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Promoting sustainable building materials and the implications on the use of wood in buildings



A review of leading public policies
in Europe and North America



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Abstract

This study provides an overview of the current policy and regulatory environment regarding sustainable construction materials in the building sector in Europe and North America, and, where applicable, offers a commentary on the effectiveness of such regimes in driving the adoption of wood products. The study's objective has been to conduct a broad survey across a range of policies, initiatives and programmes in order to document the current circumstances as a starting point for further discussions, technical meetings and policy debates with a view to enhance the use of wood in buildings through policy advice to member states.

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Foreword

Hundreds of years before sustainability was a household word, foresters were advocating the sustainable use of forests by society. Unfortunately, society often did not heed the words of our early foresters. It is only recently that the users of wood have become as concerned with sustainability as foresters. Their use of wood for building was primarily just a matter of convenience; they lived by the forest and thus utilized wood as their premier material for construction. Wood was appreciated for its accessibility and utility, but having a sustainable supply required a much longer term view than their subsistence-based existence allowed. There were also other choices of materials for building, such as stone or more recently concrete.

With the advent of modern conservation and preservationist movements, there was often concern over the exploitation of forests. Harvesting forests and the use of timber were often associated with unsustainable practices and thus had a bad connotation; many people felt that it was more environmentally friendly to use other material for building rather than wood. The forest sector has made many adjustments and the result of this has been a movement within the forest sector to demonstrate the sustainability of forest products, including third party certification; something which is not seen in most other building materials.

Many scientists and researchers now see the forest and use of wood as one of the most important solutions for achieving sustainability. The greenhouse gas emissions to produce one tonne of sawnwood are about 13 per cent of what is required for the same weight of concrete and less than 5 per cent of what is required for the same weight of steel. Aside from the low environmental impact of production, wood is easily recyclable to make other products; and at the end of its useful life, it can be used as fuel.

The relatively shallow carbon footprint of wood fits well with the UN's Sustainable Development Goals (SDGs), which place a strong emphasis on the role of forests and a sustainably managed forest sector in contributing to global sustainable development. The use of wood for the construction of buildings can directly support a number of SDGs. Specifically, these include:

- Building resilient infrastructure, promote inclusive and sustainable industrialisation, and fostering innovation.
- Making cities and human settlements inclusive, safe, resilient and sustainable.
- Ensuring sustainable consumption and production patterns.
- Taking urgent action to combat climate change and its impacts.

The “Rovaniemi Action Plan for the Forest Sector in a Green Economy” shows how the forest sector in the UNECE region could lead the way towards the emerging green economy at the global level. The Action Plan, adopted by member states at a joint UNECE and FAO meeting in 2013 (Metsä2013), has as its first pillar, “sustainable production and consumption of forest products”. This includes the use of lifecycle analysis data, based on internationally agreed standards, for all materials throughout the stages of manufacturing, use and recycling, to support decision making at all levels; and contributing to the development of green building standards. The second pillar of the action plan outlines the contribution that the forest sector could make towards mitigation and adaptation to climate change by encouraging the reduction of greenhouse gas emissions by substituting sustainably produced wood for non-renewable materials.

Promoting sustainable building materials and the implications on the use of wood in buildings is the logical next step in determining what is needed to put the principles of the SDGs and the Rovaniemi Action Plan into place. This publication provides a view on the current policy and regulatory environment regarding sustainable construction materials in Europe and North America, and a pathway for member states interested in enhancing the use of wood in buildings. It showcases many of the policy measures taken in the region to overcome the lack of knowledge and misunderstanding of wood construction. We thank the author, Helen Goodland, for taking this very important next step to address building material policies in Europe and North America.



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List of abbreviations and acronyms

APRES	Action Plan on Responsible Sourcing	kWh	Kilowatt–Hour
ANSI	American National Standards Institute	KPI	Key Performance Indicator
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers	LAP	The Netherlands' National Waste Management Plan
ASTM	American Society for Testing and Materials	LCA	Life Cycle Assessment
BIM	Building Information Modelling	LCC	Life Cycle Costing
BRE	British Research Establishment	LCI	Life Cycle Inventory
BREEAM	BRE Environmental Assessment Method	LEED	Leadership in Energy and Environmental Design
C&D	Construction and Demolition (waste)	LVL	Laminated Veneer Lumber
CARE	Carpet America Recovery Effort	MBI	Market Based Instrument
CCM	Common Carbon Metric	MJ	Megajoule
CEN	European Committee for Standardization	MLS	Multiple Listing Service
CLT	Cross Laminated Timber	MMC	Modern Methods of Construction
CMM	Common Materials Metric	MMG	Milieugerelateerde Materiaalimpact van Gebouwelementen (Environmental Performance of Materials used in Building Elements)
CO ₂	Carbon Dioxide	NIBE	Dutch Institute for Building Biology and Ecology
CSA	Canadian Standards Association	OECD	Organisation for economic Cooperation and Development
CFC	Chlorofluorocarbon	OSHA	(U.S.) Occupational Safety and Health Administration
CFCP	Coalition for Fair Construction Practices	OVAM	Openbare Vlaamse Afvalstoffenmaatschappij (Public Waste Agency of Flanders)
CWM	Construction Waste Management	PAS	Publicly Available Specification
DCC	Development Cost Charge	PCR	Product Category Rules
DHUP	Directorate of Quality and Sustainable Development in Buildings (France)	PED	Primary Energy Demand
EOS	European Organisation of the Sawmill Industry	PEF	Product Environmental Footprint
EPA	(U.S.) Environmental Protection Agency	PEFC	Programme for the Endorsement of Forest Certification
EPD	Environmental Product Declaration	PLC	Portland Limestone Cement
EPF	European Panel Federation	PRN	Packaging Responsibility Note
EPR	Extended Producer Responsibility	PVC	Polyvinyl Chloride
EU	European Union	QA/QC	Quality Assurance and Quality Control
FAR	Floor Area Ratio	R&D	Research and Development
FOE	Federal Office of Energy (Switzerland)	RMI	Responsible Managing Individual
FOEN	Federal Office for the Environment (Switzerland)	SBCI	Sustainable Building and Climate Initiative
GDP	Gross Domestic Product	SCM	Supplementary Cementing Material
GHG	Greenhouse Gas	SECO	State Secretariat for Economic Affairs (Switzerland)
GJ	GigaJoule	SIA	Swiss Society of Engineers and Architects
GOJ	Government of Japan	SME	Small or Medium-sized Enterprise
GPP	Green Public Procurement	UCB	Urban Containment Boundary
GRI	Global Reporting Initiative	UKTSB	UK Technology Strategy Board
GST	Goods and Services Tax	UNECE-FAO	United Nations Economic Commission for Europe, Food and Agriculture Organization
GWP	Global Warming Potential	UNEP	United Nations Environment Programme
FSC	Forest Stewardship Council	USGBC	US Green Building Council
HPD	Health Product Declaration	VAT	Value Added Tax
HVAC	Heating Ventilation Air Conditioning	VOC	Volatile Organic Compound
IAQ	Indoor Air Quality	WUPP	Wood Use Points Programme
IDP	Integrated Design Process		
IgCC	International Green Construction Code		
IPD	Integrated Project Delivery		
ISO	International Standards Organization		

Executive summary

This study provides an overview of the current policy and regulatory environment regarding sustainable construction materials in the building sector in Europe and North America and, where applicable, offers a commentary on the effectiveness of such regimes in driving the adoption of wood products. Given that policy-making to address the impacts of construction materials is still at an early stage of development, the study's objective has been to conduct a broad survey across a range of policies, initiatives and programmes in order to document the current "state-of-play" as a starting point for further discussions, technical meetings and policy debates with a view to enhance the use of wood in buildings through policy advice to member states.

The weight of experience, in terms of policies already in place, is with operating or "in-use" impacts of buildings such as energy and resource efficiency, the promotion of specific "green" and/or "local" materials (such as wood), the restriction of highly toxic materials (such as asbestos) as well as minimizing the worst effects of the "end-of-life" stage (specifically waste diversion from landfill). However, the policies included in this study, which were identified from a comprehensive web search and with input from 100 survey responses from 33 countries, illustrate that the emphasis of policy makers has been shifting towards a whole life-cycle approach, emphasising the effects of production and consumption on the environment, and perhaps less commonly, their social and ethical consequences.

Twenty-nine policies were selected for high-level review which were organized under the following six categories:

1. Policies that provide information and encourage voluntary action
2. Policies that advance environmental norms
3. Policies that focus on the proportion of wood in buildings
4. Policies that advance technical specifications and structural norms (height, seismic, etc.)
5. Public procurement policies
6. Policies that "close the loop" at end-of-life

In general, all of the policies included in this study have been developed with at least one, and mostly more, of the following objectives in mind:

- Support greenhouse gas (GHG) emission reduction and/or climate change policies
- Reduce environmental impacts of construction materials (embodied energy, water, waste, etc.), and/or
- Promote a local wood economy and culture

One policy from each category was selected for deeper investigation. A summary description and key lessons learnt of each policy are presented on the following pages.

Policy 1	Key lessons
<p data-bbox="193 297 571 398">Information-based policies: The WOODBOX travelling public outreach programme</p> <p data-bbox="193 427 571 667">WOODBOX, together with WOODDAYS, is an international integrated public outreach programme that aims to build public awareness of the impacts of construction materials and the benefits of using wood.</p> <p data-bbox="193 696 619 857">The result of industry-government collaboration in Austria and Germany, the exhibition visited five European cities in 2014 and welcomed an estimated 15,000 visitors.</p>	<ul data-bbox="655 297 1385 1059" style="list-style-type: none"> • Sustained advocacy over the long term is critical building awareness and changing business and public behaviours. • It is important that public outreach and advocacy initiatives link directly to the “selection” stage in building materials’ life cycle and be available at the right time. • Advocacy initiatives should be part of a larger strategic outreach approach that includes technical training and project-specific in-the-field support for the design team. • It is important to engage with those professionals who interface with the public but may be outside the core building design and construction team such as lenders, insurers, surveyors, appraisers, marketers, brokers and agents (estate agents, leasing agents, etc.). • There are regulatory “touch-points” available to policy makers that are opportunities for education (such as time of sale of a building). • Awareness-raising programmes can be strengthened by information tools such as product and building labelling programmes.

Policy 2	Key lessons
<p data-bbox="193 1227 499 1361">Policies that advance environmental norms: The 2000-Watt Society Energy Vision</p> <p data-bbox="193 1391 592 1525">A socially equitable vision that establishes clear, long-range goals for energy and GHG emissions for buildings.</p> <p data-bbox="193 1554 632 1823">Offers one of the most progressive and comprehensive life-cycle based regulatory frameworks within which all of the major energy and GHG impacts of buildings are controlled, including operations, embodied impacts from materials and, in the future, transportation.</p>	<ul data-bbox="655 1227 1385 1930" style="list-style-type: none"> • Builds upon Switzerland’s well-established track record of leadership in energy-efficient building design and construction. • Developing and implementing a life-cycle-based building policy is a significant undertaking and requires substantial investment and sustained commitment by government, utilities, researchers and industry stakeholders. • Swiss practices were identified for their relevance and replicability in jurisdictions interested in advancing an integrated, performance-based policy environment. Yet many technical and regulatory complexities still need to be resolved. • The fact that the 2,000-Watt Society’s is rooted in a philosophy of global equity and social justice has proven to be compelling to businesses and public alike. • Comprehensive and sustained public engagement was necessary to educate citizens about climate change, energy security, and the future availability of energy supplies.

Policy 2 (continued)	Key lessons
<p>Currently encompasses 20 cantons and 100 towns and cities in Switzerland and is being adopted by cities in other countries. Governments have adopted the 2,000-Watt Society for their own facilities and, currently, it is offered as a voluntary “stretch” goal for other projects.</p>	<ul style="list-style-type: none"> • The availability of a full suite of software tools, databases of materials, catalogues of assemblies and verification tools is essential to assist the design team throughout the design process. • Policies with clear long-range visions and goals provide direction to materials manufacturers and can directly inform policies such as the Wood Resource Policy.

Policy 3	Key lessons
<p>Policies that focus on the proportion of wood in buildings: The Swiss Wood Resource Policy</p> <p>Establishes clear standards and targets for the use of wood as part of a cross-cutting mechanism to reduce the embodied energy and carbon in buildings (referenced under the 2000-Watt Society Energy Vision) while increasing the opportunities for the local wood industry by promoting the consistent and sustainable harvesting of wood from Swiss forests and the resource-efficient use of wood as a raw material for a range of products.</p> <p>Although it is early days, the results so far are generally positive and there is government commitment to continuing support for the Plan until 2016.</p> <p>The goals of the Wood Resource Policy are delivered through the Wood Action Plan which provides training, technical consulting, R&D standards development and a funding programme to help researchers, designers and manufacturers to advance the use of wood. Since 2005, around 1,500 multi-storey wood framed buildings have been completed.</p>	<ul style="list-style-type: none"> • The Wood Resource Policy has established an ambitious goal of increasing in the wood content of the entire Swiss building stock by at least 50 per cent (new buildings) by 2020. • Where possible, programmes intent on increasing the use of wood in buildings need to clearly focus on helping local forestry companies build capacity as a priority over the use of imported wood products. • In most countries, the building and forestry industries are closely intertwined. Complementary “cross-sectoral” policies can be used to mutually reinforce overarching goals (such as lowering the energy and GHG impacts of buildings while increasing the opportunities for locally sourced products). • The cross-sectoral approach to forestry policy making espoused by Switzerland requires intensive advocacy and relies upon a progressive forestry industry that looks beyond production outputs.

Policy 4	Key lessons
<p data-bbox="193 297 627 398">Policies that advance technical specifications and structural norms: The “Wood First” Initiative</p> <p data-bbox="193 427 611 696">Facilitates the uptake of wood products, thereby stimulating research into new techniques and technologies, supporting market adoption and developing small local markets as “shop-windows” of wood innovation for primary overseas markets.</p> <p data-bbox="193 725 627 1059">In the five years since Wood First was introduced, the use of wood in building construction has grown rapidly. More than 150 six storey wood frame projects have now been completed, planned, or are under development. Attention is now turning to “tall wood” and the first mass timber projects (over 10 storeys) are now in development.</p>	<ul data-bbox="660 297 1385 931" style="list-style-type: none"> • Wood First policies have received significant and sustained political support particularly in regions that are home to large areas of publicly owned forested lands, where forestry has a long history and strong cultural significance and where the forestry sector is a major employer. • To secure highest and best use of wood means looking beyond commodity markets (such as dimensional timber) to where opportunities to add value exist. This requires sustained and coordinated investment in R&D, training and technical support in order to bring new technologies and solutions, such as mass timber, to market. • Policies which may be perceived as promoting the opportunities for one material over others may polarize the building product manufacturing sector as, rightly or wrongly, it may be construed as legislation that undermines the credibility and effectiveness of building codes and serves as a barrier to fair and open competition.

Policy 5	Key lessons
<p data-bbox="193 1227 608 1328">Public procurement policies: BES 6001 Responsible Sourcing of Construction Products</p> <p data-bbox="193 1357 611 1693">Requires a range of life-cycle criteria to be met as part of a construction materials procurement process, including the use of Environmental Product Declarations (EPDs). It has the potential to influence the entire life-cycle of materials. However, as it stands it is likely to most greatly impact upon the production and consumption life-cycle phases.</p> <p data-bbox="193 1722 627 1890">At the end of 2014, the total number of valid BES 6001 certificates stood at 89 certificates covering 76 companies (some companies have multiple certifications).</p>	<ul data-bbox="660 1227 1385 2000" style="list-style-type: none"> • Governments can harness the immense purchasing power of businesses and organizations to help to promote environmental stewardship. • Sustainable procurement and purchasing policies can have substantial “trickle-down” effects on the construction materials supply chain because they encourage organizations to not only take into account the economic value (price, quality, availability and functionality) but also the related environmental and social impacts of the goods and services they buy at local, regional and global levels. • Procurement standards such as BES 6001 are necessary to establish a clear frame of reference and a means to communicate the desired product characteristics. • It is not only important to shift purchasing preferences to materials with lower environmental impacts but it is also equally imperative to ensure that materials are used judiciously and not “over-consumed”. • “Greening” the construction supply chain is challenging and sustained investment in R&D is critical to understanding and resolving the barriers.

Policy 6	Key lessons
<p data-bbox="199 295 598 398">Policies that “close the loop” at end-of-life: The Dutch “Chain-Oriented” Waste Policy</p> <p data-bbox="199 421 641 667">A chain approach considers the entire material chain, including all the stages in the life cycle of a product or material from raw material mining, production and use, to waste and possible recycling, as opposed to concentrating on “end-of-pipe” solutions.</p> <p data-bbox="199 689 641 967">A key focus of the Dutch approach is on reducing the overall environmental pressures imposed throughout the life cycle of construction materials and to harmonise policy in different areas (e.g. natural resources, products and building design, waste management, and concepts such as cradle-to-cradle).</p> <p data-bbox="199 990 641 1303">Overall, the Dutch government’s chain approach appears to have been well received by industry. By 2012, recycling and recovery rates for C&D waste in the Netherlands had reached 95 per cent. The National Waste Management Plan aims to further reduce the overall environmental impact for construction waste by 20 per cent”.</p>	<ul style="list-style-type: none"> <li data-bbox="667 295 1324 398">• It is important to ensure that the environmental benefit in one life stage of a material does not cause a higher environmental impact for another stage. <li data-bbox="667 421 1380 564">• A clear, measurable reduction target provides a goal to which industry can work towards and is intended to drive innovation throughout the chain, targeting flows that can be dealt with most cost effectively. <li data-bbox="667 586 1332 689">• There is a concern that the waste policy does not leave Dutch waste management companies at a competitive disadvantage in respect to other countries. <li data-bbox="667 712 1396 891">• Working within a life-cycle based policy environment is challenging and requires significant investment in advocacy, data development and maintenance, technical resources and industry training. However, these are similar investments to those needed for implementing a life-cycle based building policy. <li data-bbox="667 913 1380 1115">• The financial burden of implementing a chain-oriented approach can be significant. Whilst the material streams can be assessed in terms of costs as well as environmental impact to ensure the most cost-effective action is taken, the R&D to arrive at such solutions will be costly and industry may look to government to provide the necessary funding. <li data-bbox="667 1137 1388 1348">• Benchmarking, monitoring and reporting are critical. LCA analysis is necessary to determine if (and to what extent) the policy is having a positive effect in one area (e.g. designing products that can be recycled more easily) may have a negative effect in another (e.g. products being made from materials with more energy-intensive extraction methods).

Most countries in which forestry plays an important economic role have policies and programmes in place to advance the use of wood in buildings. Some countries have established consumption targets and others are driving the use of wood in new types of building projects in order to achieve highest and best use of their forestlands which are, more often than not, publicly owned assets. However, simply relying on wood use policies can be problematic, both for designers who may feel compelled to use wood products in sub-optimal situations and for non-wood product manufacturers who may perceive unfair procurement practices.

Some of the most progressive and effective policies that are being put in place today address the life cycle both of the materials themselves and also the building in which they are installed. They do not single out the use (or prohibition) of specific materials but instead rely on Life-Cycle Assessment (LCA) which is a science-based state-of-the-art methodology for determining the optimal choice of materials at the design stage taking into consideration the life cycle of the material and the building as a whole. Using LCA as a way to evaluate the environmental impacts of all materials is good for the wood industry because it can capture all of the positive ecological contributions made by forests as well as the low impacts wood imposes during its life cycle.

Sustainable materials management is proving to be a far-reaching issue and, in the most successful situations, a diverse range of cross-cutting policy instruments has been applied that include both policies which promote the use of wood with the use of LCA. Indeed, the emphasis of the most progressive policies is shifting from a traditional “linear economy” of production consumption, use and disposal to a “circular economy” whereby sustainable production and consumption allows for “waste” materials to be recycled back into the production system. This transition also aims to reduce environmental pressures all along the construction industry supply chain in order to control overall consumption levels and the shifting of environmental burdens from one life

stage to another. This work is at an early stage of development. Currently, leading policies have tended to either evaluate all materials for a limited number of environmental indicators such as embodied primary energy¹ and CO₂) or a wide range of environmental indicators for a limited number of materials. There is a great deal that warrants future research. However, two key areas that have been identified through this study:

1. In this study, the policies that address buildings tend to focus on new construction. The much larger existing building stock is not specifically addressed. There may be potentially beneficial effects of materials-based policies and ratings on the large existing building market.
2. Only a selection of policies has been included in this study. Given the scale of effort currently underway across Europe and North America, it would be useful to create a more detailed inventory of all the activity as a resource for learning and collaboration.
3. Many of the policies and programmes included in this study are still at an early stage of implementation and there has been insufficient time to gather meaningful results. A means to monitor leading policies in detail over is necessary in order to provide useful and timely lessons to other regions.

While the design and development of construction materials-related policies, and the pace and scope of their implementation, will be dictated by the characteristics and priorities of the jurisdiction concerned, the steps followed by leading policy makers have broadly comprised a process of benchmarking current performance, establishing performance targets, compiling materials databases (which then need to be maintained), developing draft or “stretch” policies to be tested by pilot or demonstration projects before widespread adoption and, finally, measurement and benchmarking of success. All these steps are reinforced by continuous and comprehensive stakeholder consultation. This process is proving

to take a long time and requires sustained financial investment and political commitment.

This study has been developed to provide a starting point for countries interested in addressing the environmental impacts of construction materials in order to stimulate further discussions, technical meetings and policy debates. Although it is too soon to establish the extent to which the policies in effect today are reducing the environmental impacts of construction materials, there are some countries that are expending considerable effort in advancing materials-related building policies. Given that the building sector

accounts for more than one third of the global resource consumption annually, there is certainly an imperative to do so. The findings from this study suggest that many countries in Europe and North America have developed some form of policy aimed at reducing the impacts of construction materials and those countries that are moving towards LCA-based policies are proving the most effective at changing building design and construction practices. Given the accelerating pace of construction in countries outside Europe and North America, the pressure on policy makers to manage the environmental impacts of construction materials can only increase.

Introduction

Introduction

Purpose and methodology

The purpose of this study is to provide an overview of the current policy and regulatory environment regarding sustainable construction materials in the building sector in Europe and North America and, if applicable, to provide commentary on the effectiveness of such regimes in driving the adoption of wood products.

The study is high level and exploratory in nature. It only provides examples of some of the countries that are most active in this area of policy-making. The intention is not to list every sustainable materials policy that exists because many policies are still in the development stage. Given that policy-making to address the impacts of construction materials is still at such an early stage, this study aims to provide a broad survey across a range of policies, initiatives and programmes in order to document the current “state-of-play” as a starting point for further discussions, technical meetings and policy debates with a view to enhance the use of wood in buildings through policy advice to member states.

The policies included in this study were identified through a comprehensive web search and from a questionnaire sent to stakeholders and supporters of both the Forestry and Timber Section of UN ECE-FAO and the Housing and Land Management Unit of ECE from July to October 2014. A total of 100 responses were received from 33 different countries (see Figure 1).

A total of 29 policies were predominately drawn from countries within the ECE region and the majority are summarized in Annex A. In the body of the report, there are six policies that have been selected for deeper evaluation in order to illustrate the breadth and depth of leading practices in the advancement of sustainable construction materials and the use of wood. The objective was to select one policy from each of the following six categories for deeper investigation:

Figure 1: Survey responses by country

Countries	Responses
Albania	1
Austria	4
Azerbaijan	1
Belgium	2
Bosnia and Herzegovina	2
Bulgaria	1
Canada	5
Croatia	3
Czech Republic	1
Denmark	1
Estonia	2
Finland	4
France	3
Germany	2
Italy	2
Kyrgyzstan	1
Lithuania	2
Morocco	1
Netherlands	1
Norway	1
Poland	2
Portugal	1
Russia	1
Serbia	1
Slovakia	1
Slovenia	1
Spain	2
Sweden	2
Switzerland	5
Tajikistan	2
Turkey	11
UK	3
USA	7
EU	1
UN	3
No country defined	17
Total	100

1. Policies that provide information and encourage voluntary action
2. Policies that advance environmental norms
3. Policies that focus on the proportion of wood in buildings
4. Policies that advance technical specifications and structural norms (height, seismic, etc.)
5. Public procurement policies
6. Policies that “close the loop” at end-of-life

Each of the six policies is presented as follows:

- A **description** of the scope, characteristics, objectives and other pertinent details of the policy
- An assessment of the **impacts** of the policy in terms of its effectiveness in advancing the use of sustainable construction materials and
- A summary of **lessons** learnt and applicability to other jurisdictions

The overall aim of subjecting a small number of policies to more detailed investigation was to not only assess their scope and effectiveness but also to identify key transferable lessons regarding, for example, the required institutional setting and the nature of implementation for countries of a similar level of economic activity.

The six highlighted policies were selected based on the following considerations:

- The policy is in effect and has a track record
- The policy is part of a long-range strategy (political or regulatory) that includes measurable goals
- There is information about how the policy is enforced
- There are key performance indicators (KPIs) or metrics in place for tracking the success of this policy
- There is information about the effectiveness and ease of implementation of the policy
- There is information about the policy in terms of practical lessons learnt, reactions

by industry and stakeholders, unforeseen consequences or results (good and bad).

- There are “case study” project examples
- There is information on the web providing further details.

There has been a recent shift from single-issue sector-based policy instruments that exert an impact on only one stage of the material life-cycle, towards policy packages that adopt a cross-sectoral approach and which consider the whole life-cycle. It is therefore valuable for the six selected policies to serve as an illustration of how policies can be initiated from different vantage points along the life-cycle continuum of materials (selection, installation, end-of-life) but extend up/down the supply chain to deliver a holistic life-cycle based solution (Figure 2). In fact, two policies have been selected from Switzerland as a way to demonstrate how policies can be designed to be cross-sectoral, integrated and life-cycle focused and how they can mutually reinforce specific yet separate goals. The analysis of each policy discusses the value of such an integrated approach where it occurs. The policies selected for deeper investigation are:

1. **Policies that provide information and encourage voluntary action: The WOODBOX travelling public outreach programme** – an integrated public outreach programme that aims to build broad public awareness of the impacts of construction materials and the benefits of using wood.
2. **Policies that advance environmental norms: The 2000–Watt Society Energy Vision** – a socially equitable vision that establishes clear, long-range goals for energy and GHG emissions for buildings. It offers one of the most progressive and comprehensive life-cycle based regulatory frameworks within which all of the major energy and GHG impacts of buildings are controlled, including operations, embodied impacts from materials and, in the future, transportation.
3. **Policies that focus on the proportion of wood in buildings: The Swiss Wood Resource Policy** – establishes clear standards and targets for the use of wood as part of a cross-cutting mechanism to reduce the embodied energy

and carbon in buildings (referenced under the 2000-Watt Society Energy Vision) while increasing the opportunities for the local wood industry by promoting the consistent and sustainable harvesting of wood from Swiss forests and the resource-efficient use of wood as a raw material for a range of products.

4. **Policies that advance technical specifications and structural norms: The “Wood First” Initiative** – facilitates the uptake of wood products, thereby stimulating research into new techniques and technologies, supporting market adoption and developing small local markets as “shop-windows” of wood innovation for primary overseas markets.
5. **Public procurement policies: BES 6001 Responsible Sourcing of Construction Products** – requires a range of life-cycle criteria to be met as part of a construction materials procurement process, including the use of EPDs. It has the potential to influence the entire life-cycle of materials. However, as it stands it is likely to most greatly impact upon the production and consumption life-cycle phases.
6. **Policies that “close the loop” at end-of-life: The Dutch “Chain-Oriented” Waste Policy** – aims to address the environmental impacts acting across the whole material chain from the end-of-life stage and back up the supply chain. A key focus is on reducing the overall environmental pressures imposed by construction materials.
 - For each of the six selected policies, the assessment methodology aimed to uncover the following information:
 - The environmental effectiveness of the policy, with particular emphasis on:
 - The environmental issue that the policy sought to address *such as* pollution levels, use of natural resources, use of energy, etc.
 - The costs of the policy to different actors, if applicable
 - Other drivers that have been in place
 - The role the policy has played in changing, for example, levels of emissions/ polluting

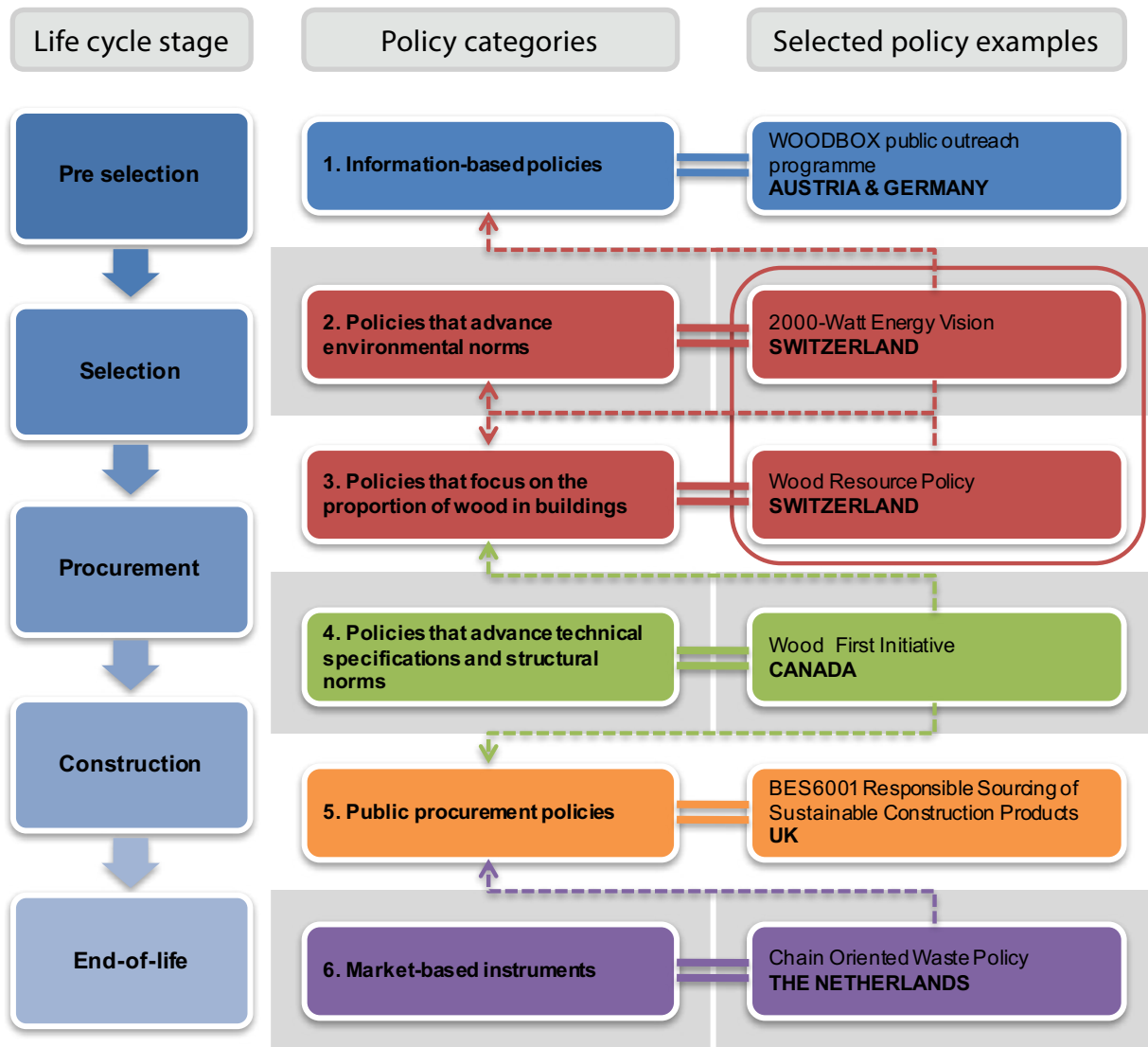
product reduction or reductions in natural resource and material use.

- The effect, if any, that the policy had on the adoption of innovative or new technologies, processes or practices.
- Any unforeseen consequences that the policy may have caused (illegal avoidance measures, etc.) and any measures that may have been deployed to address them.
- The social outcomes of the policy, such as the impact on job creation (if any).
- Where possible, the economic implications of the policy, including information about the cost effectiveness, return on investment, etc. Extracting quantitative information on the economic value of the policy may be complicated by the fact that sustainable materials policies are tending towards a broader scope, extending across multiple life cycle stages and with the objective of achieving multiple objectives.
- The extent to which they encourage the adoption of wood products.

To keep the study factual and useful, the research did not extend into evaluating what might have happened if the policy had not been implemented. Further, sustainable construction materials policymaking is a new venture in most countries and track records are, at best, short. The extent to which details of the policies can be extracted and assessed is strongly dependent on the data available in a given policy context. It is also recognised that not all of the six examples represent “hard policy”. Some of them are initiatives or programmes that are implemented on a voluntary basis or offered as “stretch” goals. Where this is the case, recommendations will be proposed, where possible, on how changes can be made to strengthen the policy implementation.

This study is intended for an audience that is familiar with policy making and the tools and mechanisms available. For background, Annex B offers a summary of the most common types of information-based, economic and regulatory policy lever in use across Europe, North America and around the world.

Figure 2: Summary of the policies selected for detailed review



Definition of sustainable construction materials

Globally, the construction industry is a significant consumer of natural resources and the pace of consumption is reaching unprecedented levels. The building sector is responsible for more than one third of global resource consumption annually,² and the manufacturing of building materials consumes about 10 per cent of the global energy supply.³ Construction and demolition (C&D) waste contributes about 30 per cent to solid waste streams in many developed countries, with most waste being associated with the demolition

phase.⁴ In the 20th century, the total natural material entering into the global economic⁵ system increased by a factor of 8, and construction materials by a factor of 34.⁶ In 1900, 33 per cent of the total non-energy materials (or non-energy carriers) were construction materials. By 1998, this number had grown to 70-73 per cent.⁷

Sustainable building materials have environmental and health merits which traditional materials have typically not considered. The production and use of these materials means less energy consumption, less natural resource depletion and pollution, and are generally less toxic for both the planet and its occupants. Ideally, sustainable materials should

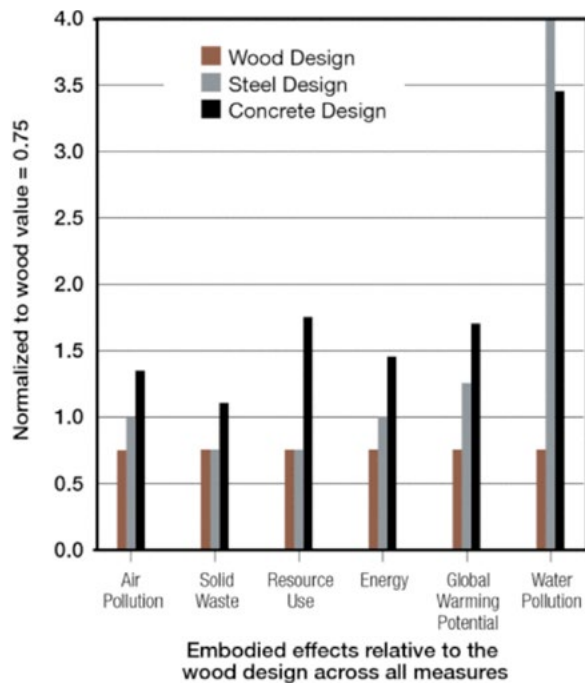
reduce environmental pressures across the entire life cycle, and not shift the environmental burden from one life stage to another. To demonstrate that a material is environmentally responsible, its impacts need to be scientifically evaluated over its entire service life from raw materials extraction through to end-of-life. The environmental and health impacts can be reduced through the following approaches:

- **Resource efficiency** can be accomplished by utilizing materials that meet the following criteria:
 - **Recycled content:** Products with identifiable recycled content including post-industrial content but with a preference for post-consumer content.
 - **Natural, plentiful or renewable:** Materials harvested from sustainably managed sources and preferably have an independent certification (e.g., certified wood) and are certified by an independent third party.
 - **Resource efficient manufacturing process:** Products manufactured with resource-efficient processes including reducing energy consumption, minimizing waste (recycled, recyclable and or source reduced product packaging), and reducing GHGs.
 - **Locally available:** Building materials, components, and systems found locally or regionally saving energy and resources in transportation to the project site.
 - **Salvaged, refurbished or remanufactured:** Includes saving a material from disposal and renovating, repairing, restoring, or generally improving the appearance, performance, quality, functionality, or value of a product.
 - **Reusable or recyclable:** Select materials that can be easily dismantled and reused or recycled at the end of their useful life.
 - **Recycled or recyclable product packaging:** Products enclosed in recycled content or recyclable packaging.

