Concepts and instruments for a sustainable construction sector

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Summary
This article presents an overview of methods used by the Wuppertal Institute to determine sustainability targets in the construction sector and to develop pathways for achieving targeted improvements. Resource productivity is considered over a building’s entire life cycle (MIPS). The COMPASS concept integrates environmental, economic and social aspects for single companies or industrial sectors in order to make progress towards greater sustainability. Profiting from each of these approaches, and based on various types of research, recommendations are derived for companies and policy makers. Multi-stakeholder processes can be used to promote overall sustainable development in the construction sector, and eventually to integrate concepts related specifically to the micro and meso levels.

Resumé
L’article examine les méthodes employées par le Wuppertal Institute pour fixer des objectifs de durabilité dans le secteur du bâtiment et élaborer les filières qui permettront les améliorations recherchées. La productivité des ressources est étudiée sur la totalité du cycle de vie du bâtiment. Le concept de COMPASS intègre les aspects environnementaux, économiques et sociaux pour des entreprises isolées ou des secteurs industriels entiers, afin de progresser vers une plus grande durabilité. Tirant parti de chacune de ces approches et des divers travaux de recherche engagés, des recommandations sont formulées à l’intention des entreprises et des décideurs. Des processus associant de nombreux acteurs peuvent être mis en place pour promouvoir le développement durable dans l’ensemble du secteur du bâtiment, voire pour intégrer des concepts spécifiques aux niveaux microsectoriels et mésosectoriels.

Resumen
El artículo presenta una visión general de los métodos del Instituto Wuppertal para definir objetivos sostenibles en el sector de la construcción y para desarrollar procedimientos que permitan lograr las mejoras deseadas. Se estudia la productividad de recursos durante todo el ciclo de vida de un edificio (MIPS). El concepto COMPASS integra aspectos medioambientales, económicos y sociales para compañías individuales o sectores industriales con miras a progresar hacia una mayor sostenibilidad. Aprovechando cada uno de estos enfoques y basándose en varios tipos de investigación, se preparan recomendaciones para las compañías y los encargados de elaborar las políticas. Procesos que cuentan con la participación de múltiples partes interesadas pueden ser utilizados para promover el desarrollo sostenible en general en el sector de la construcción y, con el tiempo, integrar conceptos relacionados específicamente con niveles medianos y pequeños.

Sustainable development has been an internationally recognized aim since the UN Conference on Environment and Development in Rio de Janeiro in 1992. Its central challenges are the maintenance of social security and justice, sustainable economic development, and the preservation and creation of an intact environment. Looking at industrial sectors, the construction sector is of particular importance. On one hand, it makes a vital contribution to the social and economic development of every country by providing housing and infrastructure; on the other, this sector is an important consumer of non-renewable resources; a substantial source of waste; a polluter of air and water; and an important contributor to land dereliction. Material flows analyses for Germany, Japan and the United States show that the construction sector accounts for between one-third and one-half of commodity flows when expressed in terms of weight (Figure 1).1

Setting the target
In many cases buildings are harmful to workers during the construction period, as well as to occupants due to unhealthy air and indoor climate. Longer-term environmental impacts also result from buildings’ use and maintenance. In Germany about one-third of total primary energy is used just to maintain existing structures and keep them running. Moreover, demolition generates enormous amounts of waste to be disposed of. A core instrument for determining the environmental impact of materials in the construction industry is the “ecological rucksack”, which describes the total quantity of material that must be extracted to obtain a unit of pure (and thus usable) material. For example, for iron ore extraction the ecological rucksack can be expressed as a ratio of 14:1—that is, 14 metric tonnes of waste in the form of tailings or mine waste are created in the production of one metric tonne of iron. In the case of rarer materials such as gold and platinum, the ratio can range up to 350,000:1.

With their knowledge of these impacts and the extent of material consumption in today’s societies, senior governmental, non-governmental, industry and academic leaders argue the following: to redirect our course towards that of a sustainable economy, each country’s total resource productivity should be increased by a factor of 2; and in industrialized countries it should be increased by a factor of 4 within the next decade and by a factor of 10 overall within one generation. To achieve these increases, every actor within the economy must optimize resource use from the national (macro) level, through the sectoral and regional (meso) levels and down to the single firm and household level (micro) levels.

Different tools have been developed to measure resource productivity and the potential for improvement. These tools can be applied to the construction sector. A sustainable construction sector also has to consider other dimensions (e.g. economic and social considerations) in order to take the holistic approach needed to build a sustainable future.

