Within the 10 YFP, UNEP-SBCI should lead a public private partnership in order to participate in a collaborative project with the main stakeholders of the value chain industry: building owners, architects, occupants associations, investors, etc. The aim is to create a database on best practice case studies, policies and programmes that could lead to a better understanding of successful sustainability efforts in the building sector supply chain.

Supply chain initiatives for Goal 1 (Pre-conditions) - Optimise the environmental outcomes

Long term engagement

➢ UNEP-SBCI should offer relevant stakeholders in the building supply chain a platform for long-term engagement in developing and implementing strategies for the systematic application of green interventions throughout the building supply chain.
Indicators

- Primary, as part of the 10 YFP, UNEP-SBCI should initiate work on the development of indicators that are needed to measure resource efficiency and performance in the building sector supply chain. These indicators are also required to identify points of leverage and the areas of highest energy efficiency/energy/carbon mitigation potential in the supply chain, including how building developers and owners can influence the performance of construction materials producers and manufacturers.

Tools

- Many life-cycle tools are available for supporting environmental decision-making during the building development process (see appendix a). In order to improve the application of tools they should be mapped in order to help stakeholders more strategically implement them throughout the building sector supply chain. Impact assessments and case studies of tools in use are required.

- Consideration should be given as to how these tools and initiatives could be internationally up-scaled, to what the real impact of these initiatives/tools are and to assessing the real costs and how those costs could be reduced through further uptake and standardisation.

Collaboration

- UNEP-SBCI should consider collaborating with the UNEP Life-Cycle Initiative and Resource panel on adapting life-cycle design and de-materialisation models for implementation in building design. There is a real opportunity to assist countries to develop national life-cycle inventories of their building materials and to adapt life-cycle modelling and design tools for use by designers and regulators.

Supply chain initiatives for Goal 2 - Minimise the impact of construction

In the construction phase of a building project, the main goal is to minimise the impact of construction and to implement the green requirements included in the design in the first phases of the project. It is in the construction phase that all elements come together, both information and material flows intersect and therefore this depends on so many other decisions and stages of the planning process as well as the supply chain.

- With this goal on mind, analysis should be undertaken to identify which government policies (procurement, labelling, standards, incentives) and support structures can encourage green improvements in the construction phase and also encourage the private sector to develop its own initiatives.

- Related to the above, there is a clear need for more building industry specific case studies and assessments of the impact of better public procurement policy.

- More research should be undertaken to develop a comprehensive database of policies and support structures.

- Pilot projects should be created that apply successful green supply chain initiatives in the construction phase and later on report the outcomes of these projects.
Supply chain initiatives for Goal 3 - Realise the Environmental Performance over time

- More research should be undertaken on how building owners and managers of contractors can avoid, reduce and recycle construction waste and whether linking directly with building materials manufacturers through programs such as extended producer responsibility is feasible. There is also a lack of data on C&D waste flows in many countries, and baseline data should be collected in order to support policy development.

Facilities management and procurement

- UNEP-SBCI should undertake work on the facilities management. The UNEP SUN Guidelines exist but have not been developed into implementable tools outside UN facilities. There is an opportunity here to develop generic and tailored tool kits for appropriate building types to ensure a life-cycle approach is taken into the operational phase of buildings. It also implicates public procurement policies as another priority for review and best-practice learning.

Data collection and performance monitoring

The outcomes of this current piece of research show that still not enough is known on the resource efficiency of materials within the building sector supply chain. Also there is a lack of understanding of how much energy, in specific, is used in each of the different phases, production, handling and transport. Even if it is a difficult task, more data on better techniques is required to better understand the use of energy in the supply chain.

- More investment in data collection should be undertaken in order to investigate in detail in which processes in the supply chain could be targeted to achieve more resource efficiency.

Impact assessment

- UNEP-SBCI should consider working on the development of common policy pathways and roadmaps for different construction markets. Components could include – developing life-cycle inventories (as mentioned above) – but this time with a focus on the macro impact assessments and modelling rather than building design. For example, basic LC inventories can be used to generate models of the carbon intensity and footprint of building materials manufacturing and use over time. The same can be said for other issues such as water, waste, energy, and persistent toxic substances, etc. This kind of MRV base-line and scenario modelling can help countries set policies for greening the supply chain and perhaps qualify for international financing and carbon financing to green the supply chain.

- UNEP-SBCI should work on assessing the co-benefits of greening the supply chain, from job creation to public health benefits. Tools such as social LCA have been developed but are yet to be piloted in the building sector. This could offer another possible link with the UNEP LC Initiative.
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APPENDIX A: LIFE-CYCLE DECISION-MAKING TOOLS & RESOURCES

Life Cycle Design

BOOKS


Construction & Structural Systems

BOOKS


Ogg, A. 1987 *Architecture in Steel*, the Australian Context, ACT RAIA


Salvadori et. al (latest ed) *Why Buildings Fall Down* Norton


Choosing Sustainable Materials

LCA DESIGN TOOLS

UNEP-SETAC Lifecycle Initiative

www.unep.fr/scp/lcinitiative/

ATHENA

www.athenasmi.org/about/lcaModel.html

Simapro (Dutch)

www.pre.nl/simapro/default.htm

Simapro Australasia


Australian Lifecycle Inventory Database

http://150.229.66.74/auslci/

Australian Lifecycle Assessment Society


SB Tool – Sustainable Building Challenge

www.iisbe.org
PRODUCT GUIDES

EcoSpecifier – Passwords available at the resource centre.
www.ecospecifier.org

RAIA Material Selector – Royal Australian Institute of Architects
www.selector.com.au

EcoBuy – Municipal Association of Victoria
www.mav.asn.au/ecobuy

Australian Eco Labelling Association
www.aela.org.au/aela/

BOOKS


UNEP 1996 *Life-cycle Assessment: What it is and how to do it* UNEP, New York USA


About UNEP-SBCI: The UNEP Sustainable Buildings and Climate Initiative (UNEP-SBCI) is a partnership of major public and private sector stakeholders in the building sector. UNEP-SBCI’s activities are guided by four key goals to ensure that the Initiative achieves its mission and promotes the worldwide adoption of sustainable buildings and construction practices.

- Provide a common platform for dialogue and collective action among building sector stakeholders.
- Develop tools and strategies for achieving greater acceptance and adoption of sustainable building policies and practices worldwide.
- Establish baselines which are globally recognized and based on a life-cycle approach. Focus has initially been concentrated on establishing baselines for energy efficiency and greenhouse gas (GHG) emissions, but is now expanding to account for additional indicators such as materials and water.
- Demonstrate through pilot projects and inform policy developments of the important role buildings have to play in mitigation and adaptation to climate change at local, national, and global levels.