- **Durable materials** that are longer lasting or are comparable to conventional products with long life expectancies.
- **Indoor air quality (IAQ)** is enhanced by utilizing materials that meet the following criteria:
 - **Low or non-toxic:** Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.
 - **Minimal chemical emissions:** Products that have minimal emissions of Volatile Organic Compounds (VOCs). Products that also maximize resource and energy efficiency while reducing chemical emissions.
 - **Low-VOC assembly:** Materials installed with minimal VOC-producing compounds, or no-VOC mechanical attachment methods and minimal hazards.
 - **Moisture resistant:** Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
 - **Healthfully maintained:** Materials, components, and systems that require only simple, non-toxic, or low-VOC methods of cleaning.

Using environmentally responsible, low carbon materials (such as wood) in buildings has become the focus for governments committed to reducing the impacts of construction related to climate change. Trees and forest products play a critical role in helping to tackle climate change and reduce GHGs. Using wood products that store carbon,⁸ as well as responsibly managing forests in a way that balances harvesting and replanting, can minimize our carbon footprint over the long term. Living, regenerating forests sequester more carbon per unit area than almost any other type of land cover. A responsibly managed forest stores more carbon than it emits from harvesting, processing, transport and fabrication. But wood's carbon storage goes beyond the forest. When the trees are harvested and used to make wood products, the carbon remains stored in the wood for the life of the product. International scientific studies have shown time and again that using wood products from sustainably managed forests compared with

Figure 3: LCA can be used to demonstrate that wood compares favourably to other materials across a number of environmental indicators



other materials such as steel and concrete, results in a reduction of GHG emissions. A life-cycle based methodology therefore is the best way to capture all the potential environmental benefits of using wood and can show that wood can compare favourably against other materials (see Figure 3).

State of development of policies promoting the use of sustainable building materials and the use of wood

Many countries are aware of the impacts of buildings on the environment and are familiar with the principles of “green” building. However, to date, policies have focused heavily on minimizing the on-going impacts of building operations (including “in-use” energy, water use, and maintenance impacts), the promotion of specific “green” and/or “local” materials (such as wood) and on limiting the

worst effects of materials through measures such as materials bans for toxic materials (such as asbestos) and C&D waste diversion. Progressive policies are now starting to consider the upstream environmental burdens of the materials and products with which a building has been built. This is particularly important when considering the environmental benefits of wood products, which can be significant, but are difficult to fully understand without taking a holistic “life-cycle” approach.

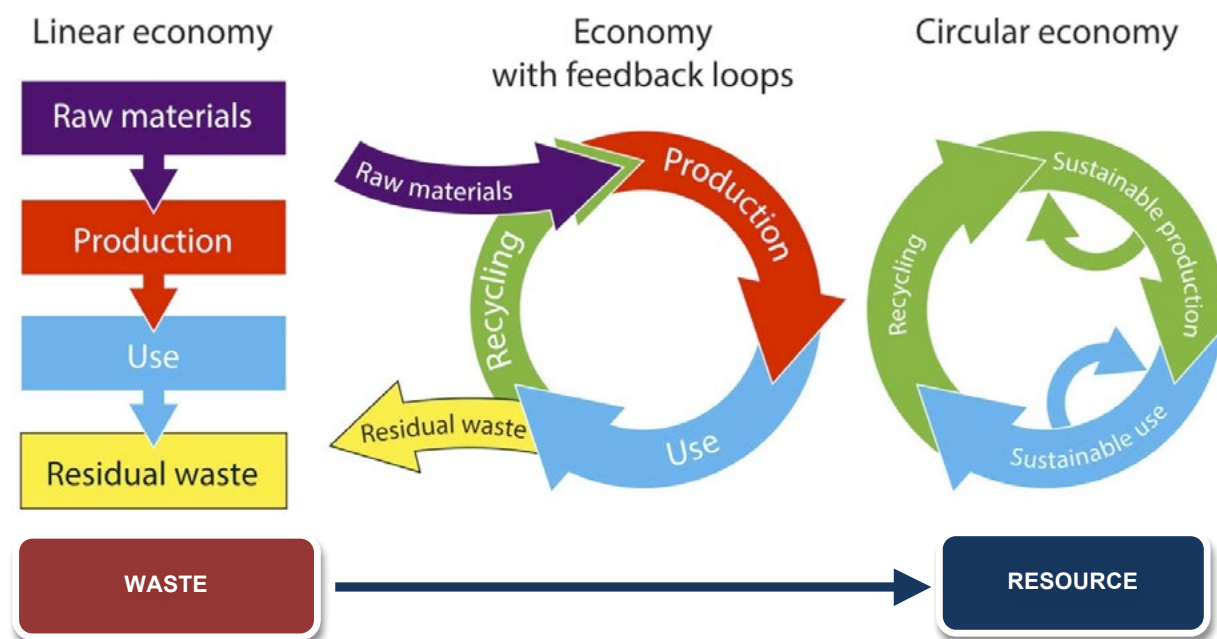
As a result, the emphasis of many policy makers is shifting, increasingly, to emphasize the effects of production and consumption on the environment, and perhaps less commonly, their social and ethical consequences. The survey responses gathered for this study concur with this perceived shift. 42 per cent of respondents stated that they had at least one policy related to the sustainable use of construction materials in effect today and a further 15 per cent were working on such a policy with the expectation that it would be implemented within the next two years (see Figure 4). The primary motivation for these policies are:

- Support GHG emission reduction and/or climate change policies
- Reduce environmental impacts of construction materials (embodied energy, water, waste, etc.), and/or
- Promote a local wood economy and culture

Figure 4: Prevalence of policies relating to sustainable building materials and the use of wood in buildings from survey

Existence of policies	Responses
We have at least one relevant policy in effect today	42
We have a policy in development and we hope that it will be implemented in the next 2 years	15
We have no plans to develop such a policy at this time	18
No response	25
Total responses	100

Figure 5: The life cycle of construction materials, transitioning from a linear to a circular economy



Some of the most progressive and effective policies that are being put in place today address the life cycle both of the materials themselves and also the building in which they are installed. Life Cycle Assessment (LCA) is an ISO-compliant state-of-the-art methodology for objectively determining the optimal choice of materials at the design stage taking into consideration the entire life cycle of the material and the building as a whole. Indeed, examples have been selected in this study to illustrate the various ways in which some countries are actively working to bring LCA into mainstream practice. A brief overview of LCA is provided in Annex B.

Green building rating systems such as BREEAM and LEED are also starting to include requirements to complete a LCA. These schemes are voluntary by nature. Generally, they are aimed towards leadership level “flagship” projects or required by regulators as “stretch” goals. The inclusion of LCA

in rating systems is primarily structured as a means to familiarize practitioners with the principles of LCA. The completion of a full building LCA is optional. While this process may be a useful first step, ultimately it does not reflect the true value and importance of LCA. It is insufficient to simply document the impacts of construction materials if those impacts are not, in fact, quantifiably reduced. The fact is that life cycle-based policies are key to the creation of a “circular economy” of construction materials (see Figure 5) in which “waste” no longer exists and the consumption of virgin materials is minimized (many of which impose high environmental impacts during extraction or manufacture). This is singularly important for the construction industry because it is not only a major producer of waste materials but also has the potential to be a primary consumer of products derived from “secondary materials” (“waste” materials which have a value in the marketplace).



POLICY 1

Information-based
policy

Policy 1: Information-based policy



The WOODBOX travelling public outreach programme

Description

WOODBOX is an initiative of proHolz Austria⁹ in cooperation with the Department of Timber Construction at the Technical University of Munich.¹⁰ With the support of the European Organisation of the Sawmill Industry (EOS)¹¹ and the European Panel Federation (EPF). WOODBOX is a compact and mobile exhibition element that can be planted directly in cities. The exhibition comprises fifty international architectural projects and is designed to illustrate the potential for forward-thinking timber architecture in Europe and to demonstrate new dimensions to the possibilities in building with wood (see Figure 6 and Figure 7).

In 2014, WOODBOX visited Bratislava, Brussels, Milan, Ljubljana and Klagenfurt. For 10 days in each location, the arrival of the exhibition was supported by a “WOODDAYS” event which features dialogues, lectures and presentations of best practices on the topics of growing cities, intelligent ways of using densely occupied space, energy efficient renovations and the creation of smart living spaces. The primary message is that wood contributes in an essential way to new, cleaner and more healthful building practices and is the focus for the green cities of tomorrow. The goal behind the WOODBOX display and WOODDAYS is to establish viable networks for the increased utilization of wood in construction and to communicate its value in sustainable building. Politics and public authorities, architecture and planning, the timber industry and building companies as well as

Figure 6: WOODBOX travelling exhibition in Ljubljana, Slovenia



Source: www.wooddays.eu

science and research were brought together to share experiences and perspectives on modern, urban wood-based construction and to learn from examples of best practices.

A key objective of the exhibition is to show how technological developments in the past several years now allow for new ways of building using wood, making this sustainable material suitable for ambitious building projects in urban areas. Growing cities create a huge demand for intelligent ways to use densely occupied space, for energy-efficient renovation and the creation of smart living spaces. The projects featured in the mobile exhibition in the WOODBOX give insight into appropriate yet exciting solutions using wood.

The architectural examples presented are designed to challenge preconceptions and show:

- Wood in unfamiliar situations, from long-span structures to high-rises,
- How wood can be applied to the expansion of existing structures.
- The compact and economic building of housing and renovations.
- The significant role wood can play in public building projects, including everything from schools to care homes.
- How the high degree of prefabrication possible with wood leads to short construction times that may well be even record-breaking.
- How timber buildings are extensions of the reservoirs of stored carbon in the form of forests. Wood-based construction allows for a secondary forest of buildings to emerge in cities and towns. Timber buildings' small carbon footprint provides an unimpeachable argument for wood as a building material when one considers the increasingly urgent questions associated with climate protection.

The majority of the model projects originate in the German-speaking countries; many of them are from Austria, which sees itself as a

pioneer in building with timber (see Annex A, 4.2 Performance-based codes and tall wood structures). Austrian know-how, as well as the specific German and Swiss experience with the material, are the starting point for the expansion of and networking between wood-based construction projects throughout Europe. The design office Gassner Redolfi¹² and Hermann Kaufmann, architect and pioneer in building with timber as well as professor in the Department of Timber Construction at the Technical University in Munich, are responsible for the idea for the WOODBOX (awarded with the European Design Award 2013) and the direction it has taken.

Impact

Moving towards the goal of increased use of sustainable construction materials requires fundamental changes in human attitudes and behaviour. Education is an essential tool for achieving sustainability. Despite the fact that the sustainability discourse has been active for several decades, sustainability remains a complex concept and so it is essential to reinforce messages, resolve disagreements and advance solutions. Further, the building industry is slow-moving and buildings take a long time to conceive, design and build.

Figure 7: WOODBOX travelling exhibition in Ljubljana, Slovenia



Source: www.wooddays.eu

Progress is thus critically dependent on a sustained advocacy and education programme for professionals and public alike in order to stimulate demand for sustainable construction materials and practices, communicate priorities and provide a long-term supportive policy environment within which researchers, manufacturers, designers and builders can confidently invest in the necessary training, business improvements and technical advances necessary to support a sustainable materials economy.

In Milan, it is estimated that an average of 250 people visited the WOODBOX for each of the 10 days that the display was open plus 450 students were given guided tours¹³ for a rough total of about 3,000 visitors. Assuming that approximately the same number of visitors participated in the other four locations, WOODBOX would have received a total of about 15,000 visitors. The WOODBOX is a distilled version of a much larger exhibition “Building with Timber – Paths into the Future” that was held in 2011/2012 in Munich and in 2012/2013 in Vienna. The number of visitors to these shows was not available.

Lessons

The costs to design and construct the project and then to transport it from Austria to five different countries are not available but are likely to be significant. Further, projects such as this need to be regularly updated and, ultimately, land will need to be provided on which to permanently locate it when the travelling is completed. Nevertheless, WOODBOX and WOODDAYS are proof of a successful international collaboration between the wood industry and government agencies whereby costs can be shared. Programmes such as WOODBOX are important to build and sustain the general dialogue about pressing issues related to the use of sustainable construction products and the role wood plays in lowering the environmental footprint of buildings. Advocacy is critical to changing business and public behaviours and an educated and engaged general population will help to drive the policy agenda forward (see Policy 2: Advance environmental norms, where 70 per cent of the residents of Zurich voted in favour of the 2000 Watt Society Energy Vision). However,

it is important that such initiatives are tactical and provide useful and timely solutions for decision-makers with clear information about how and when to choose appropriate products.

To ensure that projects such as WOODBOX lead to meaningful change, they should not be conducted in isolation but, in fact, be part of a larger strategic outreach approach that is linked to technical training and project-specific in-the-field support for the design team (see Annex A, 1.4 WoodWORKS! project-based technical assistance) and capacity-building for construction trades (see Annex A, 1.6 WoodLINKS training programme).

For most people, the decision to undertake a building project occurs very infrequently. It is therefore very important for information to complement broad-based advocacy initiatives (such as WOODBOX) with targeted information when it matters most and to those professionals who interface with the public but may be outside the core building design and construction team such as lenders, insurers, surveyors, appraisers, marketers, brokers and agents (estate agents, leasing agents, etc.). There are several “touch-points” available to policy makers when decision-makers interact with regulations or with each other that are opportunities for education. These touch-points can include:

1. Time of sale, purchase or lease of a building
2. Building regulatory approvals (building permit, demolition permits, etc.)
3. Business license application and renewal.

It can also be valuable to strengthen awareness-raising programmes such as WOODBOX and WOODDAYS with project-specific tools and resources such as product and building labelling programmes (for example, see Annex 1.2 Green Multiple Listing Service Toolkit) can be regulated and enforced (such as Energy Performance Certificates that are in effect in most European countries) that are designed to engage the public at times when they are about to make major decisions. However, in many countries, there are challenges with requiring public disclosure of such issues and there are no standards, data repositories or governing bodies to oversee the process.



POLICY 2

Advance
environmental
norms

Policy 2: Advance environmental norms



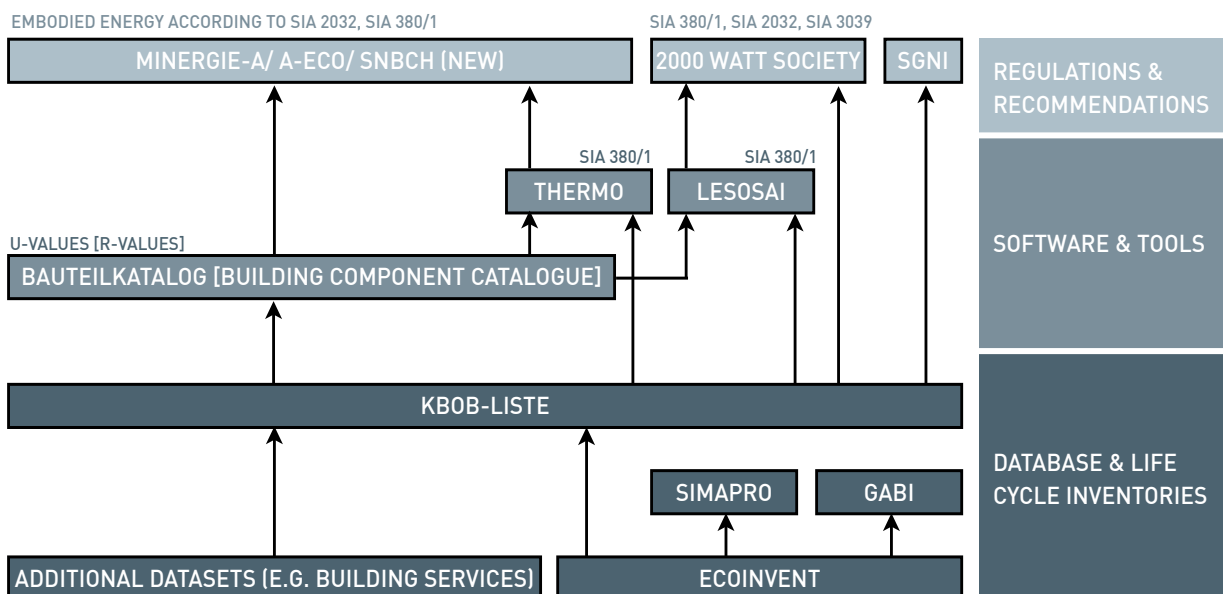
Switzerland’s 2,000 Watt Society establishes a socially equitable framework for an energy and carbon-based building policy

Description

When it comes to the successful establishment of specific carbon-based building standards that are proving to deliver measurably low-carbon buildings, Switzerland has one of the longest and most successful track records. With over 18,000 MINERGIE®-certified buildings,¹⁴ Switzerland is home to some of the most energy-efficient buildings in Europe. MINERGIE (including the more

demanding MINERGIE-P (Passive House level), MINERGIE ECO, etc.) is an energy rating standard that is used heavily to support policy directives because it is objective-oriented and focused on GHG emissions. It requires the submission of a detailed quantitative proof of “in-use” energy performance (for heating, hot water, ventilation and air conditioning). This proof is the core of the regulatory process and comprises a series of spreadsheet-based energy performance reporting forms. These calculations are based on the Swiss standards SIA 380/1 and 380/4 of the Swiss Society of Engineers and Architects (SIA). To maintain feasibility and general use, MINERGIE stipulates that the additional costs must not exceed 10 per cent of the building costs over a comparable code-compliant building.

Figure 8: Embodied energy infrastructure in Switzerland



Source: Intep LLC, Brantwood Consulting et al. "Mid Rise Multi-Residential Buildings: Operating & Embodied Energy and Carbon Framework Plan for the City of Vancouver", 2012

Building on this success, Switzerland is now implementing a life-cycle based regulatory and practical infrastructure (see Figure 8), which a science-based approach to calculate and regulate embodied energy associated with building operations, materials and construction practices. Such an infrastructure consists of a coordinated suite of:

- Regulations, guidelines and targets (SIA 2040 Energy Efficiency Path, SIA 2032 Embodied Energy of Buildings,¹⁵ the Minergie-ECO building rating standard, 2000-Watt Society, etc.)
- Software and tools (Therm,¹⁶ Lesosai,¹⁷ etc.) and
- Datasets and lifecycle inventories (Ecoinvent)¹⁸

A free online LCA-based “Bauteilkatalog”¹⁹ has also been created which offers a dynamic database of products and materials, which generates effective U-values,²⁰ grey energy (the hidden energy associated with a product, meaning the total energy consumed throughout the product’s life cycle from its production to its disposal), primary energy consumption and global warming potential and more. Information is fed into the catalogue from Life-Cycle Inventories (LCIs) and EPDs. In fact, the Swiss wood industry has coordinated information from local producers to ensure domestic wood products can be used easily in order to achieve the Swiss Wood Resource Policy target of at least 50 per cent increase in the wood content of the entire Swiss building stock (new buildings) by 2020 (see Policy 3: Focus on the proportion of wood in buildings). Designers can create assemblies and evaluate the environmental impacts over the buildings lifecycle for assemblies the designer inputs into the system (see Figure 9). The outputs are quick to access, easy to understand and provide an important resource not only for addressing functional goals while meeting GHG emission targets but also for the development of new systems and assemblies.

The impetus for a total energy/GHG impact based policy has been the adoption of the 2000-Watt Society²¹ energy vision and framework which was developed by the Swiss Federal Institute of Technology²² in order to support a balance between industrialized and developing countries

and thus make it possible for all people to enjoy a good standard of living. It proposes that if existing worldwide energy reserves were to be allocated equally on a per capita basis, then every person in every society must limit their energy consumption to a maximum of 17,500 kilowatt-hours of energy per year (global average), which corresponds to a continuous requirement of 2,000 watts (equivalent to about twenty 100W light bulbs burning per person per year). The long-term goal of the 2000-Watt-Society is therefore to achieve a sustained primary energy use of 2,000 watts per person and emissions of no more than one tonne of CO₂ equivalent per person and year by 2050.

Impact

Today, the 2000-Watt-Society plays an integral role within the Swiss regulatory infrastructure, both for building industry and the key materials manufacturing sectors (such as forestry) that support it. It takes into account the total primary energy use and total GHG emissions from all consumption sectors in Switzerland. It was piloted in Basel in 2001 and adoption has grown across Switzerland to currently encompass 20 cantons and 100 towns and cities.²³ The City of Zürich,²⁴ Switzerland’s largest city, joined the 2,000-Watt Society project in 2005. After three years of comprehensive public engagement, three-quarters of the Zürich population voted in a 2008 referendum in favour of achieving the 2000-Watt Society by 2050, which gave the programme’s goals a democratic legitimacy and enshrined them in the constitution. It is understood in Switzerland that there is a long pay back period for energy investments. It is therefore necessary to create a stable long-term policy environment in order to provide the market with the confidence required to place investments.

Switzerland is able to move forward with such a progressive life-cycle based building policy on the strength of its track record with its low energy building policies (and tools such as the MINERGIE energy rating standard). The Swiss design and construction industry is familiar with the processes and practices necessary to design, install, document

Figure 9a: Swiss online Bauteilkatalog showing summary data and global warming potential for a brick wall with exterior insulation

VUE		VALEURS D'ÉVALUATION	OUTPUT	RECHERCHE DES ÉLÉMENTS	CALCULER	ANULLER	AQ
W	Parois (homogènes)	ÉNERGIE GRISSE					
W05	Maçonnerie à simple paroi en briques de terre	ÉNERGIE PRIMAIRE PEI	aire ventilée				
exécution	Laine de verre, p 30 [kg/m3], d 0.18 m, λ 0.04	(TOTAL)					
description	Maçonnerie à simple paroi en briques de terre cuite	LIBP 2006	ziliée				
type d'élément de construction	B1 mur exposé à l'air extérieur	EFFET DE SERRE (GWP 100A)					
effet de serre (GWP 100a)	0.83						
kg/m² a, KBO/eco-bau/IPB version: juillet 2012							
coefficient U WimK	0.20						
coefficient U incl. majoration ΔU Wim2K (0.03)	0.23						

N° matériel / couche	épaisseur de couche m	lambda WimK	durée d'amortissement a	masse		fabrication		élimination		total par a	
				kg/m²	kg	%	kg	%	kg/m² a	%	
Enduit minéral	0.01	0.7	30	15.0	1.21	3%	0.07	5%	0.04	5%	
Maçonnerie en briques de terre cuite 12.5 cm [m2]	0.125	0.44	60	133.8	30.90	73%	1.22	85%	0.54	64%	
Laine de verre, p 30 [kg/m3]	0.18	0.04	40	5.4	8.08	19%	0.05	4%	0.20	24%	
vis de fixation à distance 360 mm	0	0	40	0.3	1.04	2%	0.00	0%	0.03	3%	
Lattes de bois 30/60mm [m1]	0	0.13	40	1.3	0.10	0%	0.01	1%	0.00	0%	
Bois massif épicéa / sapin / mélèze, séché à l'air, brut	0.024	0.13	40	11.3	0.90	2%	0.08	5%	0.02	3%	
majoration ΔU Wim2K [vgl./v. WB-6.2-U2 (axb=0.5)]	ΔU 0.03	0	40	0.0	0.00	0%	0.00	0%	0.00	0%	
				167	42.23	97%	1.44	3%	0.83	100%	

Source: www.bauteilkatalog.ch

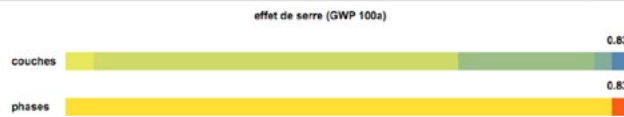


Figure 9b: Swiss online Bauteilkatalog showing summary data and global warming potential for a wood floor system

ANSICHT		BEURTEILUNGSGRÖSSE	AUSGABE	BAUTEILSUCHE	BERECHNEN	ZURÜCKSETZEN	QS
E0	Decken, Treppen und Balkone						
B101	Holzelementdecke (Holzbalkendecke beidseitig beplankt) mit zw. WD						
Ausführung	Steinwolle p 30 [kg/m3], d 0.16 m, λ 0.04 WimK						
Beschrieb	Holzelementdecke (Holzbalkendecke beidseitig beplankt) mit zwischenliegender Wärmedämmung, Trittschalldämmung, Spanplattenabdeckung						
Bauteiltyp	C2 Boden gegen unbeheizte Räume						
Graue Energie	13.95						
MJ/m² a, KBO/eco-bau/IPB Version: Juli 2012							
U-Wert WimK	0.23						

Nr. Material / Schicht	Schichtdicke m	Lambda WimK	Amortisationszeit a	Masse kg/m²	Erstellung		Entsorgung		Total pro Jahr	
					MJ/m²	%	MJ/m²	%	MJ/m² a	%
Spanplatte, UF-gebunden, Trockenbereich	0.024	0.14	30	15.6	138.15	24%	2.50	28%	4.69	34%
Glaswolle p 100 [kg/m3]	0.02	0.04	30	2.0	91.07	16%	0.49	6%	3.05	22%
Dampfbremse Polyethylen (PE)	0.0002	0	30	0.2	16.84	3%	0.06	1%	0.56	4%
3-Schicht Massivholzplatte, PVAc-gebunden	0.025	0.13	60	12.0	119.12	21%	1.68	19%	2.01	14%
Holzbohle 12/16cm [m1]	0	0.13	60	13.5	23.10	4%	1.32	15%	0.41	3%
Steinwolle p 30 [kg/m3]	0.16	0.04	60	4.8	71.85	12%	1.18	13%	1.22	9%
3-Schicht Massivholzplatte, PVAc-gebunden	0.025	0.13	60	12.0	119.12	21%	1.68	19%	2.01	14%
				60	579.24	99%	8.90	1%	13.95	100%

Source: www.bauteilkatalog.ch



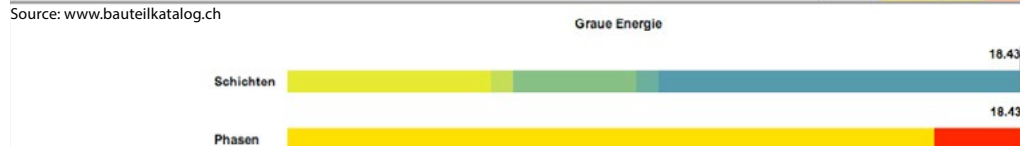
and report on “in-use” energy and GHG emission performance. Nevertheless, it is important to offer a “phased-in” approach to give the design and construction industry time to adjust. For example, the

City of Zürich has adopted the 2,000-Watt Society for its own facilities and, offers it as a voluntary “stretch” goal for other projects. In time, the 2000-Watt Society vision will be adopted into the building regulations for

Figure 9c: Swiss online Bauteilkatalog showing summary data and global warming potential for a concrete floor system

ANSICHT		BEURTEILUNGSGRÖSSE	AUSGABE	BAUTEILSUCHE	BERECHNEN	ZURÜCKSETZEN	QS		
E0	Decken, Treppen und Balkone								
B300	Betondecke, Trittschalldämmung, Unterlagsboden								
Ausführung									
Beschrieb	Betondecke, Trittschalldämmung, Unterlagsboden								
Bauteiltyp									
Graue Energie	18.43								
MJ/m ² a, KBOB/eco-bau/IPB Version: Juli 2012									
Nr.	Material / Schicht	Schichtdicke	Lambda	Amortisationszeit	Masse	Erstellung	Entsorgung	Total pro Jahr	
		m	W/mK	a	kg/m ³	MJ/m ³ %	MJ/m ³ %	MJ/m ² a	%
	Zementunterlagsboden	0.07	1.4	30	129.5	127.46 18%	24.81 23%	5.08	28%
	Dampfbremse Polyethylen (PE)	0.0002	0	30	0.2	16.84 2%	0.06 0%	0.56	3%
	Glaswolle p 100 [kg/m ³]	0.02	0.04	30	2.0	91.07 13%	0.49 0%	3.05	17%
	Polyethylenfolie (PE)	0.0002	0	30	0.2	16.84 2%	0.06 0%	0.56	3%
	Betondecke d=18cm (Fe 80kg/m ³) [m ² ±]	0.18	2.3	60	445.7	466.20 85%	84.16 77%	9.17	50%
					578	718.39 88%	109.57 12%	18.43	100%

Source: www.bauteilkatalog.ch



all buildings but before this can happen, significant groundwork needs to be completed.

To prepare the industry for this move, the Swiss Society of Engineers and Architects (SIA) has established targets, standards and protocols for implementing the 2,000-Watt-Society vision. The SIA 2040 Effizienzpfad Energie (Energy Efficiency Path) and SIA 2032 Graue Energie von Gebäuden (Embodied Energy of Buildings) technical specification and the associated documentation SIA D 0236 (2011 edition) establish a framework for the following two impact categories:

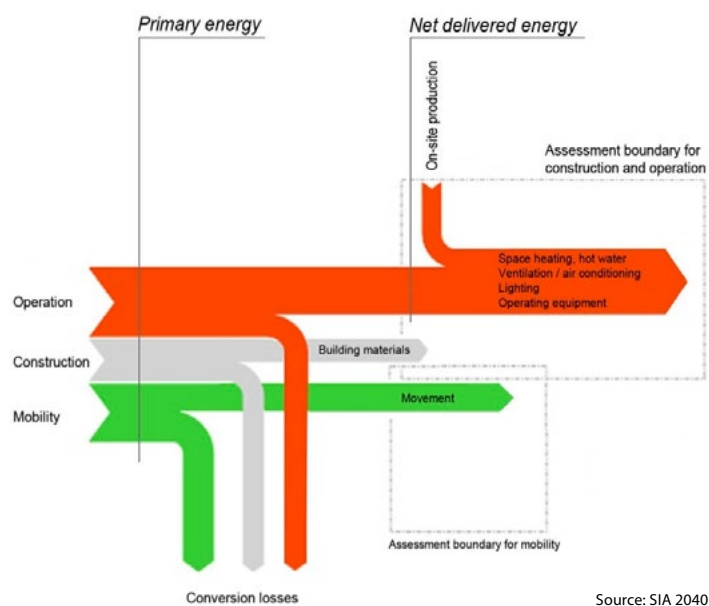
- Global warming potential measured in kg CO₂ eq./((m² yr)
- Non-renewable primary energy measured in kWh/(m² yr)

Under the 2,000-Watt Society, a building's energy and GHG footprint is deemed to include the materials and processes associated with construction, retrofits, maintenance and operation during use, as well as deconstruction at the end of its useful life. Embodied energy and associated GHG emissions from the manufacturing and transportation of building components as well as the footprint created by the building's operation are counted

continuously during the building's use. Energy and GHGs related to everyday personal travel and associated transportation infrastructure make up the transportation category and are also included (see Figure 10). All these measures are focused on driving a meaningful reduction of fossil energy use. This occurs through an associated increase of energy efficiency in all areas of usage, as well as through amplified substitutions of fossil energy with carbon neutral or minor GHG emission solutions. For this reason, all efficient, substitutive and affirmative measures should take into consideration the impact on both energy consumption and GHG emissions.

Implementation of an integrated carbon-based building policy as defined by the 2,000-Watt Society goals, requires the application of life cycle assessment (LCA) in a manner that is consistent with the design and construction process (see Annex B for a summary of LCA). Since it is impractical to include every aspect of a building in an LCA calculation, system boundaries, assumptions and limitations are developed as part of goal and scope, a standardized approach is necessary. SIA 2032 sets out impact makers - such as GHG emissions, energy use, and ozone depletion - as well as the units used for quantification - such as CO₂ eq./((m² yr), kWh, etc.

Figure 10: The 2000-Watt Society framework



delivering energy consumption and carbon emission metrics that regulators can use for community reporting and trend analysis.

The 2000-Watt Society offers a roadmap for how the role of materials can be brought into the regulatory environment. This is only meaningful to industry because the Swiss have accomplished so much in improving the in-use energy and GHG emission performance of their new buildings. The impact of materials now comprises a significant portion of the total environmental impact over a building's life cycle. Establishing goals for overall performance of materials allow designers to select the most appropriate materials for their project.

Allocation procedures, as well as the required quantity and quality of data used are also defined. The calculation of embodied energy comprises the total amount of non-renewable primary energy and GHG emissions released during its life cycle within the predefined system boundary. For policy compliance purposes, the calculation of GHG emissions for embodied energy is based on the development and adoption of four factors that are established regionally to ensure fairness, parity and comparability:

- Impact categories
- Useful life of buildings, products and building materials
- Life cycle system boundary
- Building component system boundary

These factors are consensus-based and developed, updated and reviewed by experts from the product manufacturing industries and energy utilities, thereby establishing a consistent approach to policy administration and performance comparability. In fact, SIA 2040 provides benchmark performance criteria for a wide range of energy sources, equipment and appliances to ensure consistency for all calculations and models. With common information in place, energy ratings for buildings can be created prior to occupancy,

On the strength of wood's low carbon footprint, designers that use wood in their projects may be able to achieve their 2000-Watt Society goals a little more easily than by using other materials, or trade-off the benefits of wood with other materials that may be necessary for their particular project.

The Swiss wood industry certainly believes that there is a valuable role for local wood to play in achieving the 2000-Watt Society energy vision and the Swiss Wood Resource Policy and Action Plan have been organized in a manner that aligns with, and supports, the 2000-Watt Society (see Policy 3: Focus on the proportion of wood in buildings).

Lessons

Developing and implementing a life-cycle-based building policy is a significant undertaking and requires substantial investment and sustained commitment by government, utilities, researchers and industry stakeholders. Switzerland has a long track record of leadership in this area and the implementation of these policies mean that Switzerland is now home to some of the most advanced life-cycle inventories, tools and expertise which are now being leveraged for application elsewhere.

Swiss practices were identified for their relevance and replicability in jurisdictions interested in advancing an integrated, performance-based policy environment. They have the ability to:

1. Define energy system boundaries and energy flow in order to create strategic clarity of carbon emission impacts of buildings
2. Identify and define building energy consumers (heating, lighting, materials, etc.), their respective utilization levels and drivers (building design versus occupant behaviour) in order to create clarity of accountability for regulatory purposes
3. Introduce the principles of primary energy factors and GHG emission coefficients to consistently and quantitatively describe the scope of GHG emission impacts of buildings
4. Propose concise, measurable and comparable energy and carbon performance targets that meet the intent of municipal low carbon goals and are simple, fair, measurable and enforceable, yet offer flexibility to industry
5. Introduce the principles of low carbon design to industry stakeholders and the public.