From resource management towards a sustainable construction sector
“Only what is measured gets done” is often the underlying principle of the factor X discussion. The method we use to measure resource productivity depends on the extent of information (unit) we desire. For information based on mass units, we chose MIPS (Material Input per Service Unit), and for mass and monetary units combined with social considerations we chose COMPASS (Companies’ and Sectors’ Path to Sustainability). The different methods will be briefly explained below to show which period in a building’s life cycle offers potential for improvement within the fixed targets.

MIPS: a monitoring tool for material flows
MIPS is a methodology for measuring material input at the level of products, including all their
“ecological rucksacks” – that is, the total mass of material flows activated by an item of consumption in the course of its life cycle (www.wupperinst.org). MIPS is computed in material input per total unit of services delivered by the product over its entire useful life span. Resource extraction, manufacturing, transport, packaging, operation, reuse, recycling and remanufacturing are accounted for, as well as final waste disposal. The total MIPS carried by a finished product is the product’s ecological rucksack.

The S in the MIPS formula (Figure 2) stands for the total number of units of service (utility) delivered by the product during its lifetime, or the expected total number of service units that the product might supply during its lifetime (in the MIPS concept, products are “service deliver machines”). The S number is usually greater than that implied by product warranties.

Resource productivity can thus be improved by lowering M for a given S, or by increasing S with a fixed quantity of resources. Either can be achieved through technological or managerial/societal changes/innovations.

What does this mean for the actual construction site?

For eight years the Wuppertal Institute has been working in the field of resource efficient building and construction (www.mpshaus.de). Having analyzed and assessed over 100 buildings of various sizes using the MIPS concept, we have been able to show that, in terms of resources, the relevance of various life cycle phases differs greatly between new and existing buildings (see next section). Unlike existing buildings, new buildings show a relatively small importance of the “use phase.” For example, a pair of new semi-detached houses in the ecological settlement of Flintenbreite have a TMR (total material requirement) of 122 kg/m² per year. As shown in Figure 3, the renovation and construction phases dominate the entire life cycle. The enormous relevance of the renovation process in this case results in particular from the aluminium roof, which will have to be replaced twice (according to German statistics) during the calculated life expectancy of 80 years.

Consequently, in order to achieve an improved MIPS value, true dematerialization must focus on virgin resource extraction and not just intensity of use. The environmental impacts of the technologies and substitutions that lead to dematerialization therefore need to be scrutinized carefully. Dematerialization must also focus on a shift to reuse, recycling and remanufacturing – in short, all the important aspects of closing material loops. Additionally, de-energization, decarbonization and detoxification of the industrial system should accompany dematerialization if significant resource and environmental benefits are to be achieved. Further dematerialization can be achieved through technological progress. Summarizing the potential for improving the environmental sustainability of buildings, Stefan Bringezu suggests what he calls the “Golden Rules of Eco-Design”:

1. Potential impacts on 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.

How these suggestions could be implemented in practice by enterprises in the construction sector is illustrated in Table 1.

Building renovation: a chance for climate protection and the labour market

Having shown how resource productivity and environmental sustainability in the construction of new buildings can be improved, it is important to consider the contribution of existing buildings to meeting sustainability targets. In this case, the “use phase” is of crucial importance because of the current high energy demand for heating, with around 200 kWh/m² per year or 20 litres of oil/m² per year. In a study called “The Renovation of a Building – A Chance for Climate Protection and the Labour Market” we have investigated the possible effects on the environment and on the labour market in the construction sector, of the extensive renovation of residential buildings to optimize energy savings. The starting point was the joint project “D as Plus für Arbeit und Umwelt,” which the industrial union Bauen-Agrar-Umwelt (IG BAU) and Greenpeace intend to initiate in cooperation with the housing industry (www.arbeit-und-umwelt.de).

The assumption underlying the study is that through this initiative and additional measures (such as incentives, above all on the part of the federal government), the number of residential buildings to be renovated to introduce energy-saving measures could be increased from around 150,000 in 2005 to approximately 330,000 per year. To achieve this, around DM 15 billion (approximately Euro 7.65 billion) would have to be invested annually between 1999 and 2020. This sum corresponds to almost 3% of total construction volume in 1997. Investments at this level would:

- secure and create on a long-term basis approximately 430,000 jobs (174,000 of these in the finishing trade alone);
- decrease energy costs by reducing final energy input by 1111 PJ (50%) and avoid up to 97.5 million tonnes (56%) of CO₂ compared with 1999, the reference year;
- achieve considerable resource savings.

Table 1

<table>
<thead>
<tr>
<th>Natural resources are the basis of life - today and for future generations</th>
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<tbody>
<tr>
<td>Housing</td>
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<tr>
<td>Mineral raw materials</td>
</tr>
</tbody>
</table>

Source: Behrensmeier und Bringezu 1994

Figure 1

Material input per capita for different types of needs in western Germany, 1990

- non-sellable production
- soil excavation
- erosion
- mineral raw materials
- fossil energy carriers
- biotic raw materials

Source: Lucas Epriet

Figure 2

The ecological rucksack of some products or services is too heavy.
Sustainability)

be addressed.

ment rate, overall stability in society) that have to 
(e.g. employee satisfaction over low unemploy-
high biodiversity, low erosion) and social targets 
back), environmental targets (e.g. low toxicity,
competitiveness, low rate of investment pay-
of sustainable development there are also numer-
only one important path; in the broader context 
It is important for companies and sectors to know 
COMPASS: the path to sustainability

It is widely recognized that to achieve sus-
tainable development, it is essential for dif-
different actors to work together. The federation 
of the German Cement Industry (Bun-
desverband der Dutschen Zementindustrie, 
BDZ) and the industrial union for the building 
and construction industry (IG BAU)
have concluded a sectoral agreement to facil-
imate joint consideration of economic, eco-
logical and social challenges throughout the 
whole lifecycle of cement products. Based on 
stakeholder dialogue and practical projects, 
this initiative tackles the issues of biodiver-
sity, protection of resources, sustainable trans-
port and logistics, as well as workers’ quali-
fications. The stakes in the cement industry are 
particularly high due to large capital investments 
and long amortization periods in an increasingly globalized market.

(balance of expended and saved material flows), 
which will reach a scale of around 68 million metric 
tones per year by 2020.

This investment plan, which is now activated by a 
governmental support programme (www.
.kfw.de) among other measures, will entail higher 
state revenues from national insurance and from 
direct and indirect taxes. At the same time, expend-
titure for social benefits will decrease because of 
an improvement in the labour market situation.

Comparing the potential of existing and new 
buildings, we can conclude that on the German 
and similar European markets the (energy relat-
ed) renovation of existing buildings offers a far 
more promising contribution to sustainable con-
struction than construction of new ones. Further-
more, economic and social benefits as well as land 
savings should lead us to direct our efforts towards 
the modernization of existing buildings. It goes 
without saying that where new construction is 
necessary, the utmost resource productivity and 
eco-efficiency must be targeted.

COMPASS: the path to sustainability for companies and sectors

It is important for companies and sectors to know what kind of targets and actions will lead them towards sustainability. Resource productivity is only one important path; in the broader context of sustainable development there are also numerous other economic targets (e.g. high profits, high competitiveness, low rate of investment pay-back), environmental targets (e.g. low toxicity, high biodiversity, low erosion) and social targets (e.g. employee satisfaction) over low unemployment rate, overall stability in society) that have to be addressed.

CO M PASS (Companies’ and Sectors’ Path to Sustainability)[5] is a tool developed to provide decision makers in a company or a sector with sufficient information for integrated analysis and decisions. It includes a methodological framework, instruments and measures to put the normative concept of sustainable development into practice. Step by step, it helps the user understand what sustainable development means for a enterprise or a sector – from a life-cycle perspective of a product or service – and shows the extent to which a development in the direction of a sustainable economy has already been achieved.

In cooperation with a company in the housing 
industry, the sustainability of its product range 
(four residential houses) was investigated. Eco-

economic and environmental issues were the main 
focus[5] however, it was important to record accept-
ance by tenants or buyers of the houses being 
offered. Product specific indicators apart from 
MIPS were determined in dialogues with people 
involved in the CO M PASS assessment. The prod-
ucts in question were detached houses of varied 
design, appealing mostly to the same type of 
prospective buyers. The resulting indicators con-
sidered by the company are:
• resource consumption (production and use);
• energy consumption;
• reduction of costs;
• effects on man;
• effects on the ecosystem;
• acceptance by tenants;
• profitability.