Yet many complexities remain. For example:

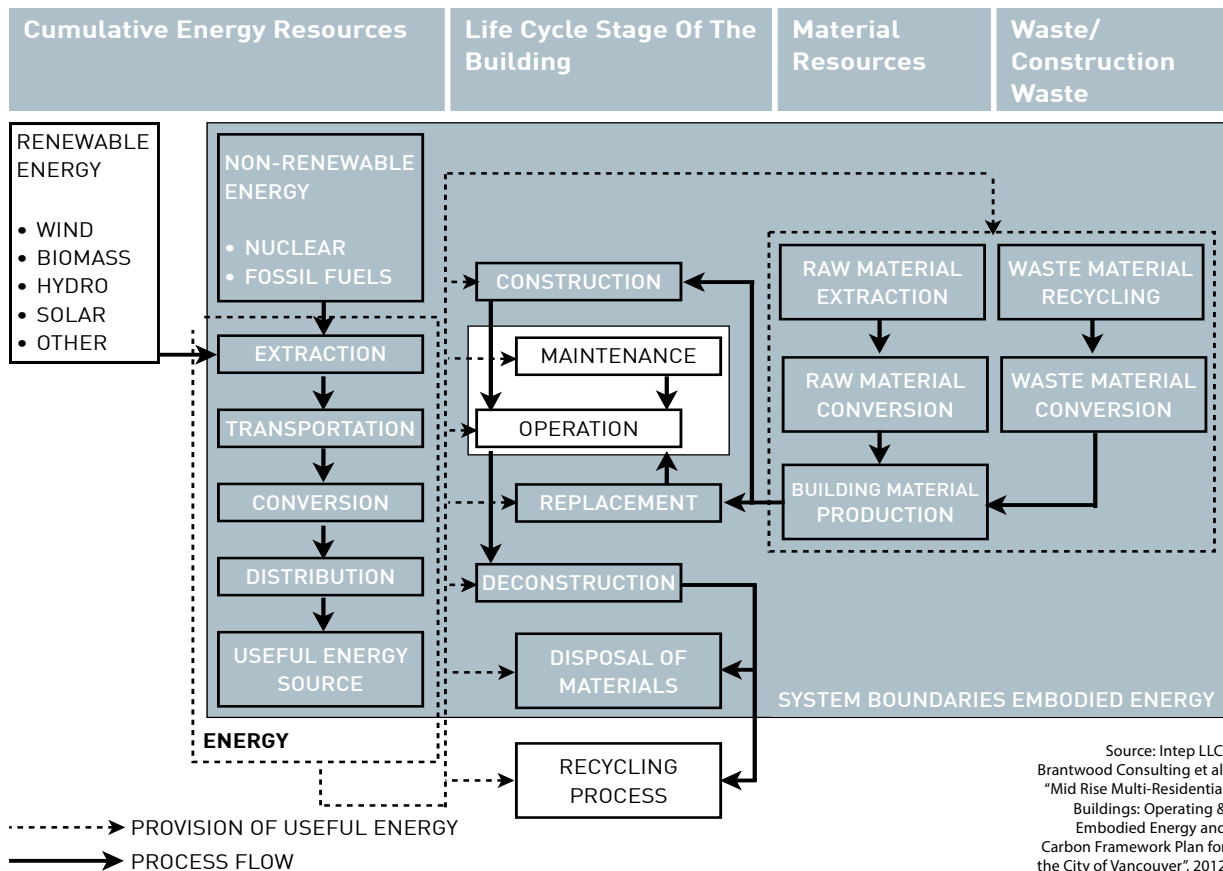
- In order to fairly compare embodied energy and operating energy in different buildings, all data is benchmarked against the number of years (total divided by lifetime of the building) and gross floor area (in order to normalize results). The useful life of a building needs to be defined in order to quantify the embodied energy markers and define target values.
- The useful life of building materials varies greatly. Structural components and insulation typically remain in use for the entire life of a building, whereas roofing, siding, windows, paint and HVAC systems will all likely be replaced once or even several times during the same time period. Replacement of products and materials has a significant impact on embodied energy. The Zürich framework is based on a cradle-to-grave approach with a system boundary (Figure 11).

- Defining the system boundary for building components is extremely complex, and it is virtually impossible to account for every resource that goes into a building over the course of its life cycle. It is therefore important for policy makers to establish limitations and assumptions for the building component system boundary. Components that do not vary much from one project to the next can be accounted for using either calculations or prescriptive methods. In an effort to simplify the verification process it makes sense to omit life cycle stages with minimal impact, and those for which data is not readily available.
- Currently, the policies do not specifically address the on-going operation and maintenance of the existing building stock.

Public education efforts are as important as developing industry capacity and expertise. Public awareness needs to be raised and sustained on a long-term basis. The City of Zürich invested in three years of comprehensive public engagement to educate citizens about climate change, energy security, and the future availability of energy supplies leading up to a 2008 referendum at which, three-quarters of the population in favour²⁵ of joining the 2,000-Watt Society project. The vote gave the programme's goals a democratic legitimacy and enshrining them in the constitution. Since then, regular events to increase public awareness continue to be held, such as annual environment days and the Zürich Multimobil action days where the inner-city is closed to cars.

Such ambitious regulatory reform needs to be equipped with powerful tools and technical resources. Switzerland's success has been built upon globally equitable long range targets, performance-based regulations, supported by a full suite of software tools, databases of materials, catalogues of assemblies and verification tools to assist the project team throughout the building design process. The Swiss LCA software tool, Lesosai, is in use in many countries across Europe. It offers both thermal performance and embodied energy/carbon impact calculations. Lesosai is underpinned by a large database for commonly used materials in Europe and the associated

Figure 11: Lifecycle system boundary of a building as applied within the Swiss building policy framework



life cycle impact data ('Liste Ökobilanzdaten' published by KBOB/ recommendations of sustainable construction and elaborated with data from ecoinvent). Boundary conditions are set in accordance with SIA 2032. For example, the Public Waste Agency of Flanders (OVAM) has relied heavily on the Swiss experience and harmonized the life-cycle data for their LCA based evaluation methodology with ecoinvent (see 2.1 Materials Awareness Policy and the "Environmental Performance of Materials used in Building Elements" method in Annex A).

There is a great deal of merit in establishing aspirational goals around which policies and programs can be structured. The fact that the 2,000-Watt Society's is rooted in a philosophy of global equity and social justice has proven to be compelling to businesses and public alike. In Switzerland, appreciation of the value of low impact materials such as wood, as articulated

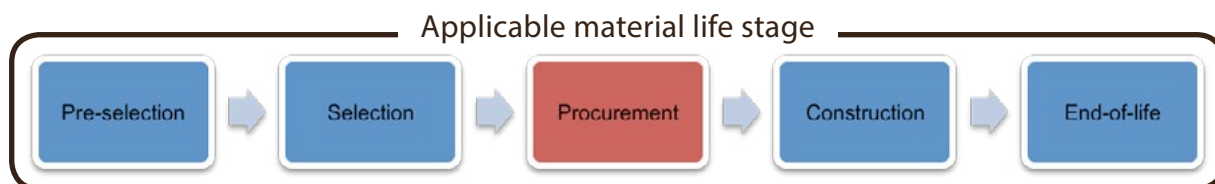
through the 2000-Watt Society vision, has encouraged the implementation of materials specific policies and the "trickle-down" effect of the vision has borne fruit. In particular, the Wood Resource Policy²⁶ was launched in 2011 and sets targets for the use of sustainable wood products at home and overseas for the period 2009 - 2016. The purpose of the policy is to support the consistent and sustainable harvesting of wood from Swiss forests and the resource-efficient use of the raw material wood. A Wood Action Plan²⁷ was launched in 2014 to facilitate the target-oriented implementation of the Wood Resource Policy. The priority in the implementation of the policy is the ecologically and economically sound use of wood. The Federal Office for the Environment (FOEN) acts as the lead agency for this policy in coordination with the relevant partners. The FOEN is committed to a long-term perspective and has the task of taking the different societal interests in relation to the forest and the raw material wood into account.



POLICY 3

Focus on the
proportion
of wood
in buildings

Policy 3: Focus on the proportion of wood in buildings



Switzerland's Wood Resource Policy and Wood Action Plan

Description

Many countries have developed policies designed to promote the use of wood in buildings, primarily for the purpose of supporting their domestic forestry economies. The purpose of the Swiss Wood Resource Policy²⁸ is to encourage the consistent and sustainable harvesting of wood from Swiss forests and the resource-efficient use of wood as a raw material for a range of products. However, it is interesting for the fact that not only does it set clear performance targets and timeframe for the Swiss wood industry, but also for how it is informed by (and informs) broader national and regional energy and climate goals. The Swiss Federal Office for the Environment (FOEN) acts as the lead agency for this policy in coordination with the relevant partners. The FOEN is committed to a long-term perspective and has the task of taking the different societal interests in relation to the forest and the raw material wood into account. The policy is based on a vision whereby:

- Wood becomes a determinant of quality of life in Switzerland and the national culture in construction and housing .
- The forestry and timber industry make an essential contribution to the policy objectives of the federal government on energy, climate and natural resources.
- The value creation chain, from the tree to the finished product, promotes international

competitiveness and environmental compatibility.

This vision is reflected in the following five policy objectives (see Figure 12):

1. Using efficient forestry practices, fully utilize the potential of producing sustainable wood products from Swiss forests
2. Increase domestic demand for wood and wood products, especially for products from domestic forests.
3. Develop bio-fuel energy generation potential, ensuring that wood is sourced and used sustainably, cleanly and efficiently.
4. Strengthen the innovation capacity of the forestry and timber products industries.
5. Through close coordination, ensure that the Wood Resource Policy contributes significantly to the success of other sectoral policies.

On average, about 5 million m³ of wood is harvested annually in Switzerland.²⁹ According to the FOEN, the domestic construction sector is the largest consumer of Swiss wood products and buildings provide the most important opportunity for wood to showcase all of its potential benefits as a sustainable, durable and beautiful material. Although many traditional Swiss buildings are built of wood, the majority of larger more recent buildings are concrete and the use of wood has tended to be restricted to small residential projects. Increasing the proportion of wood content in the Swiss building stock is an important goal for the Wood Resource Policy. There is particular

emphasis on expanding the role of wood into non-traditional sectors such as taller buildings, non-residential buildings, etc. (see Figure 13). To this end, the Wood Resource Policy aims to facilitate an increase in the wood content of the entire Swiss building stock by at least 50 per cent (new buildings) by 2020. Key to this goal is to leverage other policies related to the energy efficiency and environmental performance of buildings and, in particular, to position wood as a means to achieving the 2000-Watt Society Energy vision (see Policy 2: Advance environmental norms).

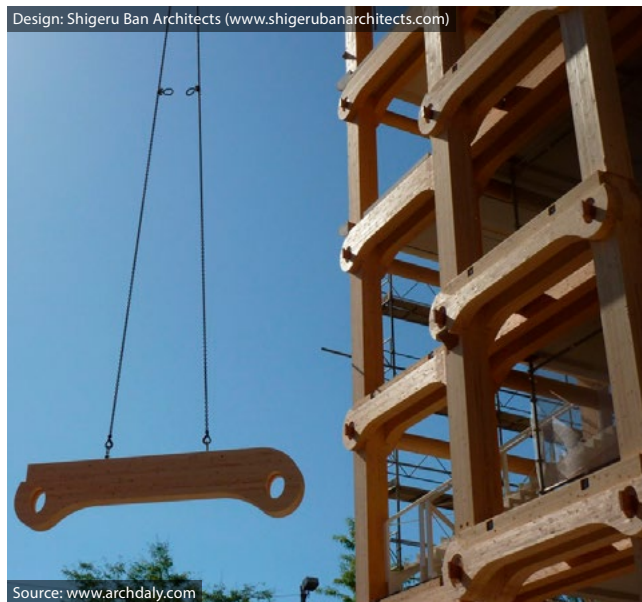
The goals of Wood Resource Policy are delivered through the Wood Action Plan.³⁰ The priority in the implementation of the policy is the ecologically and economically sound use of wood, in particular, the plan aims to establish:

- Base data including knowledge transfer (economic data, applied technical data, life-cycle considerations)
- Mobilisation of Swiss wood (concept implementation)
- Raising awareness among the general population and the institutional building sector

Figure 12: Objectives, indicators and metrics for the Swiss Wood Resource Policy

Objective	Indicator	Target value
The sustainably harvestable wood production potential of the Swiss forest shall be exploited to the full by an efficient Swiss forestry sector.	Volume of wood harvested (national level)	Exploitation of the wood harvest potential of around 8.2 million m ³ /year (compact wood, including bark and branch brushwood; derived from annual increment) ³¹
Demand for material wood products in Switzerland shall increase, with particular emphasis on wood from Swiss forests.	Per-capita consumption of sawn wood and derived timber products	20% increase in the per-capita consumption of both sawnwood and derived timber products Sawnwood: from 0.24 m ³ per capita (2006) to 0.29 m ³ per capita (2020) Wood derivatives: from 0.09 m ³ per capita (2006) to 0.10 m ³ per capita (2020) ³²
	Proportion of wood in the entire Swiss building stock (new buildings and "Bauen im Bestand") ³³	At least 50% increase in the wood content of the entire Swiss building stock (new buildings) SFD: from 11.4% (2005) to 17% (2020) MFD: from 3.6% (2005) to 8% (2020) ³⁴
The use of fuelwood shall increase while taking the principles of sustainable use and efficient and clean exploitation into account.	Volume of forest fuelwood harvested	Exploitation of the harvesting potential of around 3.1 million m ³ /year (compact wood, including bark and branch brushwood; derived from annual increment) ³⁵ or 8.3 TWh.
	Fuelwood harvested from non-forest sources (slash, old wood, wood residues from sawmills)	Exploitation of fuelwood harvesting potential outside the forest of around 2.9 Mio. m ³ /year or 7.8 TWh of heat and power
The innovation capacity of the wood value-added chain shall increase.	Research capacity (human resources, finance), number of innovative projects, patents, awards	
The Wood Resource Policy shall make an important contribution to the fulfilment of the objectives of other sectoral policies through optimum coordination.		

Figure 13: The Tamedia office building under construction in Zurich, Switzerland illustrates its innovative pre-fabricated wood structural system



- Hardwood use (applied R&D, innovation promotion, knowledge transfer)
- High-volume timber construction systems in specific areas “Bauen im Bestand” (applied R&D, innovation promotion, knowledge transfer)
- Framework conditions, coordination with partners
- Project funding from the Wood Action Plan

Seven thematic focuses contribute to the implementation of the objectives of the Wood Resource Policy. Promotional and research projects that correspond to the following thematic focus areas are supported:

1. Data: support for knowledge transfer, the publication of relevant data on wood volumes, wood utilization potential, utilization strategies and the life-cycle of wood as a material and energy source (life-cycle assessment)
2. Provision of information for and raising awareness of forest owners (mobilization of raw wood re-serves)
3. Provision of information for and raising awareness of the general public on the topic of “increased wood utilization – coordination with other forest functions

4. Development of innovative concepts for increasing the possibilities for the recycling and use of hard wood
5. Further development of energy-efficient and large-scale timber construction systems, use of wood in renovation projects
6. Raising of awareness of institutional end users in relation to timber structures and wood energy
7. Design of general conditions and coordination with relevant partners on topics concerning wood

The Wood Action Plan implements the objectives as packages of measures. Together with the forestry industry, governments and other partners, the programme provides information, gives new impetus and supports pioneering projects. In fact, a key to the success of the Wood Action Plan is the linkage to Switzerland’s green public procurement (GPP) initiatives. Annually, the value of public procurement in Switzerland stands at around 32 billion Swiss francs, or 8% of GDP,³⁶ offering immense power to shift markets. Domestic and sustainably sourced wood products can help Switzerland achieve its GPP priorities. For example, the canton of Bern specifically promotes the use of wood in public buildings.

Overall, government involvement in the context of the Wood Action Plan focuses on accompanying and supporting instruments, which create the preconditions and bases necessary to achieve the formulated objectives. These include in particular:

- Information (base data and decision-making bases)
- Consultancy and awareness-raising
- Applied research and development
- Education, further training and knowledge transfer
- Coordination and consultation
- Regulatory instruments (laws, standards, incentives)

A key element of the Wood Action Plan is the funding programme. The FOEN may consider any proposed project proposed by professionals, wood and forest cantons or by universities and decides the allocation of financial support. Project proposals should be directed towards a number of defined measures (such as the creation and expansion of materials and product databases and catalogues (such as the online Bauteilkatalog illustrated in Figure 9), increasing the uptake of the Swiss wood, building awareness of the value of wood among institutional building owners, the development of hardwood timber construction systems for large volumes). Depending on how much funding is being requested, different procedures apply. Contracts can be awarded directly, without calling for tenders for the purchase of goods up to 50,000 francs or for the purchase of services up to 150,000 francs (purchase of services). Limited tenders (at least invited participants may be offered for contracts up to 229,000 francs. Open tenders may also be offered for contracts over 230,000 francs. Funding may be provided for up to 50 per cent of the total value of the project. Projects that are eligible for funding should meet all of the following eligibility criteria:

- Match their theme to at least one of the six priority actions of the wood action plan and contribute to the achievement of relevant policy objectives of the timber resource
- If the project includes any element of research and development, then this needs to be described conceptually along with the relevance of the results of the project and how transfer of knowledge to practice or target groups will be undertaken
- Be supported by business partners involved in the process and funding
- Provide any communication operations to disseminate the results
- Display a proper balance between costs incurred and contribution to the achievement of objectives
- Contain a credible budget
- Reveal all sources of funding.

Impact

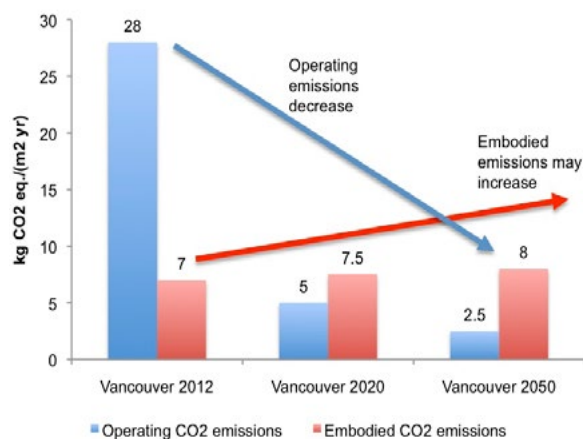
Switzerland has experienced a high level of general building activity in recent years which has helped to drive market adoption of wood construction. Also, the development of the new fire safety regulations for multi-family dwellings initiated as part of the holz21 programme³⁷ opened up the market for wood in new construction forms for the first time. For example, since the new fire safety regulations came into effect in 2005 around 1,500 multi-storey wood-framed buildings have been completed in Switzerland.

From 2009 to 2012, the Swiss Wood Action Plan initiated and supported projects related to wood. There are a few projects on technical noise protection and fire safety that are still running under the umbrella of the Wood Action Plan. It is expected that these projects will continue to have positive impacts on the development of fire safety regulations and, overall, will boost the demand for wood. It may also be assumed that based on its advantages in the areas of renovation and refurbishment, wood will also benefit from a government building programme initiated by the federal authorities and cantons in early 2010.

An evaluation showed that the measures carried out under the Wood Action Plan had generated positive stimulus for the timber sector, e.g. for timber construction through the development of fire protection and sound-proofing systems. The sector could not have achieved this under its own steam. These results show that the priorities of the first Wood Action Plan, as the principles governing its implementation remain relevant. Therefore, a further CHF 4 million per year is being made available for the implementation of the Wood Action Plan³⁸ and the plan has not been overhauled, but just updated with a few new points.

The Swiss wood industry has seized the opportunity to position wood as a “material of choice” in GPP policies and as a means to manage the embodied energy and environmental performance of buildings. These drivers have provided clear long-term direction for the industry.

Figure 14: Relationship between in-use and embodied GHG emissions (example for multi-family residential buildings modelled for 60yr service life)



Source: Intep LLC, Brantwood Consulting et al. "Mid Rise Multi-Residential Buildings: Operating & Embodied Energy/Carbon Framework Plan for the City of Vancouver", 2012

Conversely, the Swiss 2000-Watt Society (see Policy 2: Advance environmental norms) promotes a life-cycle based building policy that must, by definition, draw upon materials policies, such as the Wood Resource Policy, which clearly articulate the characteristics and benefits of the materials that can contribute to this vision.

In fact, a 2012 research study completed for the City of Vancouver, Canada³⁹ explored the potential for applying the life-cycle based Swiss 2000-Watt Society goals. The study was funded by Forestry Innovation Investment Ltd, the British Columbian wood marketing agency,⁴⁰ which also recognizes the potential market for wood in a future where the environmental performance of buildings is determined on a life cycle basis.

The research modelled the effects of achieving the in-use emission goals of 5kgCO₂e/m²/yr on embodied emissions in order to demonstrate the necessity of regulating both embodied and "in-use" impacts (see Figure 14). The reason for why, uncontrolled, embodied emissions may rise is that operationally efficient buildings may require more materials during construction (such as thicker walls, more insulation, triple-glazing, etc.) which then also requires more materials to be repaired

and replaced during its service life. The research also showed that as buildings become increasingly energy efficient in their operations, the impact of materials on the overall environmental "footprint" of the building becomes greater. In fact by the time buildings are operating at the levels of energy efficiency envisaged by the "carbon-neutral" regulations already proposed by many countries,⁴¹ the embodied impacts of materials will have a greater impact than operating or in-use impacts of the building's life cycle.

To provide designers with flexibility, a combined policy target that establishes a total limit for both "in-use" and embodied energy and GHG performance may allow trade-offs between the type of materials selected and the energy systems. Thus, a building constructed out of relatively high impact materials would have to employ a much more energy efficient system than a building that was built out of low-impact materials. A whole building LCA would be necessary to demonstrate compliance with such a target. However, this is the direction in which visions such as the 2000-Watt Society are heading. To this end, Swiss policy makers established clear objectives, indicators and targets for the Wood Resource Policy (see Figure 12), which not only establishes goals for the forestry industry but also does so in language that synchronizes with the 2000-Watt vision.

Lessons

Although it is early days for the new Wood Action Plan, the results of the evaluations so far are generally positive and the FOEN is committed to continuing support for the Plan until 2016. A challenge to increasing the proportion of the Swiss building stock accounted for by timber-framed structures as described by the Wood Action Plan is that Switzerland cannot meet this demand purely from domestic forests and local wood processing capacity. There is therefore an increasing reliance on imported wood products. While the strength of the Swiss franc makes imported wood products affordable, this does not necessarily stimulate the investment in local production capabilities necessary to fill the gaps in the local wood value-added supply chain in Switzerland.

For life-cycle based building policies such as the 2,000-Watt Society to be supported by product manufactures and be implemented effectively, it is important that complementary measures, such as the Wood Resource Policy and Action Plan, are in place to:

- Encourage designers to adopt new or unfamiliar products and techniques
- Help manufacturers focus their R&D investment and market their products effectively
- Provide confidence to builders and trades to invest in the necessary equipment and training and
- Direct the supporting efforts of professional training institutions, lenders and other industry stakeholders.
- Reinforce policy goals and convey a consistent message

For example, there is a number of federal aid programmes to support R&D within both the forestry and the building sectors, such as:

- Fund for Forest Research and the use of wood: FOEN provides funding for projects related to “Forest Applied Research” (R&D)⁴²
- “Reform of the financial equalization and the division of tasks between the Confederation and the Cantons” (RPT) forest management subsidy: offers financial benefits related to forest protection, forest biodiversity and forest management.⁴³ Environmental research and promotion of environmental technologies: FOEN supports projects and activities in the field of technology and environmental research in close collaboration with research institutes and economic enterprises.⁴⁴
- National Research Programme “Wood Resource Innovation” (NRP 66): is under the responsibility of the Swiss National Science Foundation⁴⁵ and provides a scientific basis and practical solutions to optimize the availability and expand the use of wood resources.

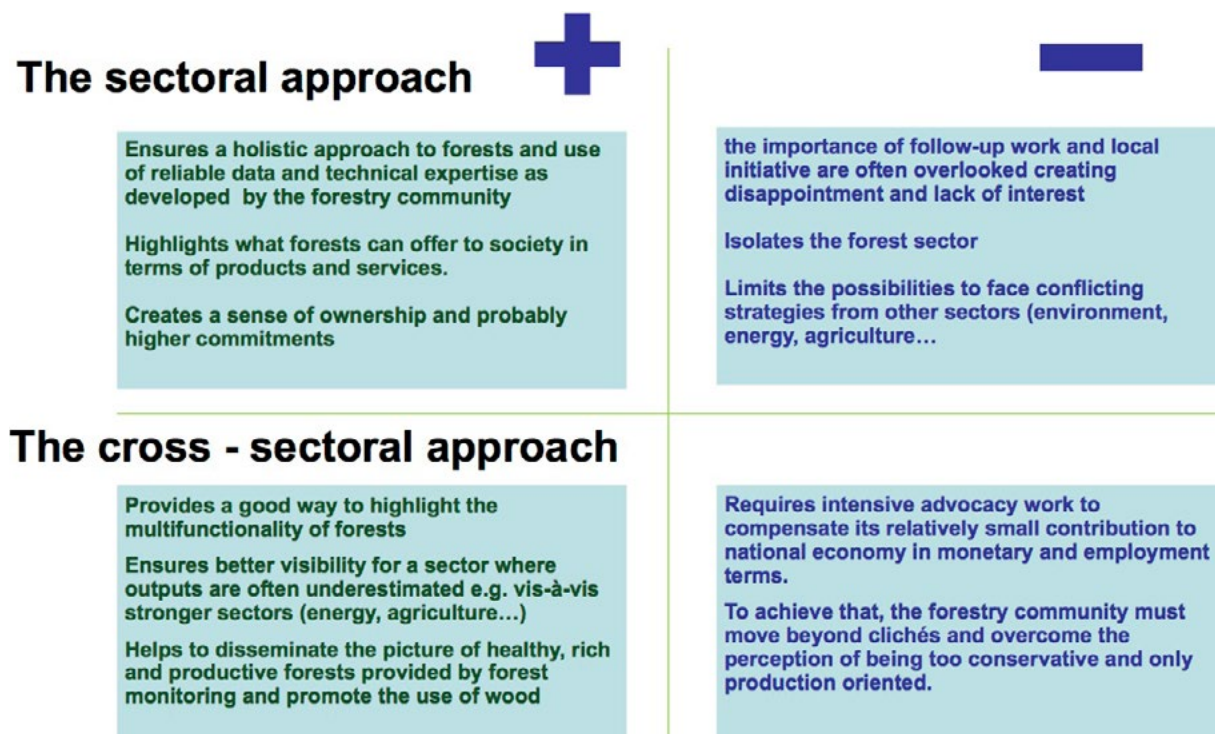
- The Commission for Technology and Innovation (CTI) is the agency of the Swiss federal government to promote innovation. It encourages the transfer of knowledge and technology between universities and businesses and aims to achieve the greatest effect on the market. Its aim is for knowledge from laboratories to be promptly applied as products and services.⁴⁶

Wood has multiple points of intersection with the Federal Office of Energy (FOE) and the State Secretariat for Economic Affairs (SECO), which are, in turn, guided by the 2000-Watt Society energy vision. Programmes include:

- Direct the supporting FOE offers a number of action plans for energy efficiency and renewable and the “Energy in Buildings” research programme⁴⁷
- A new regional energy policy administered by SECO⁴⁸

The Swiss recognize how intertwined the forestry and building industries are and how the prosperity of each relies on that of the other. They have been very successful in developing a package of cross-sectoral, mutually reinforcing policies, programmes and funding initiatives that provide an overarching long range vision and clear targets backstopped by a full suite of technical resources and financial levers to move the Swiss building industry towards low impact buildings, to appreciate sustainably sourced wood as a low carbon construction material and to incorporate as much of it as possible into new buildings and renovations. The cross-sectoral approach to forestry policy making espoused by Switzerland requires intensive advocacy and relies upon a progressive forestry industry that looks beyond production outputs. A comparison of the traditional sectoral approach and the cross-sectoral approach is presented in Figure 15). Underpinning the success of such policies is the ability for all stakeholders to work together closely and constructively for sustained periods of time. This can be challenging given short-term political timeframes, different alignments of business cycles, budgetary pressures and other external and logistical factors.

Figure 15: A comparison between a sectoral approach and cross-sectoral approach to forestry policy



As discussed under **Policies that advance environmental norms: The 2000–Watt Society Energy Vision**, these accomplishments are built on a long track record of progressive policy making and many years of experience building some of the most energy efficient buildings in the world. Given these facts, the relatively short-term rate of renewal of the Wood Action Plan of 3 years (2009 to 2012 and 2013 to 2016) seems to be uncharacteristic. Certainly, language in the policies themselves suggest that the effects can be expected more in a long-term perspective and accept that it can sometimes be difficult to separate the effects of the policy and actions from market effects.

The degree to which the Swiss success story may be translated to another jurisdiction depends on the strength and persistence of that government’s commitment and leadership. Certainly, there are a number of countries that have developed (or are developing) similar policies (such as the

“Wood First” Policies in British Columbia and Quebec, Canada discussed in Policy 4: advancing technical specifications and structural norms, as well as examples from Finland, France, Norway and USA presented in Annex A under 3. Policies that focus on the proportion of wood in buildings) and some have studied the Swiss experience carefully, leveraging tools and resources where possible. It should also be noted that the Swiss are culturally more predisposed towards law-making and, as a society, are more engaged in the political process than many other nations. The application of such a comprehensive suite of policies (and the investment in all the supporting tools and resources such as databases, education and training, standards development, etc.) may therefore be challenging for other countries, particularly those with multiple levels of government (e.g. local, regional, state/provincial, federal) where jurisdictional boundaries may not be clearly defined and where there are administrative silos between different departments and agencies.



POLICY 4

Advancing
technical
specifications
and structural
norms

Policy 4: Advancing technical specifications and structural norms



“Wood First” Policies in British Columbia and Quebec, Canada

Description

Canada is a major wood-producing nation and policy makers have made the link between the economic vitality of their forestry industry and the use of wood in buildings at home and abroad. The provinces of British Columbia (B.C.) and Quebec rely on their forestry-based economies for employment and prosperity. For example, the forestry sector employs almost 60,000 British Columbians and generates an annual manufacturing output of over Can\$12 billion. More than 40 per cent of regional economies across the province are dependent on forestry. Of the 59.1 million hectares of forestland in B.C., 55.2 million hectares (93 per cent) are publicly owned.⁴⁹

In 2009, the B.C. Government amended its building code to allow six-storey (mid-rise) wood-frame residential construction for the first time in Canada: the previous limit was four storeys. More than 150 mid-rise wood frame projects have now been completed, planned, or are under development. The impetus for this code change was the introduction of the Wood First Initiative (WFI) to promote a “culture of wood” in the province. Also in 2009, the Wood First Act was enacted by the B.C. Government to position wood as the primary choice for building material in provincially funded buildings. Together, these actions have expanded the use, application and development of wood technologies and wood

products in B.C. Wood First is part of the B.C. Jobs Plan, which is the government’s strategy for spurring economic activity and job creation throughout the province.

In 2011, Forestry Innovation Investment Ltd (FII) assumed management of the WFI. FII is the Government of British Columbia’s market development agency for forest products with the mission to help keep the B.C. forest sector growing by bringing competitive products to the world and playing a leadership role in the development of new technologies and solutions.⁵⁰ A Wood First Advisory Committee was established to provide strategic guidance on the priorities for the WFI. The committee includes a broad cross-section of representatives from value-added wood processing sector and wood products end-user communities. Presently, the strategic objectives for WFI are:

- Grow the culture of living and building with wood in B.C. and beyond.
- Maximize the appropriate use of wood in public and private projects.
- Strengthen B.C.’s capacity to produce high quality wood-based products and building systems.
- Accelerate adoption of existing and emerging wood-based products and building systems.
- Position B.C. as a world leader in the design, production and application of sustainable and innovative wood-based products and building systems.

The WFI is delivered mainly through activities and programmes proposed and managed by trade associations, knowledge centres and educational institutions. Service delivery partners are selected through an annual competitive proposal-call process. FII also delivers some activities directly. Programmes under Wood First include marketing and outreach, education and skills development, strengthening manufacturing capacity, research and innovation, reducing barriers to wood use, and providing support to decision makers for policies on wood use.

In June 2014, the B.C. government reiterated its commitment to Wood First by investing Can\$2.14 million to advance the use of wood in B.C. with a focus on expanding the use of wood in non-residential construction, strengthening manufacturing capabilities, and positioning B.C. as a global leader in wood design technologies. Funding is being provided to industry trade associations and research institutions with proven records in wood products marketing, training, wood products development and research.

The story is similar in Quebec, although the timeline is a little different (B.C. is further ahead). Directed towards non-residential and multi-family residential projects, the main objectives of the La Charte du Bois du Québec (the Quebec Wood Charter)⁵¹ is to increase wood use in the Quebec building sector and to decrease greenhouse gas emissions associated with this sector. The Charter also aimed for developing wood products with high value added. There is no obligation imposed on the designer, only measures to facilitate the use of wood material, specifically for the public buildings. The Charter is administered by the Ministère des Forêts, de la Faune et des Parcs. The Quebec Charter is not in full effect yet.

Impact

“Wood First” initiatives in key wood producing provinces such as B.C. and Quebec aim to not only increase the proportion of wood in buildings locally and build local expertise in the design, construction and manufacture of innovative wood products and

structures, but also to stimulate the adoption of innovative wood technologies for showcasing to international markets. This approach is particularly applicable to countries with large forestry resources but small domestic markets.

In the five years since Wood First was introduced in B.C., the use of wood in building construction has grown rapidly, particularly in the multi-storey residential market and in institutional and recreational buildings. New approaches to building with wood have been developed, such as the iconic wood roof of the Richmond Olympic Oval (see Figure 16), and there is the potential to use wood in much taller structures. The Wood Innovation Design Centre in Prince George,⁵² is currently one of the tallest contemporary wood buildings in North America but will soon be overtaken by an 18-storey building which is being planned for the University of British Columbia and which will be the tallest wood structure in the world.

The Quebec government is actively promoting the construction of wooden buildings of five or six floors. To do this, the Régie du Bâtiment du Québec proposes to amend the regulations by the end of 2013 to allow the construction of such buildings. The result has been the development of a number of mass timber structures using innovative structural technologies, in particular the combined use of wood with other materials such as hybrid and composite structures. In addition, allowing the construction of taller wood buildings is hoped to also have the advantage of limiting urban sprawl.

In Quebec, education and centres of expertise institutions will be asked to provide training on wood and use in structures. These institutions will also promote so that professionals, such as architects and engineers acquire the knowledge latest on the use of wood as a structural element. Through this charter, the Quebec government also plans to foster conditions conducive to research and innovation with a particular focus on the development of wood products with high value added, the use of wood in systems construction and the design of green buildings.

The success of programmes such as Wood First and the Wood Charter relies on the close

collaboration or a number of industry and government stakeholders. The North American forestry industry is large with long standing commercial relationships particularly between Canada and U.S. Both countries have a number of government agencies and NGO's, which work closely together to advance the use of sustainable wood construction materials. In B.C., the Wood First Initiative has enabled FII to create close partnerships with the Binational Softwood Lumber Council⁵³ and the Softwood Lumber Board⁵⁴ with key delivery agents such as the American Wood Council⁵⁵ and the Canadian Wood Council.⁵⁶ The result is a coordinated approach to R&D investment, professional education programmes (such as the Rethink Wood initiative)⁵⁷ and in-the-field technical support for architects, engineers and builders via the WoodWORKS! programmes (in the U.S.⁵⁸ and in Canada).⁵⁹

Lessons

In both B.C. and Quebec, the Wood First policies have received significant and sustained political support. The fact that both provinces are home to large areas of publicly owned forested lands, that forestry has a long history and strong cultural significance in each region and that the forestry sector is a major employer are all important drivers. Wood First has gained widespread support within the forestry industry, local governments and the public (particularly those living in communities which rely on the forestry industry for jobs). According to the B.C. government, nine out of ten British Columbians say wood-product manufacturing is important to the provincial economy and job growth. Throughout the province, more than 50 local governments have developed their own pro-wood policies. However, the Wood First policies are focussed on more than increasing the consumption of wood products (as described in Policy 3: Focus on the proportion of wood in buildings). Indeed, to secure highest and best use of wood means looking beyond commodity markets (such as dimensional timber) to where opportunities to add value exist.

The result has been that investment in R&D (led in Canada by FP Innovations with laboratories in both Quebec and B.C.) is necessary to bring new products such as mass timber to market. Also, the adoption of regulatory updates such as code changes (fires, seismic, etc.) to allow tall wood structure) needs to be supported by a wide range of training and technical support (in Canada and the U.S. via the WoodWORKS! programme). The industry has gained confidence to retool mills to produce new value added wood products such as cross-laminated timber panels and B.C. and Quebec are now positioning itself as a centre of excellence. Proponents believe that without the Wood First policies, the technical and structural advances necessary to design and construct tall wood structures would not have happened under their own steam.

However, despite the fact that a cornerstone to the Wood First policies has been to advance technical specifications, the B.C. and Quebec policies have also been a polarizing issue within the Canadian construction industry, primarily because it seen as a policy that simply intended to promote the use of wood. Indeed, rightly or wrongly, some opponents believe they are being forced to use wood. Both the B.C. and Quebec policies have generated a backlash from other major materials manufacturers (primarily the steel and cement/concrete industries) who believe that the legislation undermines the credibility and effectiveness of building codes and is a barrier to fair and open competition because it favours one industry over others. There has also been vocal opposition to similar policies being brought forward in the provinces of Ontario⁶⁰ and Nova Scotia. Across Canada, opponents to Wood First formed the Coalition for Fair Construction Practices (CFCP) to raise public awareness and educate federal politicians about the dangers of implementing legislation that, in their opinion, would take the decision making power out of the hands of qualified designers and construction experts. The CFCP supports the position that materials should be selected based on sound construction practices and building science, not through legislation that favours one product over another.

Figure 16: Innovative wood roof structure to the Richmond Olympic Oval, Canada



Design: Fast + Epp Structural Engineers www.fastep.com and Cannon Design www.cannondesign.com

Nevertheless, “Wood First” has served as an effective catalyst to the “non-wood” primary building material industries to agree on and adopt common science-based, performance oriented approaches to promoting their building materials, and to develop a standardized and transparent way (using LCA, EPDs, and other third-party verified quantifiable indicators)⁶¹ to report on environmental and sustainability impacts of their products. They have also invested in numerous technologies to advance the technical and structural capabilities of their materials (low-carbon concrete, 3D printing in concrete, etc.) Arguably, these organizations might not have been as motivated if there had not been the Wood First initiative for them to unite against.

In summary, policies that simply promote the use of wood may be seen to serve as “bridging” mechanisms, to stimulate sufficient economic activity to support the R&D necessary whether it is to realize advances in environmental, technical or structural norms. For these policies to be effective, they therefore need to be designed with the long-term view, and include a clear vision and strategic goals. There are several countries that have recognized the economic, social and environmental value of a vibrant forestry industry and are currently working on various industry development strategies, some of which take a “triple bottom line” approach but have yet to shift local construction norms to incorporate innovative wood solutions in the design and construction of buildings.



POLICY 5

Sustainable
procurement

Policy 5: Sustainable procurement



The UK's BES 6001 Responsible Sourcing of Construction Products supports innovation across the construction supply chain

Description

The British Research Establishment (BRE) developed the BES 6001 Standard for the Responsible Sourcing of Construction Products⁶² along with an associated independent third-party certification scheme to help organizations manage and reduce the impacts throughout the construction supply chain. BES 6001 has been in operation for about five years and provides manufacturers with a means by which their products can be independently assessed and certified as being responsibly sourced and, at the same time, offers designers and builders a holistic approach to managing a product from the point at which component materials are mined or harvested, through manufacture and processing. The scheme is recognized by the BREEAM family of green building certification schemes and the BREEAM Code for Sustainable Homes⁶³ where credits can be awarded for construction products independently certified through BES 6001.

The purpose is to support the implementation of sustainable procurement and purchasing policies (such as the EU Green Public Procurement (GPP))⁶⁴ with a means to frame potentially complex information about construction products consistently and aligned with commonly accepted

procurement procedures. The GPP programme is a voluntary instrument, which means that Member States and public authorities can determine the extent to which they implement it. GPP is defined as, "A process whereby public authorities seek to procure goods, services and works with a reduced environmental impact throughout their life cycle when compared to goods, services and works with the same primary function that would otherwise be procured".⁶⁵

Compliance with BES 6001 is demonstrated through an ethos of supply chain management and product stewardship and encompasses social, economic and environmental dimensions (see Figure 17). BES 6001 addresses aspects such as stakeholder engagement, labour practices and the management of supply chains serving materials sectors upstream of the manufacturer. BES 6001 is contained in the BRE Green Book Live Responsible Sourcing of Construction Products",⁶⁶ which includes a recently updated searchable online database of current certificate holders that displays all the environmental criteria for which each product is certified.

To meet this standard and be awarded a "Pass certificate", organizations should satisfy certain compulsory elements within each of the three following categories:

- Organizational management requirements
- Supply chain management requirements
- Requirements related to the management of sustainable development

In addition, there are higher levels of compliance available that are achieved by fulfilling a number

Figure 17: BES 6001 performance ratings and threshold scores

	Requirements	a	b	c	d	Supplementary credits
3.2.1	Responsible sourcing policy	1				
3.2.2	Legal compliance	1				
3.2.3	Quality management system	1	2			
3.2.4	Supplier management system	1				
3.3.1	Material traceability through the supply chain	1	2	3		
3.3.2	Environmental management systems in the supply chain	1	2	3	4	
3.3.3	Health and safety management systems in the supply chain	1	2	3	4	
3.4.1	Greenhouse gas emissions	1	3	5		
3.4.2	Energy management	1				
3.4.3	Resource use	1	3	5		1
3.4.4	Waste prevention and waste management	1	2	3		1
3.4.5	Water abstraction	1	2	3		1
3.4.6	Life Cycle Assessment (LCA)	1	2	3		
3.4.7	Ecotoxicity	1				
3.4.8	Transport impacts	1	3			1
3.4.9	Employment and skills	1	2	3		
3.4.10	Local communities	1	2	3		
3.4.11	Business ethics	1				
Key						
Compulsory						

Section	Excellent	Very Good	Good	Pass
Total score in 3.2. & 3.3.	13	11	9	Compulsory
Total score in 3.4	32	23	15	Compulsory

of voluntary elements that can result in a higher performance rating being awarded at the “Good”, “Very Good” and “Excellent” levels. The standard works on a point or credit system where supplementary points are available for some criteria to different levels of performance.

Impacts

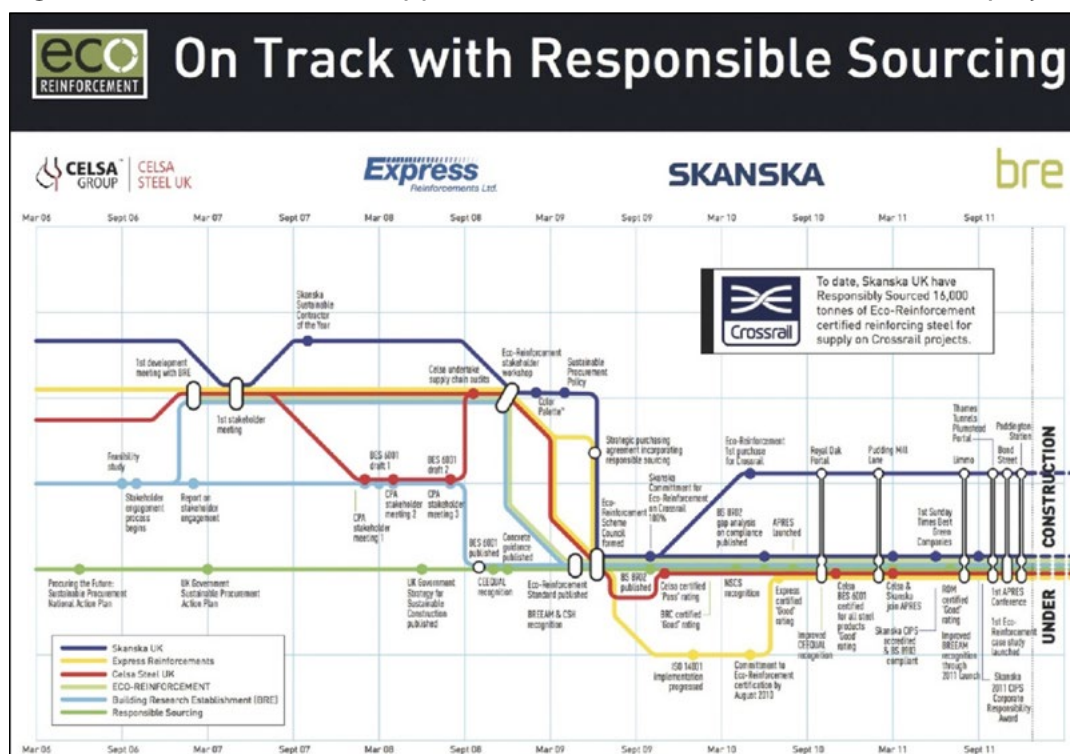
Governments can harness the immense purchasing power of businesses and organizations to help to promote environmental stewardship. Sustainable procurement and purchasing policies can have substantial “trickle-down” effects on the construction materials supply chain because they encourage organizations to not only take into account the economic value (price, quality, availability and

functionality) but also the related environmental and social impacts of the goods and services they buy at local, regional and global levels.

A sustainable procurement/purchasing policy or programme focused on reducing the impacts of construction materials might include a range of objectives such as waste prevention and reduction, resource reduction, pollution and toxin reduction, reduction of GHG emissions, etc. When buildings are tendered for construction, the bid documents can be designed to reflect “triple bottom line” goals, which encompass, environmental, social and economic criteria.

Public authorities are major consumers in Europe. They spend approximately 2 trillion euros annually, equivalent to some 19 per cent of the EU’s GDP. By using their purchasing power to choose goods and services with lower impacts on the environment,

Figure 18: Schematic of the application of BES 6001 on London's Crossrail project



they can make an important contribution to sustainable consumption and production. Green purchasing is also about influencing the market. By promoting and using GPP, public authorities can provide industry with real incentives for developing green technologies and products. In some sectors, public purchasers command a large share of the market (e.g. public transport and construction, health services and education) and so their decisions have considerable impact.

BRE is optimistic about the future for BES 6001. Issue 3 has been successfully developed and launched. With this, a new impetus has been established with existing BES 6001 licensees as well as with new entrants into the licencing arena. At the end of 2014, the total number of valid BES 6001 certificates stood at 89 certificates covering 76 companies (some companies have multiple certifications). There is now interest from non-UK based companies. In 2014, four of the certificates issued were from outside the UK – Spain, Portugal, France and Germany. The UK concrete industry has been one of the first to link its sustainable construction strategy⁶⁷ to BES 6001 and has

produced a guidance document that supports the implementation of the standard. BRE has also taken on three licensees to help to expand the programme, one of which is an international certification body and so it is anticipated that there will be an increase in international certifications.

The tiered level of performance is designed to offer an accessible “entry level” score of “Pass” as a way to encourage organisations (particularly SMEs) to take a first step and then to invest in improvements over time. This approach appears to be working. Since the establishment of the standard, a trend towards ongoing improvement in responsible sourcing has been observed with ‘Very Good’ certificates dominating over ‘Good’ in nearly all materials sectors in a ratio of about 2:1 with very few ‘Pass’ certificates.

In fact, a major boost for BES 6001 has been its adoption by the London Crossrail project⁶⁸ (see Figure 18). Crossrail is a £14.8 billion (18.5 billion euros) railway project that will run under central London to connect the city from east to west. The project aims to reduce journey times and ease

congestion on the city's transport infrastructure. With 188 km of double track and 50 km of new tunnels, Crossrail is one of the most ambitious and prestigious transport projects ever undertaken and is currently Europe's largest construction project. The immediate economy of scale afforded by this project enabled participating manufacturers and contractors to confidently invest in the changes necessary to meet the standard.

As one of the primary general contractors on Crossrail, global construction firm, Skanska,⁶⁹ was a principle industry stakeholder that contributed toward the reinforcing steel sector creating its own responsible sourcing certification scheme called Eco-Reinforcement⁷⁰ based on BES 6001. Skanska's Eco-Reinforcement Steel Supply Chain⁷¹ provided sustainable sourcing criteria for reinforcing steel products throughout the supply chain – from raw material through to the construction site. Both the steel mill and the fabricator must be certified in order for Eco-Reinforcement to be specified and procured. Eco-Reinforcement has been developed as a sector-specific third-party standard, which complies with the requirements of BES 6001.

Setting up the sustainable procurement process was a complex and a ambitious undertaking. For Crossrail, Skanska's key reinforcement supply chain consists of three steel fabricators and one steel producer, Celsa Steel UK.⁷² All supply chain partners are certified according to the Eco-Reinforcement standard. Celsa was the first steel manufacturer in the world to be certified according to BES 6001 through the Eco-Reinforcement standard and it supplies approximately 65 per cent of the steel reinforcement market in the UK. At Celsa, all reinforcing steel is produced with an electric arc furnace and uses 98 per cent recycled scrap metal. The resultant reinforcement steel emits approximately 390 kgCO₂/tonne, which is one of the lowest rates in Europe. A Skanska UK joint venture secured multiple contracts on the Crossrail project for the clients Transport for London and Network Rail. Between September 2010 to February 2013, Skanska's Eco-Reinforcement supply chain has delivered approximately 16,000 tonnes of responsibly sourced reinforcing steel on Crossrail projects. Skanska UK outperformed its declaration to responsibly source 80 per cent of its steel

reinforcement across all projects by achieving 100 per cent responsibly sourced steel to the Crossrail project.

Lessons

Public procurement can be a powerful way to send political signals to the market. Large projects, such as Crossrail, offer tremendous opportunities for innovation. Sustained investment in R&D is essential for industry competitiveness, survival and growth. It can drive competitive advantage, improve productivity and enable companies to capture higher value components of the value chain. A healthy innovation ecosystem is critical to the uptake of new technologies and solutions such as those necessary to introduce and adopt sustainable construction materials. Compared to other industries, construction in most countries remains largely locally focused, undiversified, and with relatively small export markets. There is a high level of industry fragmentation and limited collaboration. Other potential barriers to innovation include:

- Procurement impacting on the level of collaboration
- Sub-optimal knowledge transfer and lost sector-wide learning opportunities
- Issues around market uptake and awareness of benefits from innovation
- Access to finance
- Risk-averse attitude to innovation

Governments can address these barriers by using their projects as crucibles for sector-specific research and their purchasing power as a way to support technology developers. Such investment extends beyond facilitating access to capital for research and business start-ups to include the provision of testing facilities and expertise, gathering and sharing information on markets and R&D activities, creation of demonstration projects and connecting researchers to the industry applications.

Public procurement reaches beyond national boundaries. Standards that align with and facilitate internationally accepted GPP programmes, such as BES 6001, are necessary to establish a clear

frame of reference and a means to communicate the desired product characteristics. However, these policies need to be reinforced by product, assembly and whole building performance metrics against which to monitor innovation vitality in a way that reflects the unique characteristics of the building industry. The fact that BES 6001 has come to the attention of, and is being accepted by, companies outside the UK is not only in response to the size of the UK's public procurement market but also a measure of how well BES 6001 fits within the GPP environment.

To ensure the resources continue to be applied to resolving the complexities of sustainable procurement in the construction industry, the Action Programme on Responsible Sourcing (APRES)⁷³ was created in 2010 (based at Loughborough University) as an industry-oriented network of industrial and academic partners intended to provide a knowledge-sharing and dissemination focus of responsible sourcing practices with the specific objectives of:

- Procurement impacting on the level of collaboration
- Sub-optimal knowledge transfer and lost sector-wide learning opportunities
- Exploring the challenges involved in delivering responsible sourcing
- Mapping the industry's skills and knowledge needs
- Defining academic R&D directions, and improving the quality of research interactions between academics and industry
- Identifying and disseminating outcomes and best practice to the industry

There is no question that “greening” the construction supply chain is challenging and sustained investment in R&D is critical to understanding and resolving the barriers. Providing an open and impartial discussion forum for the construction industry and its customers, academics, government and standard-setting bodies is an important first step so that standards such as BES 6001 can be supported in practice. So far, BES 6001 has

focused on specific products and materials and does not consider associated techniques required to install, operate and repair. Indeed, the very large existing building and property management sectors have not yet taken it up.

Further, it is not only important to shift purchasing preferences to materials with lower environmental impacts but it is also equally imperative to ensure that materials are used judiciously. Greater use of efficient processes such as prefabrication, preassembly, modularization and off-site fabrication also need to be encouraged to prevent over-consumption and reduce the environmental pressures across the entire supply chain. In 2010, off-site construction comprised about 12 per cent of building taking place in the UK.⁷⁴ The UK government, in partnership with industry has set a series of long-range goals for transforming the construction industry, which are predicated on a whole-hearted adoption of sustainability, efficiency and productivity measures. The “Construction 2025” industrial strategy⁷⁵ sets out the following performance targets for the construction industry as a stimulus for investment in R&D:

- **Lower costs:** 33 per cent reduction in the initial cost of construction and the whole life cost of built assets
- **Lower emissions:** 50 per cent reduction in greenhouse gas emissions in the built environment
- **Faster delivery:** 50 per cent reduction in the overall time, from inception to completion, for new build and refurbished assets
- **Improvement in exports:** 50 per cent reduction in the trade gap between total exports and total imports for construction products and materials

To achieve these goals will require the British construction industry to fundamentally rethink the way buildings are designed, procured, built and operated. A comprehensive approach to policy making will be necessary to support these goals and standards such as BES 6001 will have an important role to play in bringing the powerful manufacturing sectors on board.

A photograph of a construction site. In the foreground, a large, dark metal beam is suspended by two thick cables. To the right, a wooden structure is under construction, with several curved wooden beams and vertical supports. The background shows a clear sky and some trees at the bottom. The overall tone is dark and industrial.

POLICY 6

Policies that
"close the loop"
at end-of-life

Policy 6: Policies that "close the loop" at end-of-life



“Toward a Material Chain Society”: an integrated waste policy framework helps the Dutch create a circular economy for construction materials

Description

Globally, the construction industry is a significant generator of solid waste, the vast majority of which can be recycled and re-used. The Netherlands has a strong history in waste management and has developed an effective, integrated policy-driven life-cycle approach that is predicated upon a landfill ban on construction and demolition (C&D) waste. Annually, the Netherlands generates about 60 million tonnes of waste of which 40 per cent (25 million tonnes) is C&D waste.⁷⁶ By 2012, recycling and recovery rates for C&D waste had reached 95 per cent,⁷⁷ which in part has been attributed to the “command and control” approach adopted by the government in 2001, following the centralization of waste management.⁷⁸ At €107.49 per tonne,⁷⁹ the Dutch also impose some of the highest landfill taxes and levies in the world. Landfill taxes, which are levied on solid waste by volume, weight or material type, have also been useful tools in stimulating waste diversion strategies.

Although the Dutch government has achieved a great deal of success with its traditional waste policy, there is political support to continue to streamline and improve the existing frameworks. To do so means that Dutch policy makers are

looking beyond isolated policy instruments (e.g. landfill tax, landfill bans) because, despite the Dutch system imposing some of the highest taxes and levies on waste, on their own, they are no longer sufficiently effective to further reduce environmental pressure on a larger scale. (An overview of “zero-waste goals” is provided in Annex B.)

The Netherlands’ National Waste Management Plan (LAP) 2009-2021, called “Towards a Material Chain Society”, describes the government’s ambitions to minimize environmental pressures over the whole supply chain and to harmonise policy in different areas (e.g. natural resources, products/design, waste management, and concepts such as cradle-to-cradle) by means of a chain-oriented waste policy.

Fundamentally, a chain approach considers the entire material chain, including all the stages in the life cycle of a product or material from raw material mining, production and use, to waste and possible recycling, as opposed to concentrating on “end-of-pipe” solutions. The chain approach identifies the stages in the material chain where the greatest environmental benefit can be obtained efficiently and the necessary actions for realizing this benefit. The overarching aim is to reduce the environmental impact of material chains throughout the life cycle in the most cost-effective manner, and establish a single integrated policy framework for the whole material chain. Of importance in this context is that the environmental benefit in one stage does not cause a higher environmental impact for another stage or another chain. The Dutch are actively moving towards creating a circular economy for waste materials. The programme is led by the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM).

As well as setting out various targets relating to waste prevention, recovery and diversion from landfill, the LAP sets out an indicative objective to: “Reduce the environmental impact for each of the seven priority streams which will be targeted in the context of chain-oriented waste policy by 20 per cent”. The seven priority streams, of which C&D waste is one, referred to were selected from the list of all 110 waste streams for which the Netherlands has a waste policy, on the basis of a LCA over the whole chain.

A critical element to this approach is the establishment of partnerships between stakeholders from different links in the chain, facilitated by government. Each material stream will submit an action plan, detailing measures by which to reduce the environmental impact of the material chain by 20 per cent. The 20 per cent reduction in environmental pressure will be calculated in terms of end-of-life waste tonnages, volume of CO₂ emissions, pollution from toxic substances, and land use. The ultimate aim is to establish more concrete and measurable goals, relating to specific impacts such as percentages of separate collection and waste prevention.

According to the Dutch Ministry of Infrastructure and the Environment, the elements of the Dutch waste policy are:

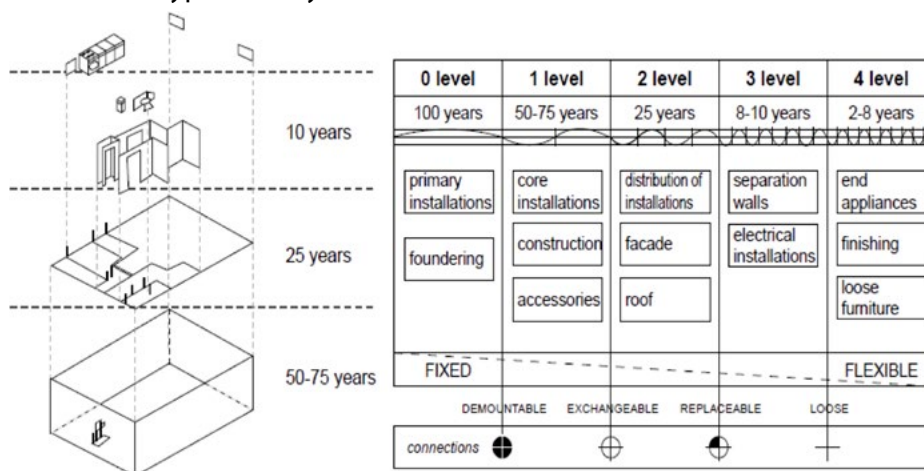
- Commitment to the 5R’s waste hierarchy: reduction and prevention, re-use, material recycling, energy-recovery, incineration and land filling.
- There are stringent standards for disposal and recycling: decrees on landfill and incineration, standards for building materials, organic fertilizers, ban on landfill. Comingled wastes are separated at government certified material sorting plants and landfills accept waste only from certified operators, who sort and certify loads.
- Economic instruments to reduce waste volumes and to steer the waste to the preferred treatment which include a municipal waste tax paid by citizens and one of the highest landfill taxes in the EU.
- Planning at the national level which starts with concessions for collection and treatment, a

pro-market approach and integral national waste planning.

- Cooperation between 3 levels of government (municipal, regional and national).
- Education and communication to create awareness and enhance participation with separate collection schemes. The focus in construction is on source separation of recyclables with the provision of collection bins on the construction site.
- Extended Producer Responsibility (EPR) programmes which are paid by consumers, producers and/or importers (such as recycling fees) for car tires, batteries, paper and cardboard, packaging, etc.
- Notification and registration of waste transports: from separate to one integral system of registration and notification of waste transports.
- Control and enforcement which includes a landfill ban on C&D waste and closed borders to the transportation of waste.

The Netherlands’ 12 provinces regulate disposal of C&D waste. They gather information about waste streams and monitor disposal and processing by requiring quarterly reports from waste collection and processing companies. Used building material reuse and recycling is estimated to be as high as 90 per cent. Asphalt, concrete and mixed granulates are used in road building. Almost all flyash produced in the country is currently used in concrete.⁸⁰ There are limits to the amount of materials that can be left on site and mixed with soil after demolition, and also regulations stipulating what materials can be reused (e.g. recycled aggregate in place of gravel in concrete). These measures have been effective at encouraging industry’s acceptance of C&D waste diversion. Further, C&D waste is highly mobile and controls need to be in place to prevent haulers from shipping waste from locations with high disposal costs and stringent regulations to neighbouring locations that may be more lax. The Dutch borders with neighbouring countries are all closed to waste transports and there are international agreements about the shipping of waste.

Figure 19: A 'Design for Adaptability' concept for a Dutch house showing typical life cycles for the various elements used in construction



Source: Durmisevic, E. and Brouwer, J. (2002), Design aspects of decomposable building structures in Chini, A.R. and Schultmann, F. (eds) Design for Deconstruction and Materials Reuse, CIB Publication 272, TG39 Meeting, 9 April 2002, Karlsruhe, Germany.

The Dutch are leveraging activities at the international level such as the European Commission Waste Framework Directive,⁸¹ which is preparing a set of “end-of-waste” criteria for priority waste streams, the majority of which come from construction. End-of-waste criteria establish the regulatory and market framework within which the collection and re-reprocessing of materials into new products can occur (a summary of “end-of-waste” is presented in Annex B). The result is that they shift the construction industry from being a “linear” economy to one with “feedback loops” (see Figure 5 in the Introduction). Ultimately, the objective is to create a truly “circular economy” for construction materials in which an entire building can be disassembled, re-configured and re-erected. This requires a fundamentally new approach to the design and assembly of buildings as well as a viable market for repossessed “secondary” materials.

Impact

C&D waste collection and recycling is rapidly becoming routine in most countries. However, “end-of-pipe” solutions do not address the volumes of waste generated. They simply seek to divert materials from landfill. Instruments such as landfill taxes, supported by waste diversion targets and materials bans, can be valuable where wide-

-ranging changes in behaviour are needed across a large number of production and consumption activities. They are all relatively simple to create and implement, and they are easy to understand. In particular, landfill taxes can have considerable environmental and economic significance, in ensuring that waste management decisions take account of the environmental consequences of different disposal options (landfill, incineration, recycling, etc.) and encouraging substitution by producers and consumers towards products and packaging that involve less waste, and more efficient recycling.⁸²

By 2012, recycling and recovery rates for C&D waste in the Netherlands had reached 95 per cent. Now, the Dutch “Chain-Oriented Waste Policy programme” aims to limit the amount of material entering the waste stream and to reduce the overall environmental impact on key waste materials by a further 20 per cent. The success of this policy relies on the presence of viable markets for the recycled materials. There is significant research into waste minimization solutions and alternative uses for materials destined for disposal underway in the Netherlands (see Figure 19). The Dutch programme is effectively driving a life-cycle approach back up the supply chain and buildings are starting to be designed with waste management strategies such as dematerialization (using less material in the building project) and disassembly.

This research work is stimulating the development of new materials reprocessing techniques, an array of novel products containing high proportions of waste materials and a raft of technical standards describing the properties, quality control procedures, etc. for the production of recycled materials for use in construction projects.

The 20 per cent reduction target provides a goal to which industry can work towards and is intended to drive innovation throughout the chain, targeting flows that can be dealt with most cost effectively. However, it is not a binding target and there are no penalties tied to non-compliance. Instead, operational targets for specific projects are formulated in co-operation between stakeholders, which are made binding by various forms of agreement.

The provisions in the LAP focus on the concept of co-operation throughout the supply chain and with all the market stakeholders. For each of the seven priority streams, the Dutch government wants to join forces with other stakeholders to encourage co-operation, innovation, a green corporate image and cost savings. It is not intended that responsibility is shifted away from government on to industry sectors, although the Dutch government does currently attach value to a strong and innovative industry sector. There are concerns that this may undermine the recent progress in Dutch waste management that has been achieved through the “command and control” approach. Much may depend upon the nature of policies used to drive forward progress.

A key element to the integration of chain policy is to make separate policy areas more coherent across the whole material chain and to create more synergy between different policy areas. This means seeking out the most efficient location and means to reduce environmental pressure without shifts to other environmental aspects or other points in the chain.

Pilot projects were launched in 2007, culminating in the submission of action plans in May 2008. Six chain pilot projects were started with the twin aims of gaining experience with a chain approach as the mode of operation and achieving a substantial reduction of waste-related environmental pressure throughout the pilot chains. It is presumed that

the financial burdens of the pilot projects also fall with the participating companies; the government only offered a small financial contribution. It is asserted that the pilot projects provided insights into the preconditions, which the government needs to create in order to enable companies to apply this approach successfully. Companies are also reliant on the government for stimulation of the programme, in terms of facilitating partnerships and raising profiles. This also holds for supporting the reduction target tied to the selected material streams. The Dutch government is monitoring and evaluating the programme. However, it is too early to evaluate the wider impacts of the programme but the pilot projects can be considered, as well as the initial reaction to the programme from industry, and any potential problems identified.

Lessons

Until the programme progresses and more information become available, it is difficult to distil any concrete lessons. Nevertheless, overall, the Dutch government’s chain approach appears to have been well received by industry although there is a concern that the waste policy does not leave Dutch waste management companies at a competitive disadvantage in respect to other countries. By comparison, the Dutch design professions (architects and engineers) are developing an international reputation for innovative solutions to reduce waste at the design stage.

The Dutch government has worked hard to nurture partnerships in order to transfer practical experiences with actors working in all the various links in the chain, for example to reduce environmental burdens through design. However, more work needs to be done to refine definitions, indicators to provide a quantitative measure of environmental burdens and the criteria against which success will be measured. Certainly, codifying strategies such as design for disassembly into building regulations is still some years away. Nevertheless, it is critical that environmental pressures must actually be reduced and not merely be shifted from one part of a material chain to another. As a result, it is very likely that industry will ask for financial and administrative support from the government to

“get over the hump” of adoption of new criteria and targets and to facilitate more innovative solutions.

It is implicit that the environmental impact is measured on a life-cycle basis (tonnes of end-of-life waste, volume of CO₂ emissions, pollution of toxic substances and land use possibly being the four most distinguishing environmental aspects). A key question may be how and where trade-offs are to be made. Working within a life-cycle based policy environment is challenging. LCA analysis is necessary to determine if (and to what extent) the policy is having a positive effect in one area (e.g. designing products that can be recycled more easily) may have a negative effect in another (e.g. products being made from materials with more energy-intensive extraction methods). The Dutch have invested heavily in developing LCIs and the NIBE “Basiswerk Milieuclassificaties Bouwproducten”⁸³ is often referenced by other countries for generic environmental data.

On the basis of the action plans submitted, the pilot projects were deemed a success. It is claimed these projects have facilitated the transfer of knowledge and expertise through newly formed partnerships, culminating in new innovative developments.⁸⁴ However, this is impossible to verify. The companies that were invited to participate in the pilot projects had a proven track record in terms of sustainability. So, it could be argued that the measures taken would have occurred anyway, although perhaps not without the additional “push” from the programme. Also, the focus of the pilot projects was much narrower, concentrating on discreet aspects of the material chains, with the intention to achieve rapid results from which to learn. In contrast, the work on the priority streams aims to take a much more holistic approach, impacting on the entire material chain and realising environmental benefits across the board.

The main challenge facing the waste sector is perceived to be the pressures to rely on market forces to induce economic efficiency and long-term viability. There are concerns that relinquishing government control may undermine the significant progress made in the handling (though not elimination) of waste during the 1980s and 1990s. However, as mentioned above the chain approach

does not intend to shift government control to the industry but merely promotes a more active role from industry in the entire material chain (not just the waste sector) and promotes better co-operation between government and industry. Another key concern is the financial burden of implementing such an approach. Whilst the material streams are assessed in terms of costs as well as environmental impact to ensure the most cost-effective action is taken, the research and development to arrive at such solutions will be costly and industry may look to government to provide the necessary funding. However, the approach aims to not only identify new solutions to minimise environmental pressure throughout the whole life cycle also that it must be appealing from an economic perspective, otherwise they would not be sustainable.

The Dutch waste policy is essentially designed to push the impact of the measures upstream to the building design phase, moving away from isolated end-of-pipe policies such as C&D recycling. However, if impacts across the whole of the chain are to be taken into account, the challenge is likely to arise in establishing who is responsible for how much of the change, and in seeking to incentivize any specific target, or make it enforceable.

In this sense, the targets may be difficult to achieve unless it is clear whom the target is addressing and what the consequences of non-compliance will be. Changes in project procurement will be necessary to cement these changes. For example, Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize the project results, increase value to the owner, reduce waste and maximize efficiency through all phases of design, fabrication and construction. IPD projects are uniquely distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, commencing at early design and continuing through to project handover. To incentivize parties, shared risk/reward contracts are established upfront with an understanding that all parties are working together for the good of the project.

The background of the page is a faded, orange-tinted photograph of a construction site. On the left, a large metal crane hook is suspended by two thick cables. On the right, there is a complex wooden scaffolding structure. The overall scene is bright and somewhat hazy, suggesting a clear day.

Summary of findings

Summary of findings

Most countries are familiar with the scale and source of environmental impacts of the construction and operation of buildings, and they appreciate the benefits of 1) wood as a sustainable construction material and 2) of forestry as a generator of economic opportunity and decent green jobs. However, policy-making to address the impacts of construction materials is still at an early stage. 29 policies have been included in this study in order to illustrate the breadth and depth of leading practices in the advancement of sustainable construction materials and the use of wood, and it is evident that a great deal more work is currently underway across Europe and North America.

The weight of experience, in terms of policies already in place, is with operating or “in-use” impacts of buildings such as energy and resource efficiency, the promotion of specific “green” and/or “local” materials (such as wood), the restriction of highly toxic materials (such as asbestos) as well as minimizing the worst effects of the at the “end-of-life” stage (specifically waste diversion from landfill). However, the policies included in this study, which were selected from a comprehensive web search and with input from 100 survey responses from 33 countries, illustrate that the emphasis of policy makers has been shifting towards a whole life-cycle approach, emphasising the effects of production and consumption on the environment, and perhaps less commonly, their social and ethical consequences.

The 29 policies were organized into the six categories for deeper investigation (see Figure 20). They tend to have been developed with one or more of the following objectives in mind:

- Support GHG emission reduction and/or climate change policies
- Reduce environmental impacts of construction materials (embodied energy, water, waste, etc.), and/or
- Promote a local wood economy and culture

However, there are several policies that take a life-cycle approach to achieve these goals, which offers designers and builders flexibility to select materials that are optimized for the function, location and life span for the specific project and which generally serves the wood industry well, given that wood offers a climate-friendly low impact building solution. The trend towards life-cycle based building policies is growing and is being led by countries that have a strong track record in low energy efficient building design and performance based regulation such as Switzerland. In fact, as operational targets are achieved and the efficiency of buildings is improved, the proportional impact of extraction, manufacture, transportation and disposal of materials increases. The countries that have made the most headway on reducing the operational footprint of their buildings are now running up against this challenge. However, establishing policies to manage materials sustainably across their whole life-cycle is much more challenging than for building operations.

Most countries in which forestry plays an important economic role have policies and programmes in place to advance the use of wood in buildings. Some countries have established consumption targets and others are driving the use of wood into new types of building project in order to achieve highest and best use of forestlands, which are, more often than not publicly owned assets. As a result, there are many policies in place that are designed to promote the use of wood in new situations (in commercial buildings, for tall structures, to solve seismic design challenges, etc.). These policies are proving effective at bringing new technologies into the market (the number of mass timber structures over 10 storeys is growing fast) but the scale and pace of government investment to implement these policies and the perception of preferred purchasing can become polarizing issues with other materials manufacturing sectors. Also, the success of these policies relies upon a progressive forestry industry that looks beyond production outputs.

Figure 20: Goals of policies included in the study
(those subject to deeper investigation are highlighted)

Selected policy	GHG reduction	Environmental impacts	Promote wood	Life-cycle based
1. Information-based policies				
WoodBox public outreach programme	•	•	•	
1.1 UNEP SBCI Common Material Metric	•	•		•
1.2 Green Multiple Listing Service Toolkit	•	•		
1.3 Publicly Available Specification 2050	•	•		•
1.4 WoodWORKS! project-based technical assistance		•	•	
1.5 Dual vocational training system and “laddering” for wood technologists	•	•	•	
1.6 WoodLINKS training programme			•	
2. Policies that advance environmental norms				
2000-Watt Society Energy Vision	•	•		•
2.1 Materials Awareness Policy and the “Environmental Performance of Materials used in Building Elements” method	•	•		•
2.2 Grenelle de l’Environnement	•	•		•
2.3 BRE Green Guide to Specification	•	•		•
2.4 Passive House	•	•		
2.5 International Green Construction Code	•	•		
2.6 Voluntary green building certification systems	•	•		•
2.7 Product certification schemes	•	•		•
3. Policies that focus on the proportion of wood in buildings				
Wood Resource Policy	•	•	•	•
3.1 Strategic Programme for Finland’s Forest Sector	•	•	•	
3.2 Wood Use Points Programme	•	•	•	
3.3 France’s action plan for the development of timber in the building sector	•	•	•	
3.4 USDA high-rise wood innovation competition	•	•	•	
3.5 Norwegian Wood-Based Innovation Scheme	•	•	•	
3.6 Promoting the use of wood in American government buildings	•	•	•	
4. Policies that advance technical specifications and structural norms (height, seismic, etc.)				
The Wood First Initiative	•	•	•	
4.1 Post-tensioned wood buildings for seismic design	•	•	•	
4.2 Performance-based codes and tall wood structures	•	•	•	
5. Public procurement policies				
BES 6001 Responsible Sourcing of Construction Products	•	•		•
5.1 Decree on Green Public Procurement	•	•		
5.2 California Green Chemistry policy	•	•		
6. Policies that “close the loop” at end-of-life				
Chain-Oriented Waste Policy	•	•		•
6.1 Collaborative for High Performance Schools	•	•		•
6.2 Portland’s ReBuilding Center	•	•		•
6.3 UK Aggregates Levy	•	•		

However, simply relying on wood use policies can be problematic, both for designers who may feel compelled to use wood products in sub-optimal situations and for non-wood product manufacturers who may perceive unfair procurement practices. Some of the most progressive and effective policies that are being put in place today do not single out the use (or prohibition) of specific materials but instead rely on Life-Cycle Assessment (LCA), which is a science-based state-of-the-art methodology for determining the optimal choice of materials at the design stage taking into consideration the life cycle of the material and the building as a whole. This can still be good news for the wood industry. The ecological and environmental benefits of using wood products from responsibly managed forests can be objectively and completely captured using LCA and wood fares well when compared to other materials.