All indicators will be applied to the service unit “living space and year”. Only the “acceptance” indicator will be assessed per tenant or buyer questioned. Taking the “resource productivity” indicator as an example, the structure and procedure are briefly explained. The “system-wide resource consumption” indicator can be subdivided into part indicators (Figure 4). The subdivision into part and sub-indicators, for example, depends on production processes and responsibilities within companies.

An assessment scale (performance comparison) for all indicators was determined, ranging from 1 (very good) to 6 (unsatisfactory). Grade 4 (satisfactory) corresponds to the state of the art. With the help of “traffic lights” – grades 5 and 6 (red), grades 2, 3 and 4 (amber) and grade 1 (green) – the management decisions or measures introduced can be observed, discussed and evaluated with respect to their effects at all indicator levels. The grades will then be equally weighted from the bottom up and identified as the arithmetical mean of the overall grade of the indicator at the next higher level. The grading system can, of course, be freely chosen and can be shown in the standards of other countries.

To compare the houses of the company men-
tioned above, results were clearly presented on the topmost indicator level as in Figure 5. In the so-called “Sustainable Development Radar” (COM-
PASS)[2] the economic, environmental and social efforts of entrepreneurial development are portrayed. The axes show the selected indicators whereby the determined grades describe the distance to the defined target (grade 1) and the state of the art (grade 4).

The “Cement and Sustainability” initiative

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tainable development, it is essential for dif-
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<table>
<thead>
<tr>
<th>Table 1</th>
<th>Eco-efficiency strategies in the construction sector</th>
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<tbody>
<tr>
<td>Level of product components</td>
<td>Level of product structure</td>
</tr>
<tr>
<td>• Selection of materials with little environmental impact, e.g.</td>
<td>Optimization of product techniques, e.g.</td>
</tr>
<tr>
<td>(small ecological rucksack, no substances toxic to</td>
<td>• alternative product processes</td>
</tr>
<tr>
<td>humans or the environment)</td>
<td>• more efficient energy use</td>
</tr>
<tr>
<td>• renewable materials (sustainably produced)</td>
<td>• less product waste</td>
</tr>
<tr>
<td>• materials with low energy content</td>
<td>Reduction of material inputs, e.g.</td>
</tr>
<tr>
<td>• recycled materials</td>
<td>• reduction of product weight</td>
</tr>
<tr>
<td>• recyclable materials</td>
<td>• reduction of product volume</td>
</tr>
<tr>
<td>• optimization of distribution systems, e.g.</td>
<td>Reduction of environmental impacts during use phase, e.g.</td>
</tr>
<tr>
<td>• less, environmentally compatible and reusable packages</td>
<td>• more efficient energy use</td>
</tr>
<tr>
<td>• use of more energy efficient transport systems</td>
<td>• energy from environmentally compatible sources</td>
</tr>
<tr>
<td>• choice of more energy efficient logistics</td>
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</table>

Shifting from product-oriented to service-oriented approaches
• mobility management, e.g. car sharing, removal services, caretaker services

Figure 2
The MIPS formula

\[ MIPS = \frac{MI}{S} \]

Figure 3
Resource intensity of the new Flintenbreite Housing Estate in Lübeck, Germany

Source: Holger Wallbaum, Denk- und Kommunikationsansätze zur Bewertung des nachhaltig Baums und Wohnens. Dissertation, Fachbereich Architektur, University of Hannover, 2002. (Also see www.flintenbreite.de.)
Multi-stakeholder processes as a means of integration

The construction sector involves a multitude of actors and stakeholders, including building material manufacturers, building and construction companies, small and medium-sized enterprises (above all those engaged in trade), unions, planners, environmental NGOs, users, governmental institutions, financial institutions and research institutes. Stakeholder-based approaches are widely seen as a promising way to use on an equal basis the expertise and experience of all those involved and affected. With a view to finding quality sustainable development solutions, such an approach is opposed to the concept of negotiation, which favours the solutions proposed by the strongest rather than the best and most sustainable solution.

A recent study from Germany found that the large majority of stakeholders asserted the need for multi-stakeholder cooperation. Many went so far as to state that it represents the only viable solution to avoid misleading incentives and to improve industrial governance. As a result, stakeholder processes can lead to voluntary self-governance or to improved and more informed governance by the state (through incentives or legislation).

However, this approach also gives rise to considerable criticism and scepticism. Critics mostly refer to these processes as merely serving as an alibi for political inertia. Furthermore, they fear that solutions will be limited to the lowest common denominator among the actors involved instead of leading a big step towards sustainable development. The constraints can be found in the organizations themselves, the relationships between the different actors, and general considerations such as the sector’s economic situation.