Sustainable materials management is proving to be a far-reaching issue and, in the most successful situations, a diverse range of cross-cutting policy instruments has been applied that include both policies which promote the use of LCA and, on account of its environmental merits, the use of wood. It is with this fact in mind that each of the six policies that has been subjected to deeper investigation starts from a distinct stage in the life cycle of materials, but reaches up and/or down the supply chain in order to maximize effectiveness.

While the design and development of construction materials-related policies, and the pace and scope of implementation, will be dictated by the characteristics and priorities of the country concerned, the steps followed by leading policy makers have broadly comprised a process of benchmarking current performance, establishing performance targets, compiling materials databases (which then need to be maintained), developing draft or “stretch” policies to be tested by pilot or demonstration projects before widespread adoption and, finally, measurement and benchmarking of success (see Figure 21). The lessons offered by the six policy examples that have been investigated in detail in this study are summarized on the following pages:

1. Information-based policies:

The WOODBOX travelling public outreach programme

WOODBOX is an integrated public outreach programme that toured through five European cities in 2014 with the aim of generating public awareness of the impacts of construction materials and the benefits of using wood in order to build up viable networks for the increased utilization of wood in construction. It is estimated that the exhibition attracted over 15,000 visitors.

Programmes such as WOODBOX are important to build and sustain the general dialogue about important issues related to the use of sustainable construction products and the role wood plays in lowering the environmental footprint of buildings.

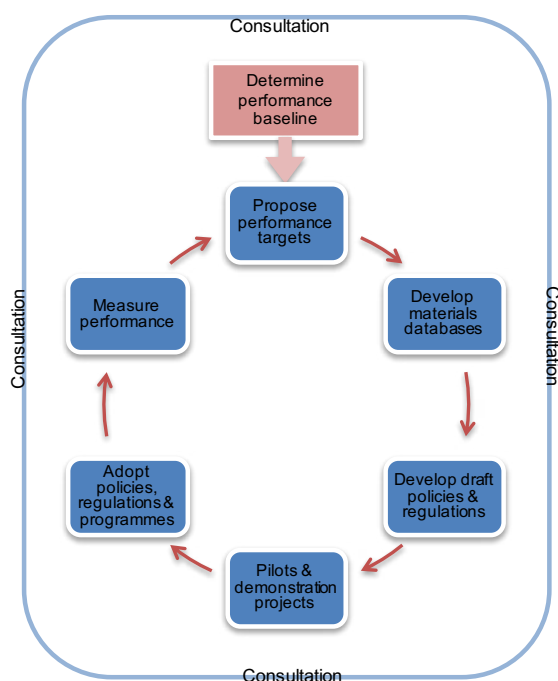
Advocacy is critical to changing business and public behaviours and an educated and engaged general population is critical to driving a policy agenda forward. To ensure that projects such as WOODBOX lead to meaningful change, it is important that they are not simply conducted in isolation but are, in fact, part of a larger strategic outreach approach that includes technical education and project-specific in-the-field support for the design team.

2. Policies that advance environmental norms:

The 2000–Watt Society Energy Vision

The 2000-Watt Society Energy Vision offers one of the most progressive and comprehensive life cycle based policy frameworks within which all of the major energy and GHG impacts of buildings are regulated, including materials. The 2000-Watt Society currently encompasses 20 cantons and 100 towns and cities in Switzerland. Outside of Switzerland, it has been adopted in Munich and served as a frame of reference for the City of

Figure 21: Simplified steps to developing performance-based building policies



Vancouver in Canada. The materials databases and other tools and resources that underpin the implementation of a life-cycled based building policy have also been referenced in other countries and harmonization efforts are now underway in several jurisdictions. Swiss practices were identified for their relevance and replicability in jurisdictions interested in advancing an integrated, performance-based policy environment. They have the ability to:

- Define energy system boundaries and energy flow in order to create strategic clarity of carbon emission impacts of buildings
- Identify and define building energy consumers (heating, lighting, materials, etc.), their respective utilization levels and drivers (building design versus occupant behaviour) in order to create clarity of accountability for regulatory purposes
- Introduce the principles of primary energy factors and GHG emission coefficients to consistently and quantitatively describe the scope of GHG emission impacts of buildings

- Propose concise, measurable and comparable energy and carbon performance targets that meet the intent of municipal low carbon goals and are simple, fair, measurable and enforceable, yet offer flexibility to industry
- Introduce the principles of low carbon design as they apply to Vancouver's multi-unit residential buildings.

There is a great deal of merit in establishing aspirational goals around which policies and programs can be structured. The fact that the 2,000-Watt Society's is rooted in a philosophy of globally equity and social justice has proven to be compelling to businesses and public alike.

3. Policies that focus on the proportion of wood in buildings:

The Swiss Wood Resource Policy

Many countries have developed policies that are designed to promote the use of wood in buildings, primarily for the purpose of supporting their local forestry economies. The purpose of the Swiss Wood Resource Policy is to support the consistent and sustainable harvesting of wood from Swiss forests and the resource-efficient use of wood as a raw material for a range of products. It establishes clear standards and targets for the use of wood as part of a cross-cutting mechanism to reduce the embodied energy and carbon in buildings (under the 2000-Watt Society Energy Vision) while increasing the opportunities for the local wood industry. A key objective is to increase the wood content of the entire Swiss building stock (new buildings) by 50 per cent by 2020. A range of funding programmes have been created under the Wood Action Plan to help the design and construction industry these goals.

For life-cycle based building policies such as the 2,000-Watt Society to be adopted by industry and implemented effectively, it is important that

complementary measures, such as the Wood Resource Policy and Action Plan, are in place to:

- Encourage designers to adopt new or unfamiliar products and techniques
- Help manufacturers focus their R&D investment and market their products effectively
- Provide confidence to builders and trades to invest in the necessary equipment and training and
- Direct the supporting efforts of professional training institutions, lenders and other industry stakeholders.

4. Policies that advance technical specifications and structural norms:

The “Wood First” Initiative

Wood First in British Columbia (B.C.) and Quebec, facilitates the uptake of wood products, thereby stimulating research into new techniques and technologies, supporting market adoption and developing small local markets as “shop-windows” of wood innovation for primary overseas markets.

In the five years since Wood First was introduced in B.C., the use of wood in building construction (beyond single family homes which is primarily wood frame) has grown rapidly, particularly in the multi-storey residential market (there are over 150 six-storey residential projects completed, under way or in development) and in institutional and recreational buildings. New approaches to building with wood have been developed, and there is the potential to use wood in much taller structures. According to the B.C. government, nine out of 10 British Columbians say wood-product manufacturing is important to the provincial economy and job growth. Throughout the province, more than 50 local governments have developed their own pro-wood policies. However, the B.C. and Quebec “Wood First” policies have also been

a polarizing issue within the Canadian construction industry. Both government-led “Wood First” policies have generated a backlash from other major materials manufacturers (primarily the steel and cement/concrete industries) who believe that the legislation undermines the credibility and effectiveness of building codes and is a barrier to fair and open competition because it favours one industry over others.

Nevertheless, “Wood First” has served as an effective catalyst to the “non-wood” primary building material industries to agree on and adopt common science-based, performance oriented approaches to promoting their building materials, and to develop a standardized and transparent way (using measures such as LCA, EPDs, and other quantifiable indicators) to report on environmental and sustainability impacts of their products.

5. Public procurement policies:

BES 6001 Responsible Sourcing of Construction Products

The British Research Establishment (BRE) developed the BES 6001 Standard for the Responsible Sourcing of Construction Products along with an associated independent third-party certification scheme to help organizations manage and reduce the impacts throughout the construction supply chain. It requires a range of life-cycle criteria to be met as part of a construction materials procurement process, including the use of Environmental Product Declarations (EPDs). It has the potential to influence the entire life-cycle of materials. However, as it stands it is likely to most greatly impact upon the production and consumption life-cycle phases. At the end of 2014, the total number of valid BES 6001 certificates stood at 89 certificates covering 76 companies (some companies have multiple certifications). There is now interest from non-UK based companies.

Public authorities are major consumers in Europe. By using their purchasing power to choose goods and services with lower impacts on the environment, they can make an important contribution to sustainable consumption and production. Green purchasing is also about influencing the market. By promoting and using green public procurement, public authorities can provide industry with real incentives for developing green technologies and products. In some sectors, public purchasers command a large share of the market (e.g. public transport and construction, health services and education) and so their decisions have considerable impact. Governments and businesses can use their projects as crucibles for sector-specific research and applied learning. Such investment extends beyond facilitating access to capital for research and business start-ups to include the provision of testing facilities and expertise, gathering and sharing information on markets and R&D activities, creation of demonstration projects and connecting researchers to the industry applications.

So far, BES 6001 has focused on specific products and materials and does not consider associated techniques required to install, operate and repair. However, it is not only important to shift purchasing preferences to materials with lower environmental impacts but it is also equally imperative to ensure that materials are used judiciously. Greater use of efficient processes such as prefabrication, preassembly, modularization and off-site fabrication also need to be encouraged to prevent over-consumption and reduce the environmental pressures across the entire supply chain.

6. Policies that “close the loop” at end-of-life:

The Dutch “Chain-Oriented” Waste Policy

Globally, the construction industry is a significant generator of solid waste, the vast majority of which can be recycled and re-used. The Netherlands has a strong history in waste management and has

developed an effective, integrated policy-driven life-cycle approach that is predicated upon a landfill ban on construction and demolition (C&D) waste. The Chain-Oriented Waste policy aims to address the environmental impacts acting across the whole material chain from the end-of-life stage and back up the supply chain. A key focus is on reducing the overall environmental pressures imposed by construction materials.

The policy is designed to push the impact of the measures upstream to the building design phase, moving away from isolated end-of-pipe policies such as C&D recycling. However, if impacts across the whole of the chain are to be taken into account, the challenge is likely to arise in establishing who is responsible for how much of the change, and in seeking to incentivize any specific target, or make it enforceable. Overall, the approach appears to have been well received by industry although there is a concern that the waste policy does not leave Dutch waste management companies at a competitive disadvantage in respect to other countries. By comparison, the Dutch design professions (architects and engineers) are developing an international reputation for developing innovative solutions to reduce waste at the design stage.

The number, scope and technical requirements of policies that are geared towards sustainable construction materials is increasing rapidly and it was not possible to include every policy in this study. Indeed, there are several areas that warrant further research. For example, there are some key policies in development that, if realized, will be important to track in detail. It will therefore be important for UNECE FAO and other interested agencies to continue to monitor these efforts to build a more detailed understanding of the policy-making landscape in order to continue to provide useful and timely policy advice, a platform for further discussions, a focal point for technical meetings and a venue for policy debates with a view to reducing the environmental impact of building materials.

It is also important to bear in mind that the policies that are specifically geared towards the managing the impacts of construction materials

(and indeed whole buildings) in the much larger existing building market have not been developed yet. However, there is potentially good reason for undertaking further research in this area. For example, Energy Performance Certificates (EPCs)⁸⁵ rate the operating energy efficiency of both new and existing buildings but do not consider the embodied energy/carbon impacts associated with achieving the energy standards. As a result, the EPC does not provide a complete picture of the energy and climate impacts of the property.

Further, in old traditional buildings, the embodied energy/carbon is low (when pro-rated on an annual basis) with most of the impacts coming from maintenance and renovation. This benefit could be used to position some old traditional buildings to better advantage, thereby helping to sustain the historic urban centres of most European cities while providing the real estate industry with more complete information and long-term market certainty as well as increased opportunities for the wood industry afforded by a prosperous building renovation market. The question of whether some form of a combined embodied and operating performance certification scheme might help to revive demand for traditional urban buildings while, at the same time, drive meaningful reduction in the environmental impacts of properties deserves further evaluation.

To conclude, this study has been developed to provide a starting point for countries interested in addressing the environmental impacts of construction materials in order to stimulate further discussions, technical meetings and policy debates. Although it is too soon to establish the extent to which the policies in effect today are reducing the environmental impacts of construction materials, there are some countries that are expending considerable effort in advancing materials-related building policies. The findings from this study suggest that many countries in

Europe and North America have developed some form of policy aimed at reducing the impacts of construction materials and those countries that are moving towards LCA-based policies are proving the most effective at changing building design and construction practices. International standards governing the LCA methodology, data collection and reporting are important to maintaining consistency and, over time, will enable comparison of performance.

Also, the policies designed to promote the use of wood are important bridging strategies that can be used to orient the construction industry towards the environmental, technical and structural advantages of wood. Ultimately, despite the fact that much work needs to be done to establish standards, build databases and train building professionals, LCA provides a holistic approach allowing designers to select the most suitable materials for their project without dictating the use of certain materials. However, environmental impacts of construction materials can be significant and sustainably sourced wood will have an important role to play once materials-based performance targets have been established.

Finally, the financial and political investment required to implement LCA-based building policies can be considerable. Though, as more countries get to work in this area (develop LCIs, etc.), there may be some economies of scale. However, collaboration and/or sharing experiences will be critical. Going forward, it will be important to not only monitor the efforts of the countries and regions presented in this study but also to document their progress in detail in order to provide useful and timely lessons to other regions. Given the accelerating pace of construction in countries outside Europe and North America, the pressure on policy makers to manage the environmental impacts of construction materials can only increase.

Annexes

Annex A

Brief descriptions of policies that promote the sustainable use of construction materials and the use of wood as provided by survey respondents

1. Policies that provide information and encourage voluntary action

1.1 United Nations Environment Programme Sustainable Building and Climate Initiative Common Material Metric

The United Nations Environment Programme Sustainable Buildings and Climate Initiative (UNEP-SBCI) is a partnership between the United Nations and major public and private stakeholders in the building sector, working to promote sustainable building policies and practices worldwide. One of the goals of the UNEP-SBCI initiative is to develop the UNEP Sustainable Buildings (SB) Protocol in order to provide globally consistent understanding, measurement, reporting and verification of actual building performance, and address core sustainability issues, particularly in developing countries. This Protocol is focused on measurable, reportable and verifiable indicators for sustainable buildings and shall be applicable to existing residential and non-residential buildings, and facilitate a top-down and bottom-up aggregation of the performance of building stocks. The Common Carbon Metric (CCM) has already been developed by UNEP-SBCI in order to provide a metric for measuring and reporting energy use and greenhouse gas (GHG) emissions associated with the operational stage of buildings (UNEP-SBCI/WRI 2010).

The Common Materials Metric (CMM)⁸⁶ is being developed by the International Reference Centre for the Life Cycle of Products, Processes, and Services (CIRAIG), a Canadian network of academics with expertise ranging from LCA studies (simplified and detailed) to product “eco-design”.⁸⁷ It is intended to provide globally applicable measurement and reporting metrics, protocols and templates that indicate the sustainability of building materials for inclusion in the UNEP-SB Protocol. The metrics developed are intended to inform policy development by jurisdictions, real estate companies and building owners for improving the sustainability of building stocks and monitoring progress in developed and developing countries. Phase 1 of the project was funded by Canada Wood, which is interested to see, “The implementation of a carbon reporting framework and a clear objective of kg of CO₂ per m² in both construction phase and operation phase”.⁸⁸

The reporting framework is intended to monitor and report at the scale of building stock rather than at the individual building level, although data from individual buildings will feed into it. Materials used in new construction, existing building refurbishment and demolition are to be considered. At this stage, the first phase of the project has been completed which comprises an extensive review of existing methods, protocols, datasets, initiatives, etc. in order to identify how the potential environmental impacts of building materials could be assessed in the UNEP-SB Protocol framework. In the second (future) phase, the metrics and indicators will be developed in a document presenting the proposed methodology. The CMM is predicated upon the use of LCA, which is framed by the ISO

14040/14044 standards and allows the potential environmental impacts of products, processes or services to be quantified over their entire life cycle, i.e. from raw materials extraction to final disposal.⁸⁹ With growing awareness of the impacts of the production of building products, construction of buildings and disposal of waste materials, green building policies are starting to include credits for LCA, particularly in European countries. Key considerations for this project, and for policy makers adopting LCA, are:

- Access to sufficient measurable, robust, reportable and verifiable data;
- Clear understanding of the scope and extent of impacts (embodied energy, global warming potential, etc.)
- A definitive data collection standard;
- Inter-connection with building regulations, policies and programs;
- Diversity of industry actors and stakeholders, from materials producers to local authorities;
- Applicability to developing countries as well as small and medium sized enterprises (SMEs);
- Compatibility with existing life cycle assessment methodology and inventories;
- How to show improvement over time.

UNEP-SBCI recognizes that some major challenges need to be resolved for LCA to be globally applicable, especially for developing countries. For the particular case of assessing building materials in the UNEP-SB Protocol framework, this means that emission and resource extraction data must be available for every supply chain, mean of transportation, installation activity, end-of-life treatment, etc. from everywhere in the world. LCAs are usually performed using a bottom-up approach, but the methodology could be used to assess building stocks using a top-down approach, in which case data collection may be more complicated. The methodology also implies subjective decisions, such as the selection of allocation criteria and system boundaries that must be framed in order to get consistent and replicable results. An increasing

number of Product Category Rules (PCRs), methods and standards are being developed to provide those frames for particular applications (e.g. buildings) or for particular impact pathways (e.g. climate change). Despite this, consensus has not yet been reached for all these issues. (A summary of PCRs is provided in Annex B.)

UNEP-SBCI understands the current limitations of LCA but believes that they may be mitigated over time – particularly given growing market adoption led by developed countries. Increased use of LCA will stimulate the creation and improvement of data and tools. In this project, however, a key objective is to understand how to apply initial efforts to best support all jurisdictions in engaging with LCA either at the individual building level or based on total material flows at the community level.

In order to identify the methods, indicators, data, assumptions, etc. used in different application contexts, a review of existing initiatives related to sustainability assessment of buildings was first performed. Such a large amount of methods and rating systems have been developed throughout the world in the past recent years that a selection of ten important and/or broadly accepted initiatives were highlighted for in-depth review. Because some of them compile intensive reviews of numerous sustainable building assessment methods and rating systems, this analysis directly and indirectly includes most of the existing initiatives.

- CEN/TC 350⁹⁰
- ISO TC59/SC17⁹¹
- International Initiative for a Sustainable Built Environment⁹²
- LEnSE⁹³
- OpenHouse⁹⁴
- Perfection⁹⁵
- SuPerBuildings⁹⁶
- Sustainable Building Alliance (SBA)⁹⁷
- 2000-Watt Society⁹⁸
- BEES 4.0⁹⁹

This critical review has identified the main guidelines to follow as well as the key questions to be considered in the development of the proposed CMM. The issues uncovered in this project are useful to policy makers in developed and developing countries intent on incorporating LCA into building policies.

First of all, the extensive review of sustainable building methodologies performed through the OpenHouse project has shown most of them follow a common structure and similar indicators are used to assess environmental, social and economic sustainability of buildings. The OpenHouse project has created a harmonized list of indicators from this review, which was used as a basis for CIRAI's indicator analysis. The CEN and ISO standards also set some general principles to follow when assessing sustainability of building materials such as the use of life cycle thinking, the need for specific guidelines, and the importance of transparency.

A list of environmental, social and economic indicators related to building materials has been created from the OpenHouse harmonized list. As a first step, four criteria have been used to analyse the environmental indicators. Among indicators that represent impact categories, the global warming potential has been identified as the first to implement because it is not subject to regional variability, the required data is the easiest to find, several policies and initiatives are addressing the issue, it has been identified as a core indicator by sustainable building experts, and it is already used in the Common Carbon Metric. Acidification, eutrophication and photochemical ozone creation are sensitive to geographical aspects, which makes them more difficult to include in an international framework. Abiotic resource depletion is also an important issue that is not subject to regional variability. However, impact assessment models continue to require improvement and their on-going development should be monitored over time.

Among indicators that do not directly represent environmental impacts, but, instead, identify behaviours that could lead to impacts, the non-renewable primary energy consumption indicator is the first to implement. Several policies, initiatives

and experts have identified it as a core issue. Data is also among the easiest to find, and is closely related to several important social, economic and environmental impacts such as global warming, acidification, photochemical ozone creation and abiotic resource depletion. Experts also identify freshwater consumption as a core indicator. Moreover, water depletion is an important issue in several countries of the world. However, data for freshwater consumption may be more difficult to find than for non-renewable primary energy consumption; the impact assessment models are sensitive to regional variability and are still in development. The freshwater resource depletion metric is important for many countries and UNEP-SBCI should monitor its on-going evolution, while providing support wherever possible to accelerate implementation.

Three indicators refer to waste flows, for which other indicators already consider the impacts associated with waste flow management if the end-of-life phase is included in the system boundaries. However, the amount and type of waste and their different end-of-life scenarios (e.g. landfill, incineration, recycling, etc.) may inform on impacts associated to waste treatment if impact indicators are lacking. Moreover, reporting of these indicators may encourage building owners or policy makers to reduce wastes and favour better end-of-life scenarios.

In summary, having completed a useful review of existing indicators, the first phase of the study proposes that UNEP-SBCI start by developing metrics and protocols for:

- Global warming potential,
- Non-renewable primary energy consumption, and
- Potentially consider indicators referring to waste flows.

However, for these metrics to be usable, the following work needs to be completed:

- The principle of functional equivalence must be described because it has to be used when defining what is in and out of the scope of the assessment. Particular attention should be

paid if a phasing approach is selected, i.e. if building materials are to be considered one portion at a time (for example, just structural materials). In that case, one must make sure that the materials considered fulfil the same function in the building. Also, results coming from different types of building should not be compared since the buildings do not fulfil the same function.

- Specific guidelines need to be created to set system boundaries and describe the appropriate LCA methodology. Different boundaries can be used for the assessment of building materials including or not the building construction and use stages, and the end-of-life of the materials. The inclusion or exclusion of one of these stages will impact the results for the considered materials. Some issues related to specific materials and/or specific indicators (e.g. carbon storage in wood products, metal recycling, etc.) may also occur and should be further addressed.
- Three major sources of data that could be interesting for the development of the CMM have been identified: EPDs, LCA databases, and the publicly available ICE database from the UK.¹⁰⁰ EPDs on building materials are still not very common and each one is prepared for one very specific material. LCA databases are an appropriate source of datasets. However, they are not freely available and some limitations regarding aggregation and geographical representativeness may be major obstacles. Finally, the ICE database is freely available and has been developed from an extensive review and analysis of published data on building materials. However, it addresses materials exclusively used in a British context.

1.2 Green Multiple Listing Service Toolkit

Building “in-use” energy labelling programmes are ubiquitous throughout the EU. In America, the Green MLS Toolkit¹⁰¹ has been adopted in several

states and cities across the U.S. (e.g. Portland, Chicago, Atlanta). It offers data entry fields to identify green features, energy performance ratings and certifications (see 2.4 Passive House). This helps agents search for sustainable homes and properties, and allows builders and sellers to market their green endeavours, thereby encouraging owners to maintain their buildings properly and keep them running efficiently. Because these labels include rating system information, as opposed to just in-use energy and GHG emissions, the impact of materials and construction processes are also included (if not explicitly stated). So, although these tools have yet to specify information relating to total environmental footprint or about materials in a manner that invites quantitative comparison, they do provide comment fields for the realtor to add additional pertinent information such as the use of low-impact and/or healthy materials and features.

Toolkit organizers surveyed participants in the programme and found that 35 per cent said it required one to four months to set up and roll out. For only one per cent did it take more than 12 months. In all the regions that adopted the toolkit, there was evidence that the programme was able to increase market demand for green buildings and, therefore, to encourage builders to invest in building green buildings. In Portland, 14 per cent of homes on the market from mid-2007 to mid-2008 were green. By mid-2010, that figure grew to 23 per cent and between mid-2008 and mid-2009, Portland’s green properties sold 18 days faster than their non-green competitors.

Despite the fact that public disclosure of building performance can bring a lot of benefits to high-performing buildings, there has been resistance from building owners and managers who are concerned that a building could be unfairly branded with a “scarlet letter” due to the actions of an energy-intensive tenant. In the age of social media, this is a major concern. For example, a number of New York owners were concerned that the Energy Star benchmarking algorithm did not adequately account for certain high-energy demands in a building and lobbied to have certain buildings excluded from the scoring entirely. As a

result, New York's Local Law 84, which mandates benchmarking and disclosure, exempts buildings that have at least 10 per cent of their floor space devoted to data centres, trading floors, or broadcast studios from receiving an Energy Star score. These "high-intensity buildings" will still have their energy use intensity (EUI) disclosed publicly, but they will not suffer the embarrassment of a low Energy Star score derived by comparing them to standard office buildings.¹⁰²

1.3 Publicly Available Specification 2050

The Publicly Available Specification (PAS) 2050¹⁰³ was launched in 2008 as a consistent way of counting the GHG emissions embedded in goods and services throughout their entire life cycle – from sourcing raw materials, through to manufacture, distribution, use and disposal. The aim of the standard is to help businesses:

- Move beyond managing the emissions their own processes create and to look at the opportunities for reducing emissions in the design, making and supplying of products, and
- Make goods or services which are less carbon intensive and ultimately develop new products with lower carbon footprints

PAS 2050 is a measurement tool/protocol for companies to make credible reduction commitments and achievements on life cycle GHG emissions of products, under a Product-Related Emissions Reduction Framework (PERF). PAS 2050 builds on existing methods established through BS EN ISO 14040 (Environmental Management. Life Cycle Assessment. Principles and Framework) and BS EN ISO 14044 (Environmental Management. Life Cycle Assessment. Requirements and Guidelines). The protocol requires inclusion and identification of the following in determining the life cycle carbon footprint of a specific product or service:

- An established "functional unit" (e.g., a 100 gram croissant or a 1-liter reusable plastic water bottle and cap).

- One of two assessment scenarios:
 - Business to Consumer (B2C) – includes emissions arising from the full life cycle of the product (aka "cradle-to-grave"), or
 - Business to business (B2B) – includes the emissions released up to and including the point where the product arrives at a new organization or business (aka "cradle-to-gate").
- Use of a carbon dioxide equivalent (CO₂e) impact over a 100-year period
- CO₂ and non-CO₂ emissions from both fossil carbon as well as biogenic carbon sources
- Carbon storage
- Direct land use change

PAS 2050 can be used as guidance for those wanting to understand product life cycle GHG emissions, and support effective communication of the life cycle GHG emissions of products and/or emission reductions. Most often, however, it is being used as a means to certify and validate the life cycle GHG emissions of a product or service.

The UK Carbon Trust has published a "Code of Good Practices on GHG Emissions and Reductions Claims"¹⁰⁴ to help businesses use certified data to clearly communicate product life cycle GHG emissions, and support effective communication of the life cycle GHG emissions of products and/or emission reductions, assessed in conformity with PAS 2050. Organizations that wish to use PAS 2050 to claim and label products (or packaging) with life cycle GHG associated with their product, must use a third-party certification body. The certification process helps understand what PAS 2050 means, how to implement it, and how to prepare for verification.

While the idea of certified product labelling would be helpful for governments trying to influence behaviours to reduce emissions by reuse, recycling, composting, PAS 2050 may take some time to formally take hold elsewhere and to train third-party verification bodies. Additionally, if a government wants to know more about life cycle GHG impacts of various products, it may be quicker and simpler to access existing life cycle data and tools, as opposed to going through the rigorous process

within PAS 2050. Nevertheless, the results and labelling of products, as a result of using PAS 2050, could be helpful for governments trying to influence businesses and consumers to buy products that have lesser life cycle GHG emissions. Also, this standard has definite value in helping everyone understand how life cycle GHG impacts can be calculated, and what information goes into such a calculation. Steps within the methodology - to gather information to determine life cycle impacts may be useful, e.g., process mapping (cradle to gate, or cradle to cradle) and other recommended steps - can be a useful framework. For example, a Canadian study of the GHG impacts of four wood products¹⁰⁵ was conducted using the PAS 2050 methodology which demonstrated that, in all cases, despite being transported more than approximately 16,000 kilometers from Canada to the UK, these products represent a net carbon sink upon delivery - that is, each product stores more carbon than is emitted during its respective harvest, manufacture and transport. The study showed that because Canadian forests are sustainably managed under some of the toughest regulations in the world, they may still be used to help UK designers achieve their low-carbon objectives and obligations.

If the goal is to influence manufacturers to determine and communicate life cycle GHG impacts of a product they are manufacturing, and consumers to understand and use that information in purchasing and use decisions, potential existing life cycle tools may be a more direct way to glean that information. In 2014, PAS 2070¹⁰⁶ was published which outlines a comprehensive approach to the assessment of GHG emissions of a city or urban area. It captures both direct and indirect GHG emissions and encourages greater disclosure and better benchmarking.

1.4 WoodWORKS! project-based technical assistance

Because, in most countries, forests are public assets from which governments seek to secure highest and best use for the purpose of supporting local economies, while achieving climate policy

obligations, many countries have invested in national or regional activities to promote the use of wood.

WoodWORKS! is a national campaign to increase the use of wood in commercial, industrial and institutional construction. In North America, this market for wood is valued at US\$20 billion. In Canada, the forest products industry is a \$57 billion dollar a year industry that represents 11 per cent of Canada's manufacturing GDP. The industry is one of Canada's largest employers, operating in hundreds of communities and providing more than 230,000 direct jobs across the country.¹⁰⁷ In the U.S., 302 million hectares or 33 per cent of the total land area of the United States is forest land¹⁰⁸ and the American forest products industry is among the top ten manufacturing sector employers in 48 states and generates over \$200 billion a year.¹⁰⁹

WoodWORKS! was established in both countries to provide free technical support as well as education and resources primarily related to the design of non-residential and multi-family wood buildings in order to expand the use of wood beyond the traditional detached home sector. WoodWORKS! in USA and Canada have field teams with expertise in a wide range of building types - from schools and mid-rise/multi-family, to commercial, corporate, franchise, retail, public, institutional, etc. in order to provide project-specific advice and make it easier to design, engineer and construct wood buildings at less cost.

The American WoodWORKS! programme is run by the Wood Products Council¹¹⁰ in cooperation with major North American wood associations as well as government agencies and other funding partners. In Canada, WoodWORKS!¹¹¹ is administered by the Canadian Wood Council and primarily government funded. It is the tactical arm of a multi-pronged government-backed effort to expand the use of wood in buildings. It collaborates closely with a number of government agencies and NGO's to advance the use of sustainable wood construction materials in Canada and in key markets overseas. Canada Wood¹¹² (export portal), the Canadian Wood Council (advocacy), FP Innovations (research), Forestry Innovation Investment

(market development) and others work together to research new sustainable wood solutions, to educate professionals via the WoodWORKS! programme of professional education, technical resources and in-the-field expertise. WoodWORKS! also puts on an annual Wood Solutions Fair in which global experts are gathered at a one day conference and trade show as well as the annual Wood Design Awards which showcases leading Canadian wood design. The particular success of the Canadian WoodWORKS! programme is predicated upon its unique integrated “turn-key” solution for manufacturers, designers and builders whereby the deep technical expertise on a project-specific basis provides a real return on the investment in research, educational materials and technical resources. Working with wood can be challenging, particularly for the engineering disciplines. The hands-on know-how of the WoodWORKS! advisors in both countries is geared specifically towards helping practitioners utilize the information effectively so the benefits of wood can be realized, and the limitations understood and managed appropriately.

1.5 Dual vocational training system and “laddering” for wood technologists

Germany’s dual vocational training system (TVET) is a time-tested economic model now incorporated into Germany’s Federal Republic’s law. This programme, many supporters believe, is the reason why Germany has the lowest jobless rate among young people of any industrialized nation in the world - around 7 or 8 per cent. Austria and Switzerland have similar programmes.

After students complete their mandatory years of schooling, usually around age 18, they apply to a private company for a two or three year training contract. If accepted, the government supplements the trainee’s on-the-job learning with more broad-based education in his or her field of choice at a publicly funded vocational school. Usually, trainees spend three to four days at work and one to two in the classroom. At the end, they come out with both practical and technical skills to compete in a global

market, along with a good overall perspective on the nature of their profession. They also receive a state certificate for passing company exams, designed and administered by industry groups - a credential that allows transfer to similarly oriented businesses should the training company not retain them beyond the initial contract.

TVET ensures there is a job ready for every young person enrolled in vocational school, because no one is admitted unless an employer has already offered a training contract. No job offer, no admission. Students also know what they are getting before the first day of class. It is essentially a new hybrid model based on cooperation with local community colleges, where an apprentice can earn credits toward his or her degree while earning money, and learning, on the job. By comparison, the apprenticeship model faces significant obstacles in North America and other regions.

To proponents, the immediate cost pays for itself in the form of a more skilled economy. The German VET builds competence and real ability in blue and in white collar jobs. Other countries are starting to notice. Germany, through its Chambers of Industry and Commerce (DIHK), has launched pilot programs all over the world, including in Madagascar.

The German education system demonstrates that there is a great deal that can be included during high school to equip students with the knowledge to assess the sustainability of all building materials and whether they meet green building standards. For example, students that have worked through the TVET system and enter the wood technology and trade programs at the Rosenheim University of Applied Science in Germany¹¹³ and the Bern University of Applied Sciences¹¹⁴ at Biel, Switzerland are able to incorporate principles of LCA and environmental building performance standards as an integral part of their vocational education programmes. Indeed, Germany, Austria and Switzerland have developed world-class education in wood technology and the sustainable use of construction materials enabling students to “ladder” in to technology programmes from trade apprenticeships, all the way up to architecture and engineering degrees.

1.6 WoodLINKS training programme

The quality of design and construction workmanship is crucial to the success and longevity of a building project. The employment of well-trained and experienced professionals and trades people is the best way to assure a high level of building craft. The employment of sustainable materials may require specialist expertise that is not readily available (such as competence in building science or wood technology). In many jurisdictions, the scope and pace of change within the design and construction industries are increasing and it is difficult for educators and training authorities to keep their curricula current. Further, the adoption of wood in non-traditional forms of construction can be challenging because it is a "living" heterogeneous material and can be complex to work with.

The past decade has seen an influx of new technologies and a raft of new building regulations predominately relating to environmental performance, all within a challenging economic climate of spiralling construction costs, increased competition for natural resources and a dwindling skilled labour pool. There are some regions that will have a large number of skilled workers retire in the next decade and are struggling to attract young workers into traditional trades. Indeed, in some regions and for some types of construction project, the industry is trending away from the established "craft" of building and towards a manufacturing mindset. Transformed by powerful digital tools such as Building Information Modelling (BIM), the industry is moving towards Modern Methods of Construction (MMC's), such as offsite construction (prefabrication, pre-assembly, etc.), which have the potential to radically improve material efficiency and reduce waste. However, they may also significantly disrupt the industry if adequate training and technical support are not provided.

Unlike countries such as Germany (see 1.5 Dual vocational training system and "laddering" for wood technologists), the North American corporate sector has not historically seen technical and vocational training as one of its key responsibilities

and has not been willing to invest in technical and vocational education and training that goes beyond a few weeks of induction or learning on the job. However, in the face of a critical shortage of skilled personnel entering the wood manufacturing industry, WoodLINKS USA was established in 1998 as a partnership between industry and education.¹¹⁵ WoodLINKS is an industry driven, secondary and post-secondary woodworking partnership program, helping to build and maintain a strong, skilled workforce so that wood products manufacturers in North America can remain competitive in today's challenging economic environment.

The long-term intent of WoodLINKS USA is to provide the wood industry with the necessary skilled workers to remain competitive at the entry and middle management levels. WoodLINKS USA encourages a cooperative, big-brother approach between the woodworking industry and the education system. With 64 sites in 16 states, WoodLINKS USA teachers reach thousands of students every day. WoodLINKS USA is the most complete educational support organization for the wood industry in the United States. Each year over 10,000 students a year come to understand the personally and financially rewarding careers available to them in the wood industry.

In British Columbia (B.C.), Canada, the WoodLINKS Wood Products Manufacturing Education and Certification program (through the Wood Manufacturing Council) was developed by industry, secondary, and post-secondary schools and is approved by the BC Ministry of Education.¹¹⁶ The WoodLINKS program was pilot tested in 16 B.C. schools during the September 1997 and 1998 school years, and subsequently received approval from the B.C. Ministry of Education for use in all B.C. high schools. The program is now offered annually in over 70 schools across Canada that are presently certifying students. This includes some schools in B.C., Saskatchewan, Ontario, New Brunswick and Yukon. WoodLINKS itself is a B.C.-registered, non-profit society whose mandate is to recruit and prepare quality young people for entry-level work in the wood products manufacturing industry and/or entry into wood-related college and university programs.

The WoodLINKS curriculum currently consists of 2 courses, representing approximately 240 hours of instruction in total. Curriculum content focuses on career exploration and basic skills in wood species identification, manufacturing processes, use of technology, product design, marketing and business skills. Assessment tools were developed to match the WoodLINKS curriculum. Schools can offer the WoodLINKS curriculum as stand-alone elective courses or embedded within existing courses, e.g., Woodworking 11/12, Construction 11/12, etc.

A certification process was also developed with industry representatives setting the standard for achieving certification. The certification indicates students have met the industry standard for entry-level employment in wood products processing. Certification consists of a 3 part assessment: an evaluation by the WoodLINKS teacher, a written test set by WoodLINKS and a Practical Skills Checklist. A student must score 70 per cent overall

to be certified. High school teachers can certify students to an industry standard and transition agreements with post-secondary institutions and training providers provide certified students with exemption from introductory courses and/or preferred entry into trade programs. Transition agreements are updated annually and distributed to high school career counsellors and teachers.

The success of the WoodLINKS programme has shown how important it is for industry to share the responsibility of training young workers, especially given the pace of advancement in new techniques related to wood construction and the use of sustainable materials and technologies. Also, to create an effective system, many advanced nations may still need to lose the stigma attached to vocational and technical school as a fallback for those who have failed in higher education and create alternative paths along which students can ladder into advanced education.

2. Policies that advance environmental norms

2.1 Materials Awareness Policy and the “Environmental Performance of Materials used in Building Elements” method

Building on over two decades of experience with C&D waste diversion and green building, the Flemish government, in partnership with industry has launched a “Materials Aware” policy programme¹⁷ with clear goals for the management of construction materials 2020 and, in the long term, looking forward to 2050 (see Figure 22).

The policy to 2020 comprises five objectives:

1. Use virgin raw materials in the manufacture of construction materials and in the construction of buildings as little possible.
2. Use the right material in the right place and with the right construction techniques in order to close the materials life cycle loop.

3. No dangerous substances are to be used in new construction and any hazardous substances are to be extracted from materials to be recycled during the demolition or dismantling of buildings and infrastructure
4. New buildings and structures are to be designed and built so that materials and building components can be easily recovered.
5. Buildings are to be easily adaptable and customizable to meet the needs of a constantly evolving society.

The programme is being led by the Public Waste Agency of Flanders (Openbare Vlaamse Afvalstoffenmaatschappij (OVAM)) in close consultation with all the various industry stakeholders as well as government agencies from other regions in Belgium. Tactically, “life-cycle thinking” is encouraged across the building supply chain by focussing on the following key areas:

- Selective demolition and dismantling
- Recycling aggregates and stone materials
- Recycling key waste materials (wood, etc.)
- Evaluation of the performance of materials in buildings
- Adaptable building design, standardization of components and design for disassembly

Figure 22: Flemish sustainable materials management goals

Situation (2013)	Ambition (2020)	Target (2050)
Flanders recycles over 90% C&D waste and has established clear commitments to build and operate energy efficient buildings	Flanders has a full-fledged policy that incorporates the accounting of the environmental impacts of materials in the overall assessment of sustainability in buildings.	Materials with the smallest environmental impact are deployed for the construction of buildings and neighbourhoods, infrastructure and roads.
A method to assess the environmental performance of buildings elements is developed.	The materials methodology is translated into a fully operational tool for architects and building professionals to calculate the total impact at the building level.	
This method has also been translated into a mathematical model and an environmental expert profile database of 115 possible variants of building elements.	Government and industry have an understanding into the costs and benefits of a roadmap and method to determine the allowable impact of the choice of materials in buildings.	
Integration of the method in existing instruments that measure the sustainability of buildings was launched		

Source: Openbare Vlaamse Afvalstoffenmaatschappij (OVAM), (www.ovam.be)

The role for OVAM in advancing these activities are broadly as follows:

- **Pull the industry forward:** OVAM will actively apply its expertise and ongoing attention to selective demolition, material innovation and materials waste diversion and management. In those areas, OVAM will take the initiative in the regulation, monitoring (including the development of sustainability indicators) partnership liaison, pilot projects and so on. OVAM will be particularly involved:
 - At the design phase to support the inclusion of measures that encourage the selection of low impact materials and to set a new building up for ease of adaptability and disassembly in the future, and
 - During the demolition and construction phase to help contractors to reduce waste and recycle materials.
- **Advise and support:** OVAM offers a wide range of coaching, technical advice and support in the field of sustainable materials management in construction. OVAM is also able to leverage the expertise of industry partners where necessary and promote pilot projects as a way to explore new techniques and technologies..
- **Advocate and inform:** to smooth the market transition, OVAM will undertake ongoing consultation with industry to gather input and provide feedback on practical insights and lessons learnt to industry partners, other government agencies and practitioners. Also, in some areas, OVAM will provide a communications role to the broad range of stakeholders by assembling information and informing on progress in order to generate interest in sustainable materials management and advocate for behaviour change.

As indicated in other life-cycle based building policies (such as the Swiss 2000-Watt Society Energy Vision), regionally-applicable data and a clearly defined evaluation methodology are both critical to success. In 2010, the OVAM begun

the development of its own “Environmental Performance of Materials used in Building Elements”¹¹⁸ (Milieugerelateerde Materiaalimpact van Gebouwelementen (MMG)) methodology specifically for the Flemish-Belgian construction industry. The rationale is that, currently, Flemish building professionals and the government are forced to use foreign environmental classification systems including the British “Green Guide” (2011) (see 2.3. BRE Green Guide to Specification) and the Dutch NIBE’s “Basiswerk Milieuclassificaties Bouwproducten” (NIBE 2011a, 2011b, 2011c),¹¹⁹ or foreign life cycle inventory databases (LCIs) such as the Swiss “coinvent” (v2.2, 2010),¹²⁰ or publicly available labels, self-declaration or Environmental Product Declarations (EPDs). The downside of these tools and information is that they are often not transparent and/or not specifically related to the Flemish-Belgian building methods and scenarios.

In the period covering February 2011 through August 2012, by order of the OVAM the project team comprising VITO, KU Leuven (ASRO) and BBRI developed an expert calculation model (including determination method) for the quantification of environmental performance of building elements. The model served as the basis for a limited database of 115 building variants that is representative of the Flemish-Belgian construction industry. The MMG methodology is built upon the criteria set out in CEN TC 350 (discussed in 1.1 United Nations Environment Programme Sustainable Building and Climate Initiative Common Material Metric) to ensure alignment with European protocols but also includes the following additional indicators:

- Climate change
- Depletion of the stratospheric ozone layer
- Acidification of land and water
- Eutrophication
- Photochemical oxidant formation (low ozone; summer smog) • depletion of abiotic resources: non-fossil resources
- Depletion of abiotic resources: fossil resources
- Human toxicity (cancer effects and non-cancer effects)

- Particulate matter formation
- Ionising radiation effects on humans
- Eco toxicity (land, fresh water, marine)
- Land use: land occupation
- Land use: land transformation
- Water depletion

A key challenge for LCA proponents has always been the sheer number of different construction materials and products in common use and the fact that many comprise proprietary substances (such as polymers). To limit the difficulties with data collection, policy makers in other jurisdictions have focussed on climate and embodied energy indicators as their starting point (for example in Switzerland) with a view to expanding the number of indicators as data becomes available. The Flemish solution takes an alternative path. By limiting the number of materials (a total of 115 to be incorporated into the MMG database by 2020), they are able to develop a much larger number of indicators. However, it is clear that there will be convergence over time. In order to seed the MMG database with sufficient generic environmental data, OVAM has worked to harmonize the Swiss ecoinvent database as much as possible with the Flemish-Belgian building context. Also, a few proactive materials manufacturers and industry organisations have provided their own specific environmental data of building products, which provided for interesting comparison with the generic ecoinvent data.

To allow for a decision-oriented selection of materials solutions, the MMG method allows for the characterisation values for each individual environmental indicator to be aggregated by means of an environmental cost method. For each individual environmental indicator, the characterisation values are multiplied by a monetization factor (e.g. X kg CO₂ equivalents multiplied by Y €/kg CO₂ equivalents). This factor indicates the extent of the damage to the environment and/or humans, expressing it in a financial amount for the purpose of avoiding potential damage or settling any damage incurred. These aggregated environmental scores are also reported separately.

While OVAM's work is ground-breaking on many levels, no clear measurable goals have yet been established in terms of environmental performance criteria or KPIs. It is expected that the strength of government commitment and the activities that have been established through to 2020 will advance industry practice to a point where a comprehensive review can be completed and performance goals then established through to 2050 in order to ensure progress continues at the necessary pace and the goal of a total circular economy is achieved.

2.2 Grenelle de l'Environnement

The French government has developed an environmental programme, "Grenelle de l'Environnement", which puts forward a cross-cutting framework of policies and measures, setting ambitious targets for specific sectors and energy sources, and guidelines for strengthening R&D on clean energy technologies. Reducing the CO₂ footprint of energy consumption and production (which includes the footprint of a wide range of materials) of the building sector is a priority area outlined in the Grenelle laws.

Loi Grenelle II (2012) *requires* companies to include information on their environmental and social performance (including all of the company's subsidiaries) in their annual report - effectively turning it into the foundation for a fully integrated sustainability report. Every French company, private and public, exceeding more than 500 employees, has to report on the social and environmental consequences of its activities. The reporting criteria include environmental policy, pollution and waste management, sustainable use of resources (which includes consumption of raw materials, measures taken to improve the efficiency of raw materials use and energy consumption), climate change, etc. The implication of this law is that applicable French construction materials manufacturers and construction companies are directed to document and report their environmental performance. As a result, not only are they well informed about the impacts of their own products but they must in

turn acquire information about the raw materials which they purchase thereby stimulating the uptake of EPDs (see 2.7 Product certification schemes) and other life-cycle based documentation for raw materials. In fact, under Loi Grenelle II, the BP X30¹²¹ standard and methodology was developed for the definition and reporting of the environmental impacts of materials. As a result, Grenelle was the first major framework to promote the use of EPDs for the major consumer goods, which includes material and immaterial goods (e.g. services).¹²²

Grenelle also offers incentive tools to local governments for advancing sustainable construction, further stimulating the adoption of sustainable building materials. For example, French municipalities have the potential to offer increased land use density ratios (building coverage ratios, i.e. the net floor area derived from use of the maximum building footprint allowable on a given parcel divided by the total parcel land area) by up to 20 per cent for energy-efficient construction that relies on renewable energy sources. This net floor area is calculated without including attic or basement space that could not be made suitable for human habitation, nor does it include roof terraces, balconies and loggias.¹²³

2.3 BRE Green Guide to Specification

To ease the British building industry into using LCA, the British Research Establishment (BRE) developed the “Green Guide to Specification” (Green Guide)¹²⁴ as an accessible accredited environmental rating scheme for buildings. The Green Guide is part of BREEAM (BRE Environmental Assessment Method) and contains more than 1,500 specifications used in various types of building (domestic, commercial, health, etc.).

The data is set out as an easy-to-understand A+ to E ranking system, where A+ represents the best environmental performance/least environmental impact, and E the worst environmental performance and/or most environmental impact (see Figure 23). BRE has provided a summary environmental rating, the “Green Guide rating”,

which provides an “at-a-glance” measure of overall environmental impacts covering thirteen issues including climate change, ecotoxicity to freshwater ad land, eutrophication, waste disposal and more.

By evaluating the performance of materials and building systems against these specific environmental impacts, which have also been ranked on an A+ to E basis, it is possible for the specifier to select specifications on the basis of personal or organizational preferences or priorities, or take decisions based on the performance of a material against a particular environmental impact.

2.4 Passive House

The term “Passive House” (*Passivhaus* in German) refers to a rigorous, voluntary standard for energy efficiency in a building, reducing its ecological footprint. It results in ultra-low energy buildings that require little energy for space heating or cooling. Launched in Germany,¹²⁵ but now offered internationally through the International Passive

Figure 23: BRE GreenGuide example for an interior timber stud partition

Green Guide 2008 ratings	
Building type >	Commercial
Category >	Internal Wall
Element type >	Framed Partitions
Element	Timber stud, plasterboard, paint
Element Number	809760003
Summary Rating	A+
Climate Change	A
Water Extraction	A
Mineral Resource Extraction	A+
Stratospheric Ozone Depletion	A+
Human Toxicity	A
Ecotoxicity to Freshwater	C
Nuclear Waste (higher level)	A+
Ecotoxicity to Land	A+
Waste Disposal	A
Fossil Fuel Depletion	A+
Eutrophication	A+
Photochemical Ozone Creation	A+
Acidification	C
Kg of CO ₂ eq. (60 years)	15.0

Source: BRE

House Association (iPHA),¹²⁶ the standard is not confined to residential properties; but has been applied to office buildings, schools, supermarkets and health care buildings. Estimates of the number of Passive House buildings around the world range from 30,000 to 40,000 structures. At the end of 2014, a major milestone was accomplished with the cumulative certification of over one million square meters of real estate to the Passive House standard.¹²⁷ The vast majority of passive structures have been built in German-speaking countries and Scandinavia.

It is important to distinguish between energy rating standards such as Passive House, which are usually closely tied to building regulations and voluntary green building rating systems, which are primarily developed as market-oriented “stretch” goals for building owners seeking to differentiate their projects. (A background on green building rating systems and how they are different from energy rating standards is presented in Annex B.)

Passive design is not an attachment or supplement to architectural design, but a design process that is integrated with architectural design. Although it is mostly applied to new buildings, it has also been used for refurbishments. The standard sets very specific requirements as follows:

- Space Heating Demand must not to exceed 15kWh annually OR 10W (peak demand) per square metre of usable living space
- Space Cooling Demand must roughly match the heat demand with an additional, climate-dependent allowance for dehumidification
- Primary Energy Demand must not to exceed 120kWh annually for all domestic applications (heating, cooling, hot water and domestic electricity) per square meter of usable living space
- Airtightness maximum of 0.6 air changes per hour at 50 Pascals pressure (as verified with an onsite pressure test in both pressurized and depressurized states)
- Thermal Comfort must be met for all living areas year-round with not more than 10% of the hours in any given year over 25°C*

To accomplish these performance goals requires the building envelope (exterior walls, roof, etc.) to be carefully designed without any thermal bridges. The results are generally very robust and durable structures because so much of the functional success of the building relies on the building envelope.

A very energy efficient building that meets a standard such as Passive House may have no need for a separate heating system due to its excellent thermal protection. So, even though Passive House buildings require more insulation than a conventional building, the embodied energy required for the materials construction of a new Passive House building can thus be less than that of ordinary new buildings on a life-cycle basis because it does not incur the large amount of primary energy required for the production and renewal of complex technical systems.¹²⁸ Importantly, the Passive House Institute not only establishes whole building performance but also certifies building components suitable for use in the building of Passive buildings. While certified components are not the only components that can be used in, using certified components simplifies their planning.

The Passive House standards have been, or are in the process of being, incorporated (in all but name) into many of EU member states performance standards for new home construction in order to achieve their “zero carbon” goals.¹²⁹ For example, the Swiss MINERGIE-P standard¹³⁰ references Passive House with MINERGIE-P overlaying holistic sustainability criteria, including measures related to the use of materials.

Currently, on an annualized basis, the energy and GHG impacts of “in-use” operations in most buildings are considerably larger than the embodied impacts associated with the materials and construction processes. However, increasingly stringent regulations governing “in-use” energy efficiency and GHG emissions such as Passive House can, uncontrolled, result in the embodied impact of materials overtaking the impacts associated with operating or in-use impacts of the building. This is because operationally efficient buildings may require more materials during construction (such as thicker walls, more insulation, triple-glazing, etc.), which then also requires more materials to be repaired and replaced during its service life.¹³¹

2.5 International Green Construction Code

Developed and primarily used in the U.S., the International Green Construction Code (IgCC)¹³² is a model code to include sustainability measures for the entire construction project and its site - from design through construction, certificate of occupancy and beyond. The IgCC creates a regulatory framework for new and existing buildings, establishing minimum green requirements for buildings and complementing voluntary rating systems, which may extend beyond baseline of the IgCC. The code acts as an overlay to an existing set of “opt-in” international building codes¹³³ including provisions of the International Energy Conservation Code¹³⁴ and ICC-700, the National Green Building Standard (which is an ANSI-approved residential green building rating system endorsed by the National Association of Home Builders (NAHB)¹³⁵) and incorporates the American ASHRAE Standard 189.1¹³⁶ as an alternate path to compliance. The IgCC includes measures to conserve materials including requirements for at least 55 per cent of construction materials to be recycled, recyclable, bio-based or indigenous and to divert at least 50 per cent of construction waste from landfill.

2.6 Voluntary green building certification systems

There are over 60 green building rating systems in effect, worldwide. They provide consumers, building professionals and government regulators with a means to evaluate the environmental impact of a particular structure under a series of categories such as energy, water, occupant health, materials and location. Green building rating systems are evolving rapidly. The majority are developed and administered by not-for-profit organizations that are independent from government regulators. These organizations are generally unregulated and non-standardized. With the growing awareness of the impacts of buildings on GHG emissions, resource depletion and eco-system degradation, the implementation of national and international building regulations is accelerating. (A backgrounder on green building rating systems and how they work is presented in Annex B.)

Figure 24: The U.S. Green Building Council's LEED Version 4 includes credits for completing a LCA

LEED Version 4 has a credit for “Building product disclosure and optimization - environmental product declarations” which requires the use of at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the following disclosure criteria:

- Product-specific declaration:
 - Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044 that have at least a cradle to gate scope are valued as one quarter (1/4) of a product for the purposes of credit achievement calculation.
- Environmental Product Declarations which conform to ISO 14025, 14040, 14044, and EN 15804 or ISO 21930 and have at least a cradle to gate scope.
 - Industry-wide (generic) EPD -- Products with third-party certification (Type III), including external verification, in which the manufacturer is explicitly recognized as a participant by the program operator are valued as one half (1/2) of a product for purposes of credit achievement calculation.
 - Product-specific Type III EPD -- Products with thirdparty certification (Type III), including external verification in which the manufacturer is explicitly recognized as the participant by the program operator are valued as one whole product for purposes of credit achievement calculation.

Source: USGBC (www.usgbc.org)

Globally, the most popular systems are BREEAM and the U.S. Leadership in Energy and Environmental Design (LEED®). Over 250,000 buildings totalling in excess of 40 million m² of floor area have been certified using BREEAM since its inception in 1990,¹³⁷ and the scheme is now used in more than 50

countries. Since 2000, there are nearly 60,000 LEED projects in the world,¹³⁸ spanning 1 billion square metres. Canada, India, China, the United Arab Emirates and Brazil are the countries with the most LEED projects outside of the U.S.

Historically, rating systems tended to under-represent the value of wood as a sustainable construction material.¹³⁹ However, the situation is changing. Rating systems such as LEED and BREEAM are starting to include credits for LCA (see Figure 24). Certainly, pressure on materials manufacturers to develop EPDs will increase as rating systems around the world continue to incorporate LCA as the method by which the impacts of materials are assessed. In many jurisdictions, policy makers are leveraging the presence of rating systems to effectively “outsource” the review and verification of the green features and performance of projects. While this may expedite the regulatory process, there are challenges in terms of:

- **Schedule:** developers need to know that their project meets the green criteria early in the construction process yet, most rating systems do not issue certification until after the project is complete making it difficult to enforce controls on entities which no longer have a relationship to the building.
- **Fit:** while rating systems are generally very comprehensive and address a wide range of environmental impacts (recycled content of materials, locally sourced materials, construction waste, etc.) they are usually positioned at a national level and do not consider the local characteristics of a particular project. They can also be prescriptive and impose prohibitions or restrictions on the use of certain materials (e.g. the use of wood of certified origin from sustainable forests).
- **Clarity:** most rating systems award points for optional building features that support green design, in categories such as location and maintenance of building site, conservation of water and energy, choice of building materials (many require an LCA analysis – see below), waste, occupant comfort and health. The more points, the greener the building.

However, it is not always possible to be sure that a certified building has scored well in particular categories. For example, a certified building may have secured the majority of its credits for energy efficiency and not addressed materials.

- **Enforcement:** rating system providers are usually not-for-profits without the legislative muscle necessary to hold developers and builders accountable in the event of failure to perform.

In effect, green building rating systems are voluntary by nature and therefore only apply to a sub-set of leadership-level buildings. Indeed, most providers state that their intention is, at best, to target the “top 25 per cent”¹⁴⁰ which therefore dilutes their intensity of effectiveness to an entire building stock. Despite these drawbacks, green building rating systems are very influential in raising awareness and prompting designers to engage in green building practices. They can be effective as transitional tools that can be employed for a limited period of time to fine-tune public policy priorities (by learning which credits work for a particular region, building type, etc.) in order to prepare the market for regulatory reform.

2.7 Product certification schemes

Environmental product labelling schemes can be voluntarily provided by manufacturers or mandated by governments to inform consumers about a product’s environmental impacts. Criteria and standards for eco-labelling schemes vary widely. The information that goes into the LCA of a product, assembly or entire building, is provided by manufacturers via an EPD. The criteria for developing EPDs are described under ISO/CD 21930. EPDs must be created in accordance with the relevant Product Category Rulings (PCRs) described under ISO 14025. PCRs provide product category specific rules, requirements, and guidelines for calculating and reporting environmental impacts across the full life cycle of a product. (A background on product certification schemes and how they work is presented in Annex B.)

Forest product certification schemes were one of the first types of product labelling programme and have been in effect since the mid-1990s. Today, they have become a respected means of demonstrating that major forest companies meet high standards of sustainable forest management, complementing the nation's already stringent laws and regulations. Under the forest certification process, independent third party auditors are able to evaluate, measure, and certify the sustainability of the forest management practices and forest products associated with a particular organization. A variety of factors are taken into account during audit, including forest inventory, management, silvicultural and harvesting practices, road construction and other related activities, and the environmental, social, and economic impacts of forest activities. Ultimately, this evaluation process results in a written statement attesting to the origin of the wood material and its qualification as a sustainably harvested product.

Forest certification programmes are able to provide data into LCI inventories for wood products and there is work underway to improve the capacity of LCA tools and protocols to account for the benefits of sustainable forest management. It is clearly important that an LCA considers how trees are harvested, whether and to what extent forests are replenished and any adverse effects of excessive logging, reduction of bio-diversity through the creation of mono-cultures, large scale clearcuts and deforestation.

There are more than 50 independent forest certification systems worldwide, addressing a variety of forest types and tenures. Despite their differences, credible forest certification systems typically uphold the following requirements, each of which can be broken down into a variety of criteria and indicators:

- Protect biodiversity, species at risk, and wildlife habitat.
- Protect water quality and other resources.
- Ensure sustainable harvest levels.
- Ensure prompt regeneration.
- Involve multiple stakeholders in the standards development process.

- Obtain third-party certification performed by accredited certification bodies.
- Make certification audit summaries publicly available.
- Provide a complaints and appeals process.

The most widely accepted forest certification programmes are the following and there is overlap with forestlands that carry both certifications:

- **Programme for the Endorsement of Forest Certification (PEFC):** PEFC is the world's largest certification system. It is active in over 30 countries and more than 240 million hectares of forest area are managed in compliance with PEFC's internationally accepted Sustainability Benchmark. More than 10,000 companies and organizations have achieved PEFC Chain of Custody certification.¹⁴¹ PEFC offers a Project Chain of Custody certification for building projects,¹⁴² which utilizes a simple percentage-based method to account for all the various PEFC certified forest-based material and products used for the project. Although certification standards can vary depending on the jurisdiction, this system can offer a simple tool for the promotion of local and sustainable wood.
- **Forest Stewardship Council (FSC):** FSC is the fastest growing and one of the most stringent global forest certification programmes, accounting for over 180 million hectares of certified forestland across 80 countries. FSC operates a chain of custody programme and 28,000 companies (forestry companies, mills, manufacturers, etc.) are FSC certified. Like PEFC, certification standards can vary depending on the jurisdiction and this can affect available volumes of certified wood. However, unlike PEFC, all national standards must start from the international FSC Principles and Criteria and the final outcome needs FSC International's board approval before it can enter into force.¹⁴³ The US and Canadian LEED green building rating systems accepts FSC and PEFC certification schemes.

3. Policies that focus on the proportion of wood in buildings

3.1 Strategic Programme for Finland's Forest Sector

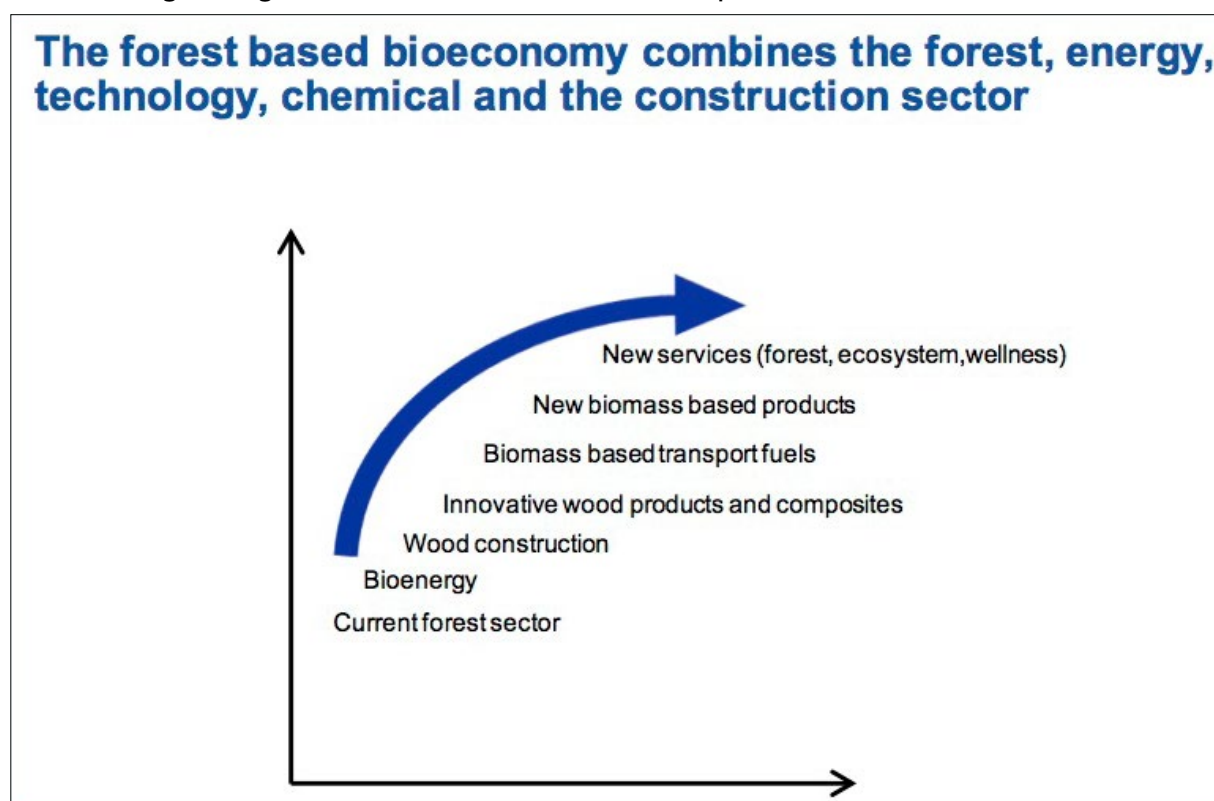
With over 200,000 people working in the forestry sector, Finland has a long tradition in the production and use of wood. The yearly growth of forests exceeds 100 million cubic metres and total incremental growth is greater than utilization. Of this, just over half is processed into various products. The value of the production by the forest industry is approximately 20 billion euros annually, and its products account for about one-fifth of the value of total goods exports. The sector also generates

about 70 per cent of Finland's renewable energy. Finland has been actively investing in innovative solutions to optimize the use of wood, particularly in multi-storey construction techniques, since 1995.¹⁴⁴

In October 2011, the Finnish Ministry of Employment and the Economy set up the Strategic Programme for the Forest Sector¹⁴⁵ a key component of which is the Finnish National Wood Construction Programme¹⁴⁶ which is directed towards promoting wood construction in urban areas and the use of wood products in construction (see Figure 25). With no special funding (in other words using normal funding with a high priority), the main measures in the next coming years are focussing on:

- Increasing the market share of wooden multi-storey houses up to 10 per cent
- To double the exports of value added wood products

Figure 25: Finland is using construction as a springboard to a strategic approach to growing its market for sustainable wood products and services



Source: Ministry of Employment and the Economy of Finland (www.tem.fi/mso)

The tactics being employed to achieve these targets are based upon strong commitment from the Finnish government, very concrete and tightly scheduled actions, and close partnerships with researchers and industry. Accomplishments reported in 2013 include:

- The development of customer-oriented and competitive wood construction
 - 7,500 multi-storey house apartments under planning and several large projects starting
 - An open industry standard for prefabricated wood construction
- Creating a ecological and experimental wood brand
 - Ongoing project planning and stakeholder negotiations
- New operating models for achieving business and export growth
 - Tens of SME's in different development projects
 - Several business studies implemented
 - Wood products promoted by the Team Finland network
- Increasing competence and R&D cooperation
 - Thousands of experts have participated in a wood construction road show
 - 150 new structural engineers trained in wood construction to enter the job market in the coming years
 - Several pilot projects on going in R&D

The Strategic Programme for the Forest Sector (MSO) helps in the implementation of the Government Programme's focus area concerning the strengthening of economic growth, employment and competitiveness by promoting competitiveness and renewal in the forest sector. For Finland, securing a solid role for wood in the construction industry is seen as a first step in a long-range, cross-sectoral approach that will result in a broad market development strategy into a wide range of industries and services. A comprehensive website promoting Finnish wood architecture has already been created.¹⁴⁷

3.2 Wood Use Points Programme

Two-thirds of Japan's land area is covered with forests, with a total forested area of 25 million hectares. Approximately 40 per cent of these forests are artificially planted forests and the major planted species are sugi (cedar), hinoki (cypress), and karamatsu (larch). The total volume of the forest inventory reached 4.4 billion m³ in 2007 and the share of the planted forest area exceeding 50 years in age will exceed 60% by 2017. Yet domestic wood supply has declined steadily from a high in the early 1970's of more than 50 million m³ to just over 19 million m³ in 2011. Forest ownership in Japan can be divided into approximately 70 per cent for private owners including local governments, and 30 per cent for the national government.¹⁴⁸

Japan's forest resources are now mature enough for intensive harvesting. However, the industry is not sufficiently well developed to sustain large-scale production. Most often forestry is a part-time activity for farmers or small companies and so productivity is low. For example, while Japan has manmade forests that equal Germany's 10 million hectares of forestland, Germany steadily produces about three times more logs than Japan.¹⁴⁹ The Government of Japan (GOJ) is concerned that because Japan's domestic forest resources are not fully utilized, some forests are at risk of losing their ability to provide multiple environmental functions because of the lack of proper forest management. The GOJ is working to strengthen and revitalize the domestic forestry industry with a raft of policy measures focusing on the coordination and consolidation of forestry practices, construction of a forest road system, and human resource development.

Japan's Wood Use Points Programme (WUPP) is an innovative market-based approach to promoting the use of local wood products in buildings. Launched in 2013 with the intention of kick-starting a sluggish housing market, WUPP was also aimed at stimulating local forestry activity by subsidizing the increased use of "local wood" species (sugi, hinoki and karamatsu) in both new home starts as well as renovation work. "Local wood" species must satisfy two conditions in order to be included within the WUPP:

- The resource inventory of the timber species must be increasing in the country where it grows, and
- The consumption of the “local wood” species must have a significant economic ripple effect within Japanese rural agriculture, forestry and fisheries communities.

An additional benefit of WUPP is to lower the carbon footprint of building projects by substituting high impact materials such as concrete and steel with wood. Sourced from sustainably managed forests and manufactured efficiently, wood products are considered environmentally low impact building materials. Trees and forest products play a critical role in helping to tackle climate change and reduce greenhouse gases. A responsibly managed forest stores more carbon than it emits from harvesting, processing, transport and fabrication. When the trees are harvested and used to make wood products, the carbon remains stored in the wood for the life of the product.

During the 2013 fiscal year, Japan’s Ministry of Agriculture, Forestry, and Fisheries (MAFF) set aside a budget of approximately about US\$400 million to provide a subsidy worth as much as US\$6,000 (¥600,000) in equivalent points to a homeowner who uses more than 50 per cent of “local wood” species for structural components and/or uses certain amounts of “local wood” species for non-structural interior or exterior decorations. The points are awarded in the form of vouchers and do not have a cash value. They can be redeemed for a variety of products, such as energy-efficient windows or wooden furniture.

If successful, this scheme could lead to a significant increase in Japan’s wood self-sufficiency and reduce reliance on imports. At the same time, the program aligns with other “Buy Japanese” efforts currently underway. However, given that Japan is nowhere close to self-sufficient in wood supply (fulfilling only 26.6 per cent of total demand in 2011), a number of imported wood species such as American Douglas Fir, Austrian Spruce, Swedish European Spruce, Scots Pine and New Zealand Radiata Pine have been added to the eligible species list.¹⁵⁰

Approvals to add species and applicable construction methods are made at the prefecture.

Approved species and type of construction as of June 2014 are as follows:

- Prefecture of Gifu, Fukui, Nagano approved post and beam construction built with majority of structural members by cedar, cypress, larch, fir, red pine, black pine, Ryukyu pine and yellow cedar or American Douglas fir for the system.
- Prefecture of Kanagawa, Gifu, Shiga, Fukuoka, Nagasaki approved log house and platform construction with cedar, cypress, larch, fir and American Douglas fir.
- Prefecture of Hokkaido, Ibaraki, Tokyo, Kanagawa, Nagano, Miye, Shiga, Osaka, Hyogo, Wakayama, Okayama, Hiroshima and Yamaguchi approved post and beam construction with cedar, cypress, larch, fir, red pine, black pine, Ryukyu pine, yellow cedar, American Douglas fir and Austrian spruce.
- By all those approvals, American Douglas fir is qualified for both post and beam and platform construction in 42 prefectures and log house in 41 prefectures.

As with any government-backed preferential purchasing programme, there is the potential for push-back from other materials producers. It is early days for WUPP and difficult to determine the effect it is having on other materials providers. However, Japan’s construction industry is far more reliant on imports than Canada and the Japanese government has made the priority of economic benefit to local Japanese businesses very clear, so the backlash may be less severe than in Canada which is predominately a resource-based economy with a significant domestic steel, cement and concrete production.

The key innovation of WUPP is the voucher system. Many countries operate rebate and “cash-back” programmes for construction materials and products – particularly energy efficient equipment. The idea that a voucher can have significant value but must be used towards the purchase of other sustainable and energy efficient products will likely function as an effective market “pull” and accelerating market adoption of sustainable energy efficient construction solutions.