As for the organizations seen as collective actors, it is important to note their specific logic and functioning. Most serve specific aims in the first place and find it hard to justify any slightly differentiating position to their members. This is especially true for the federations of the German construction industry concerned with overcoming the grave economic crisis, and for unions concerned with the preservation of jobs and fair working conditions in times of economic recession. In addition, a long tradition of corporatism in Germany has produced well-established relationships and modes of negotiation that are difficult to change.

In examining the commitment of business in stakeholder processes, we must identify the difference between the construction industry itself and producers of building material. The first, represented by its federations, shows very little commitment to sustainability issues, which is explained by the fact that firms only carry out decisions taken by others. The latter are exposed to much higher pressure from outside civil society because of their direct access to resources. This is directly noticeable by neighbours and concerned citizens.

As a result, we can observe increasing readiness to cooperate by manufacturers of building materials, as seen in the BD Z/IG BAU initiative at the national level as well as the World Business Council for Sustainable Development (WBCSD) “Cement and Sustainability” initiative.

These examples and others show that rather than abandoning multi-stakeholder processes before they have even started to work efficiently, we should seek to explain the constraints and try to find ways to improve their performance. In particular, power relations between actors and stakeholders and the perception of indivisible problems are main fields for further investigation.

Simultaneous action at different levels

The old saying that too many cooks spoil the broth is certainly not the right approach to creating a sustainable construction sector. The call for simultaneous action at different levels can only be repeated as a conclusion to this article. Necessary coordination through a broadly accepted framework could be established in national and regional multi-stakeholder processes. This, along with the COMPASS methodology, also seems a suitable approach to push forward integration of the core dimensions of sustainability. In addition to the MIPS concept on the environmental side, and economic indicators, more effort still needs to be put into determining the social dimension of sustainability in order to use the COMPASS indicator set.
Construction products and life-cycle thinking

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Summary
Life-cycle concepts, in the context of the building and construction sector, are particularly suited to analysis of building products. Such products play an essential role in increasing the energy efficiency of buildings and contributing to economic prosperity. It has been estimated that the construction sector is responsible for up to half of material resources taken from nature and of total waste generation. To manage and minimize the impacts of construction products, the impacts have to be measured using a life-cycle approach. This article reviews life-cycle concepts and considers recent developments. Materials and sustainable construction, environmental product declarations, embodied energy and differences encountered in the assessment of construction products in the North and South are among the topics addressed.

Résumé
Dans le contexte du bâtiment, les concepts fondés sur le cycle de vie se prêtent particulièrement bien à l’analyse des produits de construction, lesquels jouent un rôle essentiel dans l’amélioration de l’efficacité énergétique des bâtiments et la prospérité économique. On estime que le secteur du bâtiment est responsable de près de la moitié des ressources naturelles consommées et du volume total de déchets produits. Pour gérer et limiter le plus possible les impacts des produits de construction, il faut pouvoir les mesurer selon une méthode fondée sur le cycle de vie. L’article fait le point sur les concepts liés au cycle de vie et sur les tendances récentes dans ce domaine. Matériaux et techniques de construction durables, déclarations de produits respectueux de l’environnement, contenu énergétique et différences entre le Nord et le Sud dans la façon d’évaluer les produits de construction figurent parmi les sujets abordés.

Resumen
Los conceptos de ciclo de vida, en el contexto del sector de la construcción y edificios, resultan particularmente apropiados para los productos de construcción. Estos productos desempeñan un papel capital para el aumento de la eficiencia energética de los edificios y el desarrollo de la prosperidad económica. Según estimados, el sector de la construcción utiliza la mitad de los recursos materiales provenientes de la naturaleza y es responsable de la mitad de todos los desechos generados. Para poder administrar y minimizar el impacto de los productos de construcción, es necesario medir dicho impacto utilizando criterios de ciclo de vida. Los autores examinan conceptos de ciclo de vida y analizan la evolución reciente. Algunos de los temas tratados son: materiales y construcción sostenible, declaraciones de productos ambientales, energía incorporada y diferencias en la evaluación de productos de construcción en el Norte y el Sur.

Different contexts for considering construction products: North and South
When considering differences related to construction products in the North and South, it is important to make a distinction between “global” and “local” construction. At the most simplistic level, this can be considered as a split between city-based commercial buildings and dwellings, and rural dwellings and public buildings. The distinction can also be applied to products required to...