3.3 France's action plan for the development of timber in the building sector

The "Action plan for the development of timber in the building sector" and the "Action plan for the development of bio-sourced materials in the building sector" came into effect in 2009. They are published within the framework of the "action plan for the development of timber in the building sector",¹⁵¹ supervised by the sub-Directorate of Quality and Sustainable Development in Buildings, and is applicable to all types of buildings (individual houses, collective housing and tertiary buildings). It aims at lifting the barriers (technical, normative, regulation, and structuration barriers) to the development of timber and more generally bio-sourced materials in the building sector. The policy is co-financed by the sub-Directorate of Quality and Sustainable Development in Buildings (DHUP) together with professional organizations, supervised by the DHUP and the actions are led by the professionals with the intention of supporting GHG emission reduction and/or climate change policies, reducing environmental impacts of construction materials (embodied energy, water, waste, etc.) and promoting a local wood economy and culture.

The action plans are composed of many actions (about 20 for the wood action plan, about 30 for the biosourced materials action plan) that are followed individually. There is no global indicator available yet. Although, a project of "global economic monitoring for the forestry industry" is under construction. This project is led by the Ministry of agriculture. Many technical, normative and regulation barriers have been lifting. Today, the positive effects of this program are recognized by the professionals. The effectiveness of such an approach is conditioned by the capacity of the professionals, across the entire value chain, to work on collective projects.

3.4 USDA high-rise wood innovation competition

The U.S. Forest Service is part of the US Department of Agriculture (USDA), and is mandated to sustain the health, diversity, and productivity of America's forests and grasslands to meet the needs of present and

future generations. The agency manages 193 million acres (78 million hectares) of public land, provides assistance to state and private landowners, and maintains the largest forestry research organization in the world. The agency also has either a direct or indirect role in stewardship of about 80 per cent of the 850 million forested acres (344 million hectares) within the U.S., of which 100 million acres (40 million hectares) are urban forests where most Americans live.

In 2011, a three-part plan addressing the USDA's green building practices¹⁵² was launched to promote the use of wood, in which the Forest Service will:

1. Preferentially select wood in new building construction while maintaining its commitment to certified green building standards. The USDA will also make a commitment to using wood and other agricultural products as it fulfills President Obama's executive order on Federal Leadership in Environmental, Energy, and Economic Performance.
2. Examine ways to increase its already strong commitment to green building by reporting to him on ways to enhance the research and development being done around green building materials.
3. Actively look for opportunities to demonstrate the innovative use of wood as a green building material for all new structures of 10,000 square feet (1,000m²) or more using recognized green building standards such as LEED, Green Globes or the National Green Building Standard.

By making the case for more wood in buildings, the USDA is calling attention to the value of sustainably grown forest products in storing carbon throughout the building's lifecycle, which helps maintain America's working forests and supports rural economies.

This strategy has paved the way for the White House Rural Council and the USDA to further recognize the environmental benefits of building with wood and opportunities to advance the use of wood in construction in 2014, with the announcement that a new prize competition¹⁵³ is expected to begin in 2014, for developers,

institutions, organizations and design teams competing to demonstrate the architectural and commercial viability of using sustainable wood products in high-rise construction. The USDA is proposing to invest up to US\$1 million to launch the competition. The Binational Softwood Lumber Council (a not-for-profit partner) has committed an additional US\$1 million for the competition. The competition is intended to spur increased sustainability in construction and will give priority to applicants that source materials from rural domestic manufacturers and domestic, sustainably-managed forests.

Emerging engineered wood technologies can be used in industrial building projects such as tall buildings and skyscrapers, as well as other projects. By some industry estimates, a 3-5 story building made from emerging wood technologies has the same emissions control as taking up to 550 cars of the road for one year. Wood-based designs have also been demonstrated to improve energy efficiency, thereby reducing energy consumption for heating and cooling.

To complement this proposed competition, USDA's Forest Products Laboratory in Madison, Wisconsin¹⁵⁴ has invested over US\$2 million in research and technical support for emerging wood technologies and USDA has also announced a new partnership to train architects, engineers and builders about the benefits of advanced wood building materials. Innovative use of wood products is already beginning to change the face of construction across the country, and USDA is undertaking efforts to support these advancements. These efforts also support President Obama's Climate Action Plan goal of preserving the role of forests in mitigating climate change.

3.5 Norwegian Wood-Based Innovation Scheme

Norway has an ambition to be a global leader in the innovative use of wood. An important goal for both the Norwegian government and the wood

Figure 26: Verdens Høyeste trehus is a 14 storey wood apartment building being developed outside Bergen, Norway



processing industry is to increase the use of wood where it can replace materials with higher negative environmental impact.

The Norwegian Wood-based Innovation Scheme¹⁵⁵ addresses different parts of the market: companies, decision-makers, architects, entrepreneurs, traders, research and innovation. Economic support is given in three areas: Industrial building and construction, Wood products and traditional use of wood and Innovation systems. The policy is administered through Innovation Norway¹⁵⁶ and has assisted a number of innovative projects such as a 14 storey tower which is being proposed outside Bergen (see Figure 26). The policy's success is documented in an annual report describing how the money is used, what kind of project that has been supported and a summarising of the activity compared to the goals.

To support technical innovations such as high-rise wood structures, the Norwegian government has adopted "functional-based" building codes allow for "alternative designs" where the designer must propose an evaluation method and define his/her own acceptance criteria based on the functional requirements. An innovative design may be submitted to a 3rd party expert for review. As a result, Norway does not, for example, impose height limits for wood buildings.¹⁵⁷

3.6 Promoting the use of wood in American government buildings

Promoting the use of forest products from responsibly managed forests in the United States creates a number of significant benefits consistent with President Obama's Climate Action Plan, including strategies to mitigate carbon emissions, and ensuring forests and forest-based communities are prepared in the face of a changing climate.

At the state level, policies to encourage more wood use are under consideration in several regions (such as the states of Washington and

Oregon). In August 2014, the State of Georgia's Senate Bill (S.B.) 301¹⁵⁸ was brought into law, allowing greater use of wood materials in public school construction. The bill removes language from the Georgia Department of Education (DOE) Guideline for Educational Facility Construction¹⁵⁹ that prohibited the use of light wood framing (or wood stud partitioning) and ordinary wood construction. Schools are now not allowed to discriminate against wood in school construction and the Georgia department of education will not approve contracts for construction unless wood was considered. For at least 30 years, the State of Georgia has required the consideration of Georgia grown wood in state building construction.

4. Policies that advance technical specifications and structural norms

4.1 Post-tensioned wood buildings for seismic design

A number of countries are located in seismically active regions. While life safety must remain the top priority in seismic design, lessons from the Christchurch earthquakes in New Zealand in 2010 and 2011 suggest that this goal, on its own, is no longer sufficient as many buildings (even modern ones) were no longer viable after the earthquakes and had to be demolished. Several years after the earthquakes, Christchurch City Council is still working to process an estimated four million tonnes of rubble¹⁶⁰ from earthquake-damaged buildings.

There are now “Low Damage Design” approaches that allow buildings to not only withstand seismic

Figure 27: Detail of the Merritt building in New Zealand is the first post-tensioned wood frame building designed to withstand extreme seismic events



Structural design credit: Kirk Roberts Consulting Engineers Ltd, (www.kirkroberts.co.nz)

Image source: “Wooden skyscrapers could be the future of flat-pack cities around the world”, The Guardian, (www.theguardian.com/cities/2014/oct/03/sp-wooden-skyscrapersfuture-world-plyscrapers)

forces sufficient to protect lives, but also to maintain and/or regain structural integrity. This substantially reduces economic losses, the amount of new materials required to repair and replace buildings as well the amount of waste materials generated from building damage, demolition or collapse. Low Damage Design can include various approaches such as isolating the base of the building, rocking structural system and designing for controlled repairable damage.

The Christchurch experience shows that wood performs better than other structural systems in earthquakes. Timber has inherent seismic-resistant properties – light weight and high strain to failure. All loss of life occurred during the 2011 “aftershock”. Of the 182 deaths reported, 115 were in the 6 storey concrete Canterbury Television (CTV) building (built in 1986), 18 were in the 5 storey concrete Pyne Gould Corporation (PGC) building (built in 1963),¹⁶³ 42 were in masonry buildings and 7 were in rockfalls. By comparison, there was no serious damage to any non-residential timber buildings beyond shear cracks in columns. Most wood frame houses remained structurally stable despite effects of liquefaction and, in many cases, the roofs being shaken off. A few suffered wall bracing failures. Solid wood houses performed well despite differential slab movement.

As a result, engineers in Christchurch have developed a post-tensioned wood structural system¹⁶² with built-in replaceable dissipaters and re-adjustment capabilities after a seismic event. This solution leverages advanced manufacturing and uses low environmental impact materials (such as Laminated Veneer Lumber (LVL) and Cross Laminated Timber (CLT) panels) to create a structural solution that is able to absorb complex seismic forces with little residual deformation. In New Zealand, there is also a strong local tradition of timber construction, and ample timber resources, mainly Radiata pine.

The Merritt building is the first multi-storey post-earthquake timber building using low-damage post-tensioned timber technology. It opened in Christchurch in March 2014. The pre-fabricated timber structural system of glue-laminated box beams and solid columns timber

is threaded with high-tensile steel strand cables and a steel shock-absorbing system (comprising dissipator clamps at the junctions) to seismically strengthen and brace the building during a seismic event (see Figure 27). Essentially, the building is designed to move back into alignment after a major quake. The building is designed to withstand a one-in-2500-year event with controllable, minimal and repairable damage. A design guide has been developed by the University of Canterbury to introduce designers to the principles of post-tensioned wood structures.¹⁶³

Regulatory lessons from the Christchurch experience also illustrate how important it is to allow designers the flexibility to create alternative solutions and/or establishing performance-based building codes can encourage innovative approaches to seismic design. Further, dealing with the scale and urgency of rebuilding after a disaster can be extremely challenging. To this end, it is important for regions at risk to develop and disseminate resources to designers and builders for sustainable reconstruction of buildings prior to a catastrophic event. For example, the United Nations has developed a set of practical guidelines for the sustainable reconstruction of buildings applicable to developing and developed countries¹⁶⁴ that aim to optimize the use of scarce materials and manage waste.

4.2 Performance-based codes and tall wood structures

In many countries, there is a concerted effort to move towards performance or “outcome-based” codes. The initial impetus has been various national and international directives related to operating energy consumption and GHG emissions. In fact, many countries have established energy use intensity (EUI) limits in kWh/m²/yr for new buildings. Austria was one of the first to adopt performance-based codes and has had prescriptive energy efficiency requirements for buildings within each of the 9 regions (Länder) since the 1970’s. The first nationwide performance-based code was introduced in 2006, to be individually implemented by each of the Länder. The latest code Austrian Institute of Construction

Figure 28: Life Cycle Tower (LCT) is a 10 storey wood office building in Austria



Engineering (OIB) Richtlinie 6 (2011)¹⁶⁵ and supporting policies encompass many dynamic aspects including, air-tightness testing, thermal bridging considerations, well-established energy efficiency disclosure programmes and incentive schemes, voluntary low energy classes and the implementation of Passive House standards by 2015 for residential buildings (see 2.4 Passive House).

Now, there are a few countries that are actively working to develop regulatory frameworks that can support and facilitate technical innovations such as high-rise wood structures. Austria was one of the first countries to allow a “tall” wood structure with the completion of the 10 storey Life Cycle Tower¹⁶⁶ in Dornbirn (see Figure 28). “Functional-based” building codes allow for “alternative designs” where the designer must propose an evaluation method and define his/her own acceptance criteria based on the functional requirements. An innovative design may be submitted to a 3rd party expert for review. For example, the design team for the Life Cycle tower worked directly and collaboratively with the fire authority to research, test, and prove final concept.¹⁶⁷

5. Public procurement policies

5.1 Republic of Slovenia Decree on Green Public Procurement

In 2007, public procurement in the Republic of Slovenia represented 13 per cent of GDP, which accounts for as much as 47 per cent of national budget expenditures,¹⁶⁸ and recent legislative actions have been designed to bring forward a shift towards greener decision-making in the public sector.

The national Action Plan for Green Public Procurement (2009) is intended to establish an operational system of green public procurement. Concrete specific targets are aimed at achieving certain shares of green public procurement by 2012. The Action Plan for Green Public Procurement lists 14 measures, including: preparation of a governmental decree on green public procurement, trainings and educational activities, a green procurement web platform, dialogue with the commercial sector to develop a green market, and introduction of an Eco-Management and Audit Scheme (EMAS) into the public sector.

Close cooperation between the Building and Civil Engineering Institute (ZRMK) and responsible ministries of the Slovenian government (Ministry of Public Administration, Ministry of Environment and Spatial Planning) has been necessary to implement a “Buy Smart” public procurement project that has been incorporated into the national Action Plan for Green Public Procurement.

The Decree on Green Public Procurement came into effect in March 2012 and is binding for public purchasers. Appendices to the decree are intended to provide basic and additional requirements for certain public procurement procedures for a number of product groups including the construction and renovation of buildings, appliances and other energy labelled products, etc. At least 30 per cent of all public construction and buildings are to be procured under this plan.

The use of wood is included in the Action Plan’s Appendix related to buildings. It stipulates that at least

30 per cent of certain types of buildings should be built from local wood (or alternatively at least 15 per cent local wood and the remaining up to 30 per cent from materials which comply with certain environmental standards). The wood-related standard came into effect at the end of 2012 and there are no data/results regarding implementation available yet. On-going workshops and awareness raising campaigns with architects and designers show that a lot more has to be done. In particular, there is a lack of awareness at the implementation part (both procurers and designers/architects) and lack of public awareness about positive characteristics of wood buildings.

Important stress has been put onto the value of life cycle costs (LCC) assessment in the Slovenia’s procurement processes. LCC are to be taken into account whenever the procured item and the procurement boundary conditions allow it. In particular:

- Purchasing (or renting, or leasing) costs, including eventual additional financial duties,
- Operational costs, including costs of consumed material,
- Maintenance costs
- Costs occurring after the period of use or after the completion of service, including removal, disposal, deconstruction and renovation costs
- External environmental costs (if methodology is available in each particular case).

Although LCC is based on life cycle approach (i.e. cradle to grave), it should not be confused with life cycle assessment (LCA). LCC looks at the direct monetary costs involved with a product or service and not environmental impact. However, LCC can provide a good starting point for life-cycle methodologies and can be expanded to consider environmental impacts in the future.

5.2 California’s Green Chemistry policy

The majority of modern buildings are constructed with some amount of materials that are synthetic, chemically processed or treated. There is increasing concern that some products can affect human health. Restrictions and bans on the use

of certain constituents such as asbestos, heavy metals (lead, mercury, etc.) and ozone depleting substances (such as CFCs) have been in effect in the EU and elsewhere for several decades. Many green building rating systems go further and set limits on the types of permissible products for health reasons. For example, there may be volatile organic compound (VOC) emission limits for paints, solvents and glues. A few rating systems impose outright bans on toxic substances. The U.S.-based Living Building Challenge¹⁶⁹ includes a “Red List” of toxic materials and chemicals that are prohibited from a building following LBC certification. Red List materials include: Asbestos, Cadmium, Chlorinated Polyethylene and Chlorosulfonated Polyethylene, Chlorofluorocarbons (CFCs), Chloroprene (Neoprene), Formaldehyde (added), Halogenated Flame Retardants, Hydrochlorofluorocarbons (HCFCs), Lead (added), Mercury, Petrochemical Fertilizers and Pesticides, Phthalates, Polyvinyl Chloride (PVC), Wood treatments containing Creosote, Arsenic or Pentachlorophenol.

Such prohibitions can be challenging in markets where there are no readily available substitutes. For example, polyvinyl chloride (PVC) is a ubiquitous material that is commonly used in buildings (e.g. plumbing and piping systems). There are concerns about the potential for “persistent bioaccumulative toxicants” from the release of dioxin not only during the manufacturing process, but also during the product’s lifecycle, including possible burning in landfill fires. However, PVC is such a dominant material in the market, that the availability and affordability of lower impact alternatives such as high-density polyethylene (HDPE) is limited. Regulators therefore need to ensure there are ample supplies of cost-comparable alternatives prior to imposing restrictions on materials.

California is the first U.S. state to enact a green chemicals policy into law. This is an outcome of California’s Green Chemistry Initiative, which was launched in 2007 and led by the California Department of Toxic Substances and Control (Cal/DTSC) (California Environmental Protection Agency, 2007). Green Chemistry is the design of chemical products or processes that reduce or eliminate the

use of hazardous chemicals. It addresses the design, manufacture and use of efficient, effective, safe and more environmentally benign chemical products and processes. It has gained momentum in the political and industrial spheres, as a more comprehensive solution to addressing the emerging ethical and environmental concerns of the chemicals industry. The introduction of the Green Chemistry Initiative and ensuing laws has been attributed to strong environmental leadership, responding to an outcry from consumers, environmental groups, industry and academia. The State Governor and the Director of the Cal/DTSC are advocates of Green Chemistry and are said to have played a catalytic role for its implementation.¹⁷⁰

State legislators have developed a sophisticated awareness of the impacts of products containing toxic chemicals at all stages of their life cycle. Of particular relevance to the building industry, the California Carpet Stewardship Bill (AB 2398), which was signed into law in October 2010¹⁷¹ requires carpet retailers to help divert used carpet from landfills. Carpets can contain a wide range of toxic chemicals in the backing materials, glues, fire retardants, etc. At the same time, carpet can be easily recycled and many U.S. carpet manufacturers (such as Interface)¹⁷² are at the leading edge of closed loop manufacturing and sustainable materials management. Retailers are now required to create and implement a carpet-recycling plan to increase the percentage of post-consumer carpet diverted from the landfill.

The non-profit Carpet America Recovery Effort (CARE) operates a carpet stewardship program that retailers can choose to participate in to meet AB 2398 requirements; otherwise, retailers must submit their own diversion implementation plan - including consumer education, fees, progress measurement, and annual reporting - to the California Department of Resources, Recycling, and Recovery (CalRecycle). California retailers charge customers a fee for all new carpet purchased; the revenue will fund post-consumer carpet recycling measures. CalRecycle lists compliant manufacturers on its website and enforce penalties for noncompliance. This programme has subsequently informed NSF/ANSI 140-2007 Standard, which is a third-party, multi-attribute national standard for sustainable carpet.

6. Policies that “close the loop” at end of life

6.1 Collaborative for High Performance Schools

Deconstruction describes the selective dismantling or removal of materials from buildings prior to or instead of conventional demolition. It is an approach to building removal that can convert this waste stream into highest-value resources in a manner that retains their original functionality as much as possible for re-use in future buildings. Thus, deconstruction can reduce the use of new materials, extend the life of existing materials, reduce the amount of materials entering recycling/reprocessing centres and minimize/eliminate the amount of materials destined for landfills. Building deconstruction can be handled in several ways:¹⁷³

- Manual building deconstruction is the systematic disassembly of a structure to maximize reuse and recycling.
- Hybrid deconstruction describes the use of people and machines to efficiently deconstruct buildings, with the goal of maximizing reuse and recycling. It refers to the hybrid of demolition and manual deconstruction.
- Building harvesting is the fastest way to remove a building while still trying to divert materials from the landfill, especially focusing on reusable materials.
- Partial deconstruction is the removal of part of a structure without harming the remaining section(s) while still focusing on maximizing reuse and recycling.
- Building kits are collections of materials that have been labelled, diagrammed, and then carefully disassembled in order to be reassembled at another job site.

Deconstruction requires policy makers to re-think the entire design and construction process in order to increase the scope for building deconstruction in the future. Indeed, there are opportunities to

enhance flexibility and future adaptability over the entire service life of the building. Not only should the construction solutions allow for easy non-invasive maintenance and repair but also spatial reorganization, adaptability and even re-use of the whole building. Characteristics of buildings that are likely to be good deconstruction candidates:

- Wood-framed with heavy-timbers and beams, or with unique or “old growth” woods such as oak or douglas fir
- Large proportion of pre-fabricated components where documentation exists which illustrates the location of fixings
- Constructed with high-value specialty materials such as hardwood flooring, multi-paned windows, architectural moulding, and unique doors or plumbing/electrical fixtures
- Constructed with high-quality brick laid with low-quality mortar (to allow relatively easy break-up and cleaning)
- Structurally sound (i.e., generally weather-tight to minimize rotted and decayed materials)
- Buildings constructed mainly of concrete and/or steel may be good candidates for partial deconstruction, or the “stripping” of salvageable materials. Stripping out these materials may make it easier to recycle the concrete and steel as well.

The complete deconstruction of buildings is very challenging today because existing buildings have not currently designed to be taken apart and re-used in the first place. Nevertheless, deconstruction can offer economic and environmental benefits such as:

- **Availability of construction materials with low environmental impacts** – deconstructed materials can be re-used in new projects, so long as they meet the performance criteria of the prevailing building regulations (for example, some deconstructed windows may no longer be permissible on account of their thermal performance)
- **Lower building removal costs** – when implemented with landfill taxes, tipping

fees, and other market-based instruments, deconstruction can cost less than demolition because of the value of the salvaged materials and the avoided disposal costs.

- **Reduced impact to site** – Deconstruction results in significantly greater protection to the local site, including the soil and vegetation. In addition, deconstruction creates less dust and noise than demolition.
- **Conserved landfill space** – Deconstruction can divert up to 90 percent of a building into reuse or recycling. This can play an important role in helping some states reach their recycling goals, as well as helping private companies in their marketing or public relations efforts.
- **Job creation** – Manual disassembly of buildings offers an excellent opportunity to identify and train minimally-skilled workers with an aptitude and interest in the building trades.

Although the potential benefits of deconstruction are significant, in reality it is difficult to achieve. The barriers to building deconstruction include:

- The pricing structure related to construction and demolition assigns high values to labour and land, and low values to materials.
- The skills required to deconstruct a building may not be readily available.
- The deconstruction process takes much longer than conventional demolition. Depending on the type of building and the size of the crew, deconstruction can take two to ten times longer than conventional demolition.
- Although some building typologies lend themselves to deconstruction better than others, most existing buildings have not been designed with disassembly in mind and are not easy to deconstruct.
- Lack of facilities to handle the materials generated or markets for the materials.
- There may be hazards associated with building deconstruction because some

building materials may contain toxins such as lead and asbestos.

Currently, few countries have established policies promoting full building deconstruction and design for disassembly although there are numerous programmes in development and pilot projects. The countries that have made the most progress so far (such as the Netherlands) are basing their efforts on well-established construction waste management policies and regulations. This includes the presence of comprehensive economic measures such as landfill charges, command-and-control regulations such as materials disposal bans, the availability of a qualified workforce, clear regulations related to the management and disposal of hazardous materials, access to licensed materials handling and processing facilities, and a ready market for the secondary materials produced. To optimize the potential for deconstruction, policies need to encourage designers to consider future disassembly at the beginning of the design process.

However, for the deconstruction process to truly close the materials consumption and production loop, there must be a viable market for the secondary materials being produced not only to adequately supply the market with a range of good quality options but also to stimulate market demand. Further, clear product descriptors and quality control criteria must be in place to ensure that industry can confidently purchase and use these materials in building projects or product manufacturing.

Although it only addresses educational facilities, the American Collaborative for High Performance Schools (CHPS)¹⁷⁴ is one of the most progressive rating systems in operation that includes for building disassembly or deconstruction. Twelve states have state or region-specific high performance school building criteria, including California, Washington, New York, Massachusetts, the New England States (Maine, Vermont, New Hampshire, Connecticut, and Rhode Island), Texas, Colorado and Virginia. Hawaii is under development. There are 86 completed CHPS schools across America and approximately 300 schools underway in the U.S. seeking CHPS

recognition. 41 school districts, with over 1.6 million total students enrolled, have committed to building new schools or modernizing to the CHPS high performance building standard, or using CHPS resources. Over 225 organizations are members of the collaborative, including utility companies, professional design and construction firms, product manufacturers, non-profit organizations, schools and school districts, and professional societies.

The average age of a school building in America is 40 years and most schools are typically demolished by the age of 60. School owners may spend up to three times the cost of the original construction in repairs, renovations and demolition over a school's lifespan. CHPS therefore promotes designing for adaptability and disassembly as a way for schools to economically act as stocks of materials for future buildings with minimal to zero loss of the materials during renovations and disassembly. As a by-product of this concept, schools will be able to extend the lives of their materials through whole building flexibility.

The designer is also encouraged to design major systems with differing functions and lifespans to promote disentanglement. For example:

- Separation of envelope from structure.
- Dedicated service voids (chases, raceways).
- Separation of interior spatial plan from structure.
- Separation of finishes from substrate associated with spatial plan, structure or weather envelope.
- For major systems such as roof or HVAC, etc. provide access to and types of connections that allow disassembly, e.g.:
 - Visible and/or ergonomic connections
 - Human scale components and use of industry standard connectors and tools / equipment that are trade-friendly.
 - Minimize number and different types of connectors over whole building.
 - Use of reversible connections (screws, bolts, nails, clips).

CHPS includes a sample building disassembly plan (see Figure 29) as part of credit “LE3.2: Design for Adaptability, Durability and Disassembly”, the intention of which is to:

1. Reduce building material waste and promote local building material reuse during construction, renovation, repurposing of space, and disassembly.
2. Provide spaces that are adaptable, durable, and flexible.
3. Drive innovation in designing schools to support disassembly and reuse.

Green building rating systems, such as CHPS, are important mechanisms for introducing new approaches and “stretch” goals for progressive builders to adopt on a voluntary basis (see 2.6 Voluntary green building certification systems and the overview provided in Annex B). As the industry becomes familiar with the techniques, policymakers can expand the application of the policies to a broader range of building types and, eventually, incorporate elements of the rating system into legislation. In fact, these approaches can leverage LCA as a methodology to evaluate the benefits of deconstruction and material use against the impacts of new materials on a life cycle basis.

6.2 Portland's ReBuilding Center

In order for deconstruction policies to work, it is important to make it easy for the deconstructed materials to find their way back into the market. The creation of centralized materials “reuse centres” provide “one-stop-shops” for builders by not only acting as used building material depots, but also offer deconstruction services and consulting to project teams.

The ReBuilding Center in Portland, Oregon¹⁷⁵ was set up in 1998 to offer deconstruction services which, on average, savages 85 per cent of a typical wood frame house and then wholesales and retails a wide range of used building and remodelling materials (see Figure 30). The Center is currently

working on the ReFind Education programme, featuring workshops and classes on how to safely and creatively work with used building materials. The Center was founded on government grants,

private donations and volunteer support but is now a successful financially self-sustaining social enterprise with non-profit federal tax status. In 2008, it won the City of Portland BEST Business Award.

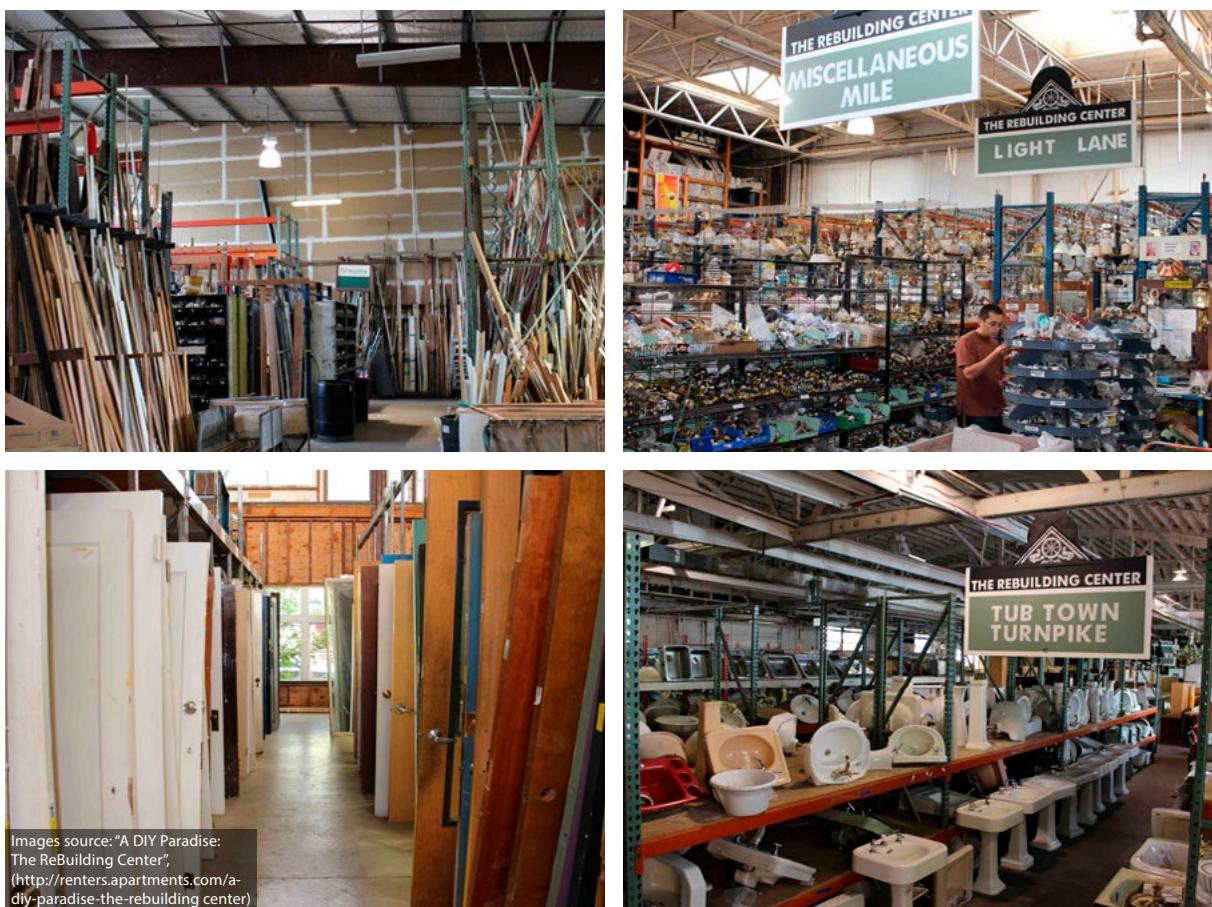
Figure 29: Illustrative Building Disassembly Plan

Develop a comprehensive Disassembly Plan that incorporates design for disassembly, durability, and adaptability principles. Even the best design for adaptability and disassembly will not be realized if the building constructors, operators, and deconstructors do not understand how to implement the disassembly processes as they were intended. Therefore, an important element of the design process is the documentation and dissemination of the building's design intent per its materials, components, connections and form. The Disassembly Plan should also be updated to mitigate the deconstructor's need to "start from scratch" to understand the building. Include in specifications and contractor agreement language that stipulates development of as-built drawings and materials inventory of major systems. A successful Disassembly Plan should include:

- Statement of strategy for design for disassembly and adaptability relating to the building
- Demonstrate the strategy behind the designed reusable elements and describe best practice to ensure they are handled in a way which preserves maximum reusability.
- Building elements
- Provide an inventory of all materials and components used in the project together with specifications (including Material Safety Data Sheets as applicable) and all warranties, including manufacturers' details and contacts.
- Describe the design life and/or service life of materials and components.
- Explain reusable, recyclable, and durable component and material selections that facilitate adaptability, disassembly, reuse, and recycling.
- Describe modular components and dimensions and plug and play components for major systems.
- Identify best options for reuse, reclamation, recycling for all building elements. This may change between time of construction and time of disassembly so the Plan should be updated.
- Provide instructions on how to deconstruct elements
- Provide up-to-date plans for identifying information on how to adapt and deconstruct the school.
- Where necessary add additional information to the "as built" set of drawings to demonstrate the optimum technique for removal of specific elements.
- Describe the equipment required to dismantle the building, the sequential processes involved and the implications for health and safety as part of the management requirements.
- Advise the future contractors on the best means of categorizing, recording and storing dismantled elements.
- Distribution of Disassembly Plan

Source: American Collaborative for High Performance Schools

Figure 30: The ReBuilding Center in Portland, Oregon



Images source: "A DIY Paradise: The ReBuilding Center", (<http://renters.apartments.com/a-diy-paradise-the-rebuilding-center>)

6.3 UK Aggregates Levy

Increasingly, environmental policy cannot be approached purely as a technical issue, to be resolved solely by requiring the use of specified abatement technologies and setting limits on emissions, etc. Where extensive and far-reaching changes to existing patterns of production and consumption are needed to achieve climate change and sustainability goals, incentive-based environmental regulation, that is, through market-based instruments (MBIs) are being introduced. (A summary on MBIs is provided in Annex B.)

Over ten years ago, the UK government has introduced a national environmental tax on virgin materials – specifically the commercial exploitation of aggregates (quarry products). Virgin materials taxes have been imposed in several countries,

including Sweden, Denmark and the UK, for aggregates – specifically gravel, rock, stone, etc. These types of taxes tend to be applicable to situations where monitoring of environmental impacts (such as non-point source emissions) or property rights regimes are had to implement.

Virgin materials taxes tend to be applicable to situations where monitoring of environmental impacts (such as non-point source emissions) or property rights regimes are had to implement. For such tax systems to work, there needs to be sufficient price elasticity for the market to substitute alternative (e.g. recycled) materials. Further, producers of recycled materials may have few incentives to enhance their waste sorting and processing activities in the presence of virgin materials taxes. So, additional policies may need to be introduced to increase the supply of recycled materials.

The UK Aggregates Levy¹⁷⁶ came into effect in 2002 and imposes a fixed rate (£2.00) per tonne of materials removed from its originating site. While the primary objective is to limit the ecological impact of extraction, an associated impact of such a levy is on cement and concrete production, which is one of the largest consumers of aggregate products, and thereby to shift the market towards lower impact material choices, such as wood. However, for such tax systems to work, there needs to be sufficient price elasticity for the market

to substitute alternative materials (such as recycled materials or tax-exempt materials, such as wood). Further, producers of alternative materials may have few incentives to enhance their capacity to serve the market in the presence of virgin materials taxes. For example, regulations may need to be adjusted to allow the use of alternative materials, such as wood and additional policies may need to be introduced to increase the supply of recycled materials via improved and expanded waste sorting and processing activities.

Annex B

Definitions of terms

Product certification and labelling schemes

Environmental product labelling schemes (also known as “green labels” or “eco-labels”) can be voluntarily provided by manufacturers or mandated by governments to inform consumers about a product’s environmental impacts. Criteria and standards for eco-labelling schemes vary widely. Some are set through government regulation such as the EU Ecolabel,¹⁷⁷ others may be developed by industry for industry (e.g. the U.S. Carpet and Rug Institute’s GreenLabel program).¹⁷⁸ Ideally, criteria are developed and revised in a transparent way by a group of experts. International standards for product labelling practices are provided within the ISO 14020 to 14025 series, which deals with environmental labels and declarations.

The information that goes into the life-cycle assessment (LCA) of a product, assembly or entire building, is provided by manufacturers via an Environmental Product Declaration (EPD). An EPD includes information about the environmental impacts associated with a product, such as:

- Raw material acquisition
- Energy use and efficiency
- Content of materials and chemical substances
- Emissions to air, soil, and water
- Waste generation

The criteria for developing EPDs are described under ISO/CD 21930. EPDs must be created in accordance with the relevant Product Category Rulings (PCRs) described under ISO 14025. PCRs provide product category specific rules, requirements, and guidelines for calculating and reporting environmental impacts across the full

life cycle of a product using life cycle assessment (LCA). As a contribution to standardizing product sustainability assessment and communication, the Guidance for Product Category Rule Development (developed by the Product Category Rule Guidance Development Initiative)¹⁷⁹ specifies requirements and recommendations on:

- Steps to be taken before PCR creation,
- Elements of PCRs,
- Review, publication, and use of PCRs, and
- Best practices with PCR development and management.

Also, the European Commission (EC) just recently released its Communication on a Single Market for Green Products,¹⁸⁰ which includes the use of a product environmental footprint (PEF) – a type of product claim that requires PEFCRs (equivalent to PCRs).

There is also a movement to introduce Health Product Declarations (HPDs) that are designed for the accurate and impartial reporting of product contents and each ingredient’s relationship to the bigger picture of human and ecological health. The HPD objectively defines the critical information needed to support accurate supply chain disclosure by manufacturers and suppliers, and informed decisions by building designers, owners, and users.

Life-cycle assessment (LCA) of building materials, assemblies and structures

A product or material life cycle is defined as the “Consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to final

disposal”.¹⁸¹ LCA is a universally accepted tool to assess and compare the environmental impacts of products and services that go into buildings as well as the buildings themselves. It is a state-of-the-art methodology, framed by the ISO 14040/14044 standards,¹⁸² that allows the potential impacts of products, processes or services to be quantified over their entire life cycle, i.e. from raw materials extraction to final disposal (ISO 2006a; ISO 2006b). LCA can evaluate a broad range of environmental considerations (such as embodied energy, global warming potential, impacts on water quality, impacts on human health, etc.) against explicitly declared criteria and give a summary of environmental performance. Such assessments can be used for benchmarking performance and monitoring progress towards improvement of performance. LCA is therefore a powerful way to provide manufacturers and suppliers with science-based information to manage and reduce the environmental impacts of their materials and products as well as make operating, manufacturing and supply chain decisions. At the same time, LCA can inform designers and the public of the impacts associated with a material, product or entire building and also provide a basis for demonstrating and communicating the result of efforts to improve environmental performance in construction works (assemblies, structures, civil infrastructure, etc.). Of course, LCA is essentially a tool that enables objective evaluations to take place it is not intended to be used in place of policies and regulations which are essential to, for example, establish sustainable forest management practices, energy efficiency standards in buildings, etc..

For a long time, LCA has existed largely within the domain of academic and research activities. However, the situation is changing. Arguably, the most advanced research and development is in Europe where the CEN/TC 350 technical committee (an initiative from the European Committee for Standardization (CEN)) administers a range of pan-European standards for LCA that are also the national standards for each of the member states. CEN signed an agreement with the International Organization for Standardization (ISO) in 1991 to ensure technical cooperation between the ISO and European standards.¹⁸³

The challenge to widespread adoption of LCA is the availability of data and tools. LCA is a data-intensive process and current, comprehensive, regionally appropriate life cycle inventories (LCIs) of materials data need to be developed, collected and maintained prior to the implementation of a successful LCA-based building policy. Also, materials-based performance metrics are necessary to ensure consistency and fairness for industry so that improvement can be measured over time. A report from the OECD on sustainable materials management provides a critique of LCA¹⁸⁴ and notes that while LCA approaches may help to identify differences in potential environmental impacts from different approaches to production, or to different consumption decisions, economic consequences do not emerge through a LCA. The economic implications of a policy may need to be addressed separately using cost-benefit analysis or other economic decision-making tools.

Green building rating systems and standards

There are over 60 green building rating systems in effect, worldwide. They provide consumers, building professionals and government regulators with a means to evaluate the environmental impact of a particular structure under a series of categories such as energy, water, occupant health, materials and location. Green building rating systems are voluntary by nature and therefore only apply to a sub-set of leadership-level buildings. Indeed, most providers state that their intention is, at best, to target the “top 25 per cent”¹⁸⁵ which therefore dilutes their intensity of effectiveness to an entire building stock. Many green building rating systems are administered by not-for-profit organizations that are independent from government regulators. In some jurisdictions, policy makers are attempting to leverage the presence of rating systems to effectively “outsource” the review and verification of the green features and performance of building projects. While this may expedite the regulatory process, there may be challenges in terms of:

- **Schedule:** builders need to know that their project meets the green criteria early in the construction process, yet most rating systems do not issue certification until after the project is complete making it difficult to enforce controls on companies which no longer have a relationship to the building.
- **Fit:** while rating systems are generally very comprehensive and address a wide range of environmental impacts, they are usually positioned at a national level and do not necessarily consider the local characteristics of a particular project.
- **Clarity:** most rating systems use a checklist approach to award points for optional building features that support green design. The more points, the greener the building. However, it is not always possible to be sure that a certified building has scored well in particular categories. For example, a certified building may have secured the majority of its credits for “in-use” energy efficiency and not addressed materials.
- **Enforcement:** rating system providers are usually not-for-profits and may not have the legislative muscle necessary to hold developers and builders accountable in the event of failure to perform.

Green building standards are different from rating systems and set pass-fail levels of performance. They are confirmed early in the construction process and are more likely to be administered by government agencies with enforcement capabilities. Examples include Passive House (Passivhaus)¹⁸⁶ in Germany, ASHRAE 189¹⁸⁷ in the U.S. and MINERGIE-ECO¹⁸⁸ in Switzerland.

Market-based instruments (MBIs)

To make a serious impact on some of the major environmental problems now facing policy-makers, environmental policy cannot be approached purely as a technical issue, to be resolved solely

by requiring the use of specified abatement technologies and setting limits on emissions, etc. Extensive and far-reaching changes to existing patterns of production and consumption are needed to achieve national and international climate change and sustainability goals, and these changes will inevitably entail substantial economic costs. The search for instruments capable of minimizing these costs, and of achieving behavioural changes across all sectors, has led policy makers to pay close attention to the potential for incentive-based environmental regulation, that is, through economic instruments. The range of possible tools includes:

- Grants, subsidies and other types of funds
- Preferential loans (such as low or zero interest that may be backed by governments)
- Land-pricing strategies
- Fees and licenses
- Government-backed insurance policies
- Taxes and levies (such as import tariffs)
- Tax incentives (such as rebates, credits or exemptions on Value Added Tax (VAT), Goods and Services Tax (GST), etc.)
- (Tradable) supplier obligations and responsibility notes
- Third party financing
- Audits
- Minimum requirements and penalties
- Deposit-refund systems

Implementing an MBI commonly requires some form of regulation. They can be implemented in a systematic manner, across an economy or region, across economic sectors, or by environmental goal (e.g. primary energy). For example, environmental taxes (such as virgin materials taxes) can be particularly valuable where wide-ranging changes in behaviour are needed across a large number of production and consumption activities. They can be simple, easy to understand and generate revenues for governments. Altering market dynamics at the production and end-of-life stages of building materials can have a striking effect on the

environmental impacts of the resulting products in terms of emissions and waste reduction as well as energy and water efficiency during their life cycle. However, the effect on materials prices should be considered to avoid substitution for cheaper less sustainable options.

Many types of MBIs designed by governments and utilities to address “in-use” energy and GHG emissions exist today, which could provide useful models for encouraging the use of sustainable materials. Product and technology incentives, grants, equipment rebates could be extended to recognize the environmental footprint of the materials. They can also target local manufacturers with incentives to improve the efficiency of industrial processes. For example, an energy-efficient equipment upgrade for a building materials manufacturing facility will help to reduce the primary energy consumption and embodied GHGs associated with the materials produced.

Performance-based building incentives

Builders who achieve prescribed environmental performance standards may be rewarded with additional developable floor area, exemptions from (or reductions in) certain building permit fees, development cost charges, or other economic considerations. For example, “Density Bonuses” can be used to inform the scope, form and use of development as well as functional, environmental and social performance outcomes. Density Bonuses offer developments a level of density that surpasses the allowable Floor Area Ratio (FAR) in exchange for greener development (including the use of sustainable construction materials). In some locations where green building rating programs are in use, density bonuses can be offered for achieving certain certification levels. A number of Swiss cantons have adopted this instrument in order to promote the construction of buildings that comply with the MINERGIE¹⁸⁹ building standard.

Development Cost Charges (DCCs) are designed to help finance growth-related infrastructure. They are one-time charges that local governments can

levy on most new subdivision and building at the time of approval. DCCs shift financial responsibility for providing capital costs for off-site infrastructure, including sewer, water, storm drainage, roads, public amenities and parkland, from the general tax base to the developers of new growth requiring the infrastructure. Conditions to DCCs in terms of sustainable materials use can be stipulated.

Land use plans and zoning laws

Legislation can be established that requires or prohibits certain building uses or types of construction (e.g. in climatically or seismically high-risk locations). Special designations may be applied to lands that require specific environmental measures or performance criteria (for example, the building or neighbourhood must achieve a certain green building rating system certification level or score).

Planning, designing and constructing buildings is a long-term undertaking and developers appreciate certainty in the market. Long-range plans are particularly important mechanisms to send clear and sustained signals to industry of current and future development priorities. For example, an Integrated Community Sustainability Plan (ICSP) is any existing or new long-term plan, developed in consultation with community members, to help the community realize sustainability objectives within environmental, cultural, social and economic dimensions of its identity. An ICSP can be part of an overall Official Community Plan (OCP) and can incorporate policies to address land pricing, use of local materials and/or sustainable building performance requirements.

Policies describing desired building form, function and character

Policies and regulations can be established as a means of controlling development to achieve a specific urban form, function or character. “Form-

based codes” can be an effective response to the challenges of urban sprawl, deterioration of historic neighbourhoods and neglect of pedestrian safety in new development. Tradition has declined as a guide to development patterns, and the widespread adoption by cities of single-use zoning regulations has discouraged compact, walkable urbanism.

Form-based codes are a tool to address these deficiencies, and to provide local governments with the regulatory means to achieve development objectives with greater certainty. For example, form-based codes can be used to promote historical or local character, which promote retention of existing buildings and traditional construction techniques, which may encourage the use of local materials, and, at the same time, deliver climate-appropriate solutions.

Building codes

Building codes and regulations specify the minimum standards to which buildings and non-building structures (such as bridges, tunnels, etc.) must be designed to perform, primarily in order to protect public health and safety. Building codes can be complex and are usually intended to be applied by design and construction professionals. Increasingly, building codes have started to include issues relating to “in-use” energy and water efficiency and some are being extended to consider the construction process, materials and assembly. For example, building codes can include requirements for construction waste diversion, prohibit the use of certain materials, and establish minimum environmental performance criteria.

Historically, regulatory controls have generally been highly prescriptive in nature. In the last 20 years, however, there has been a growing transition to objective-, functional- and performance-based building regulations. In these regulations, the focus has shifted from prescribing solutions to identifying objectives, functional requirements, and performance expectations, and allowing for a wider selection of compliance options. These “functional-based” policies can help

to encourage advances in building technology and can lead to innovative, efficient solutions using sustainable materials.

Legislation that promotes renovation and adaptability

Requirements for building renovations and upgrades may be imposed to ensure that the existing building stock complies with certain regulatory criteria. This is quite common where jurisdictions are accountable for ensuring that the existing building stock performs to specified levels of energy efficiency, GHG emissions, etc.

Policy triggers (such as time of sale or purchase, age of building or equipment or the building’s location) can be established which cause a certain number and type of improvements to be required. Renovations may be mandated by legislation or the indirect consequence of the implementation of a building environmental labelling scheme.

Functional adaptability is the ability of a building to be adaptively reused for a different purpose to that for which it was originally designed. This is indicated by qualities of design such as generous ceiling heights, over-designed structure and high-levels of ‘buildability’ (a combination of simple, standardized construction and often prefabricated construction systems). Climate change adaptability requires the use of resilient materials, bio-climatic design strategies and integration of strategies for more autonomous provision of essential building services. The extent to which buildings are designed for deconstruction using recyclable materials is also an important indicator of the potential for future economic feasibility of achieving a zero-waste building sector.

End-of-waste criteria

The construction industry is a significant generator of waste, the vast majority of which can be recycled and re-used. In order to facilitate and promote recycling of construction and

demolition (C&D) waste, while ensuring a high level of environmental protection, reducing the consumption of natural resources and minimizing the amount of waste sent for disposal, some countries have established criteria to define when a waste ceases to be a waste and becomes a secondary product.¹⁹⁰ Certain specified waste ceases to be waste when it has undergone a recovery operation and complies with specific criteria developed in accordance with the following conditions:

- The substance or object is commonly used for specific purposes
- A market or demand exists for such a substance or object
- The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products
- The use of the substance or object will not lead to adverse environmental or human health impacts
- Limiting values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object

Consistent definitions of secondary products create legal certainty for waste management decisions and for the different actors dealing with specific waste streams, including producers and users of the recycled material. Investment decisions on new treatment capacities for the management of waste require legal certainty. Definitions would also improve compatibility of regulatory frameworks for the recovery and reuse of secondary materials.

Currently, in some cases, materials generated in one country are not considered to be wastes; however, if transported to countries with different regulatory approaches, they might be considered wastes and require waste management control, hampering the functioning of the internal market.

Consequently, producers and users tend to restrict themselves to national markets avoiding administrative and judicial costs or risks of an unclear waste status of the materials.

“Zero-waste” goals

Most countries monitor the flows of material into their waste streams. The most prevalent construction waste materials are wood, mineral aggregates, metals, other waste (paint, ceramics, rubber, bitumen, etc.), plastics, organics and glass. Reducing waste generation over a building’s life-cycle is crucial to the sustainable performance of buildings and creating a “circular economy” for construction materials. Material wastage on building sites due to managerial or technological deficiencies increases materials consumption as well as the amount of waste generated.

Fundamental to waste diversion is the 5Rs waste hierarchy, which prioritizes policy approaches:

- Rethink waste and adopt environmentally-friendly practices
- Reduce the amount of waste produced
- Reuse materials repeatedly.
- Recycle materials through local programs
- Recover the core properties of the materials (such as embodied energy) by using them to generating energy-from-waste (e.g. through landfill gas-to-energy).

Zero-waste goals are designed to minimize waste to landfill and to encourage diversion solutions. Targets can be set for C&D waste diversion. Tipping fees and/or landfill taxes can be imposed for materials disposed in landfills and “eco-fees” can be charged on the purchase of new materials that are difficult to dispose of. Where a viable market solution (including the provision of collection and processing centres) is in place for waste minerals, disposal bans can be implemented.

Endnotes

- 1 Primary energy (also known as source energy) is defined as the raw energy found in nature. It has not been subject to any technical conversion process or transportation. Primary energy can be non-renewable or renewable. Non-renewable primary energy is found in sources that are finite like oil, uranium, or coal. Renewable primary energy is found in virtually endless sources like water, solar radiation, or wind.
- 2 UNEP (2007) Buildings & Climate Change Sustainable Buildings & Climate Initiative, Paris.
- 3 Roodman, D. & Lenssen, N. (1995) A Building Revolution: how ecology and health concerns are transforming construction. World Watch Paper No. 124, March. World Watch Institute, Washington DC.
- 4 Graham, P. (2003) Building Ecology: First Principles for a Sustainable Built Environment, Blackwell, U.K.
- 5 Except water and from land exploitation
- 6 M. Fischer-Kowalski, (2011) Decoupling natural resource use and environmental impacts from economic growth, International Resource Panel, Paris, United Nations Environment Programme
- 7 M-S. Low, (2005) Material Flow Analysis of Concrete in the United States, Master, MIT.
- 8 Dovetail Partners, Inc. "Carbon in Wood Products – the Basics", www.dovetailinc.org/land_use_pdfs/carbon_in_wood_products.pdf
- 9 www.proholz.at
- 10 www.holz.tum.de
- 11 www.eos-oes.eu
- 12 www.gassner-redolfi.at
- 13 Il Legno magazine, April 2014 (accessed via http://issuu.com/web-and-magazine/docs/il_legno_aprile)
- 14 www.minergie.ch
- 15 SIA 2040 Effizienzpfad Energie (Energy Efficiency Path) available in German, French, Italian and English, SIA 2032 Graue Energie von Gebäuden (Embodied Energy of Buildings) available in German, French and Italian, both available from the Swiss Society of Engineers and Architects (SIA), <http://www.sia.ch>
- 16 <http://windows.lbl.gov/software/therm/therm.html>
- 17 www.lesosai.com
- 18 www.ecoinvent.ch
- 19 www.bauteilkatalog.ch (available in French and German)
- 20 A U value is a measure of heat loss in a building element such as a wall, floor or roof. It can also be referred to as an "overall heat transfer co-efficient" and measures how well parts of a building transfer heat.
- 21 www.2000watt.ch and www.stadt-zuerich.ch/portal/en/index/portraet_der_stadt_zuerich/2000-watt_society.secure.html
- 22 www.ethz.ch
- 23 Stulz, R. "The 2,000 Watt Society: from efficiency to lifestyle" presentation to IEA/DSM workshop October 2013, available at www.slideshare.net/drsea/the-great-vision-of-a-2000-watt-society
- 24 www.stadt-zuerich.ch/2000-watt-society
- 25 www.stadt-zuerich.ch/2000-watt-society
- 26 www.bafu.admin.ch/wald/01152/10307/index.html?lang=de
- 27 www.bafu.admin.ch/aktionsplan-holz/index.html?lang=de
- 28 The legislation under which the Wood Resource Policy was enacted is the Federal Law of October 5, 1990 on financial aid and allowances (LSu SR 616.1), art. Ss 35 of the Federal Act of 4 October 1991 Forests (WaG SR 921.0) www.bafu.admin.ch/wald/01152/10307/index.html?lang=de
- 29 UNECE Timber Committee, Country Report 2012 for Switzerland www.unece.org/fileadmin/DAM/timber/country-info/switzerland2012.pdf
- 30 www.bafu.admin.ch/aktionsplan-holz/index.html?lang=de
- 31 Cf. Federal Office for the Environment (FOEN) 2013. Hofer P. et al. 2011.
- 32 Cf. Bundesamt für Umwelt (BAFU) 2008 (a).
- 33 This refers to both residential and commercial buildings, buildings belonging to the public sector, new and renovated structures.

- 34 Cf. KMU Zentrum Holz 2006. The wood content is the proportion of wood used in newly constructed SFD or MFD as compared with the total volume of newly constructed SFDs and MFDs in Switzerland. (SFD: single-family dwelling; MFD: multi-family dwelling).
- 35 Cf. Hofer P. et al. 2011.
- 36 www.svoeb.ch/uploads/media/Leitfaden_IgOeB_oekologische_Beschaffungen_GV_2012.pdf
- 37 www.holz21.ch
- 38 www.unece.org/fileadmin/DAM/timber/country-info/switzerland2012.pdf
- 39 Intep LLC, Brantwood Consulting. “Mid Rise Multi-Residential Buildings: Operating & Embodied Energy/ Carbon Framework Plan for the City of Vancouver”, for the City of Vancouver, Forestry Innovation Investment Ltd and the University of British Columbia, 2012 <http://brantwoodreci.drupalgardens.com/content/materials-matter-low-carbon-buildings>
- 40 www.bcfii.ca
- 41 A summary of the current status of low-carbon building regulations can be found in the “Zero Carbon Compendium: Who’s doing what in housing worldwide” www.zerocarbonhub.org/sites/default/files/resources/reports/Zero_Carbon_Compendium_Whos_Doing_What_in_Housing_Worldwide.pdf
- 42 www.bafu.admin.ch/whff
- 43 <http://www.bafu.admin.ch/forets> > Application of the Law on Forests > Conventions –programs
- 44 www.bafu.admin.ch/innovation
- 45 www.nfp66.ch
- 46 www.bbt.admin.ch
- 47 www.bfe.admin.ch
- 48 www.seco.admin.ch
- 49 www.for.gov.bc.ca/hfp/sof/2006/charts/c11_1.jpg
- 50 www.bcfii.ca
- 51 www.mffp.gouv.qc.ca/forets/entreprises/entreprises-transformation-charte.jsp
- 52 www.unbc.ca/engineering/wood-innovation-and-design-centre
- 53 www.softwoodlumber.org
- 54 www.softwoodlumberboard.org
- 55 www.americanwoodcouncil.org
- 56 <http://cwc.ca>
- 57 www.rethinkwood.com
- 58 www.woodworks.org
- 59 <http://wood-works.ca>
- 60 Bill 61: “An Act to enact the Ontario’s Wood First Act, 2012 and to amend the Building Code Act, 1992 with respect to wood frame buildings”, www.ontla.on.ca/web/committee-proceedings/committee_business.do?locale=en&BillID=2606+&CommID=&BusinessType=Bill&detailPage=references
- 61 For example, the North American Precast Concrete Associations issued the first EPD for precast concrete in 2014 www.cpci.ca/en/resources/technical_publications/
- 62 www.bre.co.uk/page.jsp?id=1514
- 63 www.breeam.org/page.jsp?id=86
- 64 http://ec.europa.eu/environment/gpp/index_en.htm
- 65 Communication (COM (2008) 400) “Public procurement for a better environment”, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52008DC0400>
- 66 www.greenbooklive.com/search/scheme.jsp?id=153
- 67 <http://www.concretcentre.com/Concrete-Design/Environmental-Assessment/BES-6001-and-Responsible-sourcing.aspx>
- 68 Crossrail website: www.crossrail.co.uk
- 69 www.skanska.com
- 70 www.eco-reinforcement.org
- 71 <http://group.skanska.com/globalassets/sustainability/environmental-responsibility/materials/sustainability-of-materials/ecoreinforcement.pdf>

- 72 www.celsauk.com/CorporateResponsibility.mvc/OurEnvironment
- 73 <http://apres.lboro.ac.uk>
- 74 UK government, Technology and Skills in the Construction Industry, 2012
- 75 “Construction 2025 Industrial Strategy” HM Government, Great Britain, 2013
www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf
- 76 Dutch Waste Management Association Annual Review 2013
www.wastematters.eu/uploads/media/DWMA_Annual_Review_2013.pdf
- 77 Dutch Ministry of Housing, Spatial Planning and the Environment, “The National Waste Management Plan Part 1 Policy framework”,
https://www.ilent.nl/english/Images/English%20translation%20of%20the%20The%20National%20Waste%20Management%20Plan,%20policy%20framework_tcm343-364126.pdf
- 78 OECD, “Sustainable Materials Management: Making Better Use of Resources,” (2012)
- 79 Bio Intelligence Services, “Use of Economic Instruments and Waste Management Performances”, for the European Commission (DG EV) Unit G.4 Sustainable Production and Consumption, 2012
http://ec.europa.eu/environment/waste/pdf/final_report_10042012.pdf
- 80 Cited from “Market Analysis of Used Building Materials in Metro Vancouver”, prepared for Metro Vancouver by Kane Consulting et al, February 2012
http://www.metrovancouver.org/services/solid-waste/SolidWastePublications/Market_Analysis_of_Used_Building_Materials_Final_Report.pdf
- 81 The criteria have been laid down for iron, steel and aluminium scrap (Council Regulation (EU) No 333/2011). Next waste streams to be addressed include copper scrap, recovered paper, glass cullet, plastics and biodegradable waste / compost. Technical proposals have been submitted for the end-of-waste criteria on copper scrap metal, recovered paper, glass cullet and is conducting further studies biodegradable waste/compost and plastic.
http://ec.europa.eu/environment/waste/framework/end_of_waste.htm
- 82 Fullerton, D., Leicseter, A., Smith, S. “Environmental Taxes”, Working Paper for the National Bureau of Economic Research, July 2008
www.nber.org/papers/w14197
- 83 www.nibe.info
- 84 OECD (2012), Sustainable Materials Management: Making Better Use of Resources, OECD Publishing.
<http://dx.doi.org/10.1787/9789264174269-en>
- 85 Energy Performance Certificates (EPCs) have become established in many countries as a means to disclose the operational energy performance of domestic and non-domestic buildings in response to the implementation of EU Directive 2002/91/EC (EPBD, 2003) on the energy performance of buildings (EPBD). The purpose of an EPC is to indicate the operational energy efficiency of the fabric and the heating, ventilation, cooling and lighting systems of a building. The rating is compared to two benchmarks for this type of building: one appropriate for new buildings and one appropriate for existing buildings.
- 86 Levasseur, A, et al. “Technical Report: Development of a Common Material Metric for the UNEP-SBCI Sustainable Building Protocol”, April 2014
- 87 Founded initially by École Polytechnique de Montréal, in collaboration with Université de Montréal and HEC Montréal, the CIRAIIG was created to meet the demands of industry and governments to develop leading edge academic expertise on sustainable development tools. The CIRAIIG is the only university research centre on life cycle in Canada. It is also one of the largest internationally (www.ciraig.org).
- 88 Bureau de Promotion des Produits du Bois du Quebec (QWEB)
- 89 ISO 2006a; ISO 2006b
- 90 www.cen.eu/cen/Sectors/Sectors/Construction/EPB/Pages/CEN_TC350.aspx
- 91 www.iso.org/iso/iso_technical_committee?commid=322621
- 92 www.iisbe.org
- 93 http://cordis.europa.eu/projects/rcn/78620_en.html
- 94 www.openhouse-fp7.eu
- 95 www.ca-perfection.eu/index.cfm?n01=general_info
- 96 <http://cic.vtt.fi/superbuildings/node/21>
- 97 <http://sballiance.org>
- 98 <http://www.novatlantich.ch/wissenstransfer/2000-watt-gesellschaft/>
- 99 www.nist.gov/el/economics/BEESSoftware.cfm
- 100 Hammond Prof. G and Jones C., “Inventory of Carbon and Energy (ICE).”, Sustainable Energy Research Team, Dept. Mechanical engineering, University of Bath, UK
http://ecocem.fr/bibliotheque/bibliographie/ecologie/34_energie_primaire_et_co2_incorpore_royaume_uni_en.pdf

- 101 MLS is the Multiple Listing Service for the resale of homes and buildings in the U.S., <http://greenthemls.org>
- 102 For more information about the state of building energy disclosure in the U.S., Malin, N. and Roberts, T., "Energy reporting: it's the law", Environmental Building News, July, 2012 www2.buildinggreen.com/article/energy-reporting-its-law
- 103 Available for purchase from www.bsigroup.com
- 104 www.carbontrust.com/client-services/footprinting/footprint-certification
- 105 Athena Institute and FP Innovations, "A Carbon Footprint of Four Canadian Wood Products Delivered to the UK: as per PAS 2050 methodology" www.naturallywood.com/sites/default/files/UK-Carbon-Footprint-Factsheet.pdf
- 106 <http://shop.bsigroup.com/Browse-By-Subject/Environmental-Management-and-Sustainability/PAS-2070-2013/>
- 107 Canadian Forest Service <https://cfs.nrcan.gc.ca/statsprofile> and StatsCan www.statcan.gc.ca
- 108 U.S. Department of Agriculture Forest Service <http://fia.fs.fed.us>
- 109 www.fs.fed.us/research/forest-products
- 110 www.woodworks.org
- 111 <http://wood-works.ca>
- 112 www.canadawood.org
- 113 www.fh-rosenheim.de
- 114 www.ti.bfh.ch/en
- 115 www.woodlinksusa.org
- 116 <http://www.woodlinks.com/>
- 117 www.ovam.be/sites/default/files/2014-DEF-Milieuverantwoord-milieugebruik-bouw-3luik-LR.pdf
- 118 www.ovam.be/sites/default/files/FILE1368696514672Environmental_profile_buildig_elements_LR.pdf
- 119 www.nibe.info
- 120 www.ecoinvent.ch
- 121 Government of France, "BP X30 - Principes généraux pour l'affichage environnemental des produits de grande consommation - Partie 0 : principes généraux et cadre méthodologique" (2011), <http://affichage-environnemental.afnor.org/referentiel-bp-x30-323-0/resume-du-bpx30-323>
- 122 www.pcet-ademe.fr/le-grenelle
- 123 Construction Durable et Bonus de COS: Bonifier les droits à construire pour les constructions et rénovations à haute performance énergétique et environnementale, Guide d'application pour les collectivités locales, Arene, Ademe, RDI, 2008. www.areneidf.org
- 124 www.bre.co.uk/greenguide
- 125 Passivhaus Institut <http://passiv.de>
- 126 www.passivehouse-international.org
- 127 www.passivehouse-international.org/download.php?cms=1&file=2014_12_09_Passive_House_Million_PressRelease.pdf
- 128 Röhm, T., "Der Energieaufwand zur Herstellung des Energieautarken Solarhauses Freiburg; Diplomarbeit", Universität Karlsruhe, 1993 (The manufacturing energy demand for the energy-autarchic Solar House in Freiburg, Thesis, University of Karlsruhe, 1993). Source: Passipedia www.passipedia.org/passipedia_en/basics/energy_and_ecology/embodyed_energy_and_the_passive_house_standard#literature
- 129 A summary of the current status of low-carbon building regulations can be found in the "Zero Carbon Compendium: Who's doing what in housing worldwide"
- 130 www.minergie.ch
- 131 www.iccsafe.org/CS/IGCC/Pages/default.aspx
- 132 www.iccsafe.org/CS/IGCC/Pages/default.aspx
- 133 www.iccsafe.org/Pages/default.aspx
- 134 <https://law.resource.org/pub/us/code/ibr/icc.iecc.2012.pdf>
- 135 www.nahb.org/en/research/nahb-priorities/green-building-remodeling-and-development/icc-700-national-green-building-standard.aspx
- 136 www.ashrae.org/standards-research--technology/standards--guidelines
- 137 BREEAM website www.breeam.com
- 138 US Green Building Council, November 2013 [/www.usgbc.org/articles/nearly-60000-global-lead-green-building-projects-span-106-billion-square-feet-new-report-us](http://www.usgbc.org/articles/nearly-60000-global-lead-green-building-projects-span-106-billion-square-feet-new-report-us)

- 139 Light House Sustainable Building Centre, “Green Building Rating Systems and How They Relate to Wood”, for Forestry Innovation investment Ltd, January 2010 <http://www.bcfii.ca/industry-tools-resources/school-resources>
- 140 For example, as stated in the U.S. LEED Homes rating system introduction (www.usgbc.org)
- 141 PEFC International Press and Media Information www.pefc.org/news-a-media/press-information
- 142 A project is a tangible product (e.g. house) or part of a product that forms a functional unit (e.g. the roof of a house) which is clearly specified in terms of location and time. www.pefc.org/certification-services/project-certification
- 143 FSC Facts and Figures <https://ic.fsc.org/en/facts-figures>
- 144 www.tem.fi/files/39718/Suomalaiset_puukerrostalot_1995-2014.pdf
- 145 <http://tem.fi/documents/1410877/2937056/Strategic%20Programme%20for%20the%20Forest%20Sector%20%28MSO%29%202011-2015/6a42513a-add4-462b-b4d8-6221d5f24c28>
- 146 Sunabacka, S. presentation “the Finnish National Wood Construction Programme”, The Strategic Programme for the Forest Sector, Ministry of Employment and the Economy of Finland, 2013
www.tem.fi/files/36433/Esitys_MSO_Sunabacka_Vaxjo09042013_final.pdf
- 147 <http://www.woodarchitecture.fi/>
- 148 Annual Report on Forest and Forestry in Japan, Fiscal Year, 2012 (Summary) Forestry Agency, Ministry of Agriculture, Forestry and Fisheries, Japan (<http://www.rinya.maff.go.jp/j/kikaku/hakusyo/24hakusyo/pdf/h24summary.pdf>)
- 149 Hisashi Kajiyama, “Reviving the Japanese Forest Industry: A Comparative Study of Japan and Germany”, Fujitsu Research Institute, February 2005 <http://jp.fujitsu.com/group/fri/en/economic/publications/report/2005/report-216.html>
- 150 PEFC Asia <http://www.pefcasia.org/japan/whatsnew/index-e.html>
- 151 www.developpement-durable.gouv.fr/Bois,13394.html
- 152 www.usda.gov/wps/portal/usda/usdahome?contentid=2011/03/0143.xml&navid=NEWS_RELEASE&navtype=RT&parentnav=LATEST_RELEASES&deployment_action=retrievecontent
- 153 www.usda.gov/wps/portal/usda/usdahome?contentid=2014/03/0041.xml&contentidonly=true
- 154 www.fpl.fs.fed.us
- 155 www.regjeringen.no/upload/LMD/skogaaret/vedlegg/Brosjyre_Norsk_skogpolitikk_2011_ENGELSK.pdf
- 156 www.visitnorway.com/en/about-visitnorwaycom/innovation-norway/
- 157 Norway National Office of Building Technology and Administration www.dibk.no. Information sourced from the Inter-jurisdictional Regulatory Collaboration Committee (IRCC) http://www.ircc.info/Doc_page.html
- 158 http://openstates.org/ga/bills/2013_14/SB301/
- 159 GDE guidelines which prohibits the use of wood in school buildings (outdated). www.gadoe.org/Finance-and-Business-Operations/Facilities-Services/Documents/2.%20Guideline%20for%20Educational%20Facility%20Construction%20051012.pdf
- 160 Christchurch City Council website: <https://www.ccc.govt.nz/>
- 161 www.mbie.govt.nz/publications-research/research/building-and-construction/quake-pyne-gould-corp-investigation-report.pdf
- 162 University of Canterbury, New Zealand, “A design guide for Expan multi-storey timber buildings incorporating Pres-Lam technology” (June 2013) available at <http://assets2.expan.co.nz/assets/NZ-EXPAN-Post-Tensioned-Timber-Buildings---June-2013-presentation.pdf>
Also: Buchanan, Prof. A., University of Canterbury, New Zealand, “Post-tensioned multi-storey buildings” presentation to International Wood Symposium for WoodWorks BC, January 2014
<http://wood-works.ca/wp-content/uploads/3-andy-buchanan-international-wood-symposium-v2.pdf>
- 163 Buchanan, A., Pampanin, S., Palermo, A., “Post-Tensioned Timber Buildings - Design Guide”
<http://assets2.expan.co.nz/assets/NZ-EXPAN-Post-Tensioned-Timber-Buildings---June-2013-presentation.pdf>
- 164 “Sustainable Reconstruction in Disaster-Affected Countries: Practical Guidelines”, United Nations Environment Programme and Skat – Swiss Resource Centre and Consultancies for Development, 2012
www.unep.org/sbci/pdfs/PracticalGuidelines_SustainableReconstruction.pdf
- 165 www.oib.or.at
- 166 www.lifecyclehub.com
- 167 “International Survey of Tall Wood Buildings”, May 2014
www.mbie.govt.nz/publications-research/research/building-and-construction/quake-pyne-gould-corp-investigation-report.pdf
- 168 Analysis report of procurement standards and procurement praxis in Slovenia
www.buy-smart.info/media/file/1600.D2_2_BuySmart_ProcurementStandards_SLOVENIA.pdf
- 169 https://living-future.org/sites/default/files/reports/FINAL%20LBC%203_0_WebOptimized_low.pdf
- 170 OECD, “Sustainable Materials Management: Making Better Use of Resources,” (2012)

- 171 www.carpetrecovery.org
- 172 www.interface.com
- 173 Source: Re-Use Consulting www.reuseconsulting.com
- 174 www.chps.net
- 175 <http://rebuildingcenter.org>
- 176 http://customs.hmrc.gov.uk/channelsPortalWebApp/channelsPortalWebApp.portal?_nfpb=true&_pageLabel=pageExcise_InfoGuides&propertyType=document&id=HMCE_CL_001169
- 177 <http://ec.europa.eu/environment/ecolabel/>
- 178 www.carpet-rug.org/CRI-Testing-Programs/Green-Label-Plus.aspx
- 179 www.pcrguidance.org
- 180 <http://ec.europa.eu/environment/eussd/smgp>
- 181 ISO 14040:2006.
- 182 The International Standards Organization (ISO) has developed a suite of protocols under which LCA is to be conducted, data is to be collected and information is to be reported. LCA methodology is set out in the ISO 14040 series. Supporting documents include Product Category Rules (PCRs) described in ISO 14025 and Environmental Product Declarations (EPDs) outlined in ISO/CD 21930 (see below). An additional standard—ISO 21931-1:2010— establishes a framework for methods of assessment of the environmental performance of buildings and related external works. An additional standard—ISO 21931-1:2010— establishes a framework for methods of assessment of the environmental performance of buildings and related external works. ISO 21931 does not set benchmarks or levels of performance relative to environmental impacts and aspects. Instead it aims to bridge the gap between regional and national methods for the assessment of the environmental performance of buildings, by providing a common framework for their expression.
- 183 EN 15643-1:2010: “Sustainability of construction works – Sustainability assessment of buildings – Part 1: General framework” establishes very general principles and requirements for the development of a number of subsequent standards. The methodological framework defined is applicable for all kinds of buildings and is based on a life cycle approach
 EN 15643-2:2011: “Sustainability of construction works – Assessment of buildings – Part 2: Framework for the assessment of environmental performance” establishes specific guidelines for the assessment of the environmental performance of buildings
 EN 15804:2012: “Sustainability of construction works - Environmental product declarations – Core rules for the product category of construction products” provides a structure for the development of product category rules (PCR) for construction products so that the environmental product declarations (EPD) created using these PCRs are harmonized. The PCRs for different construction products in compliance with the EN 15804 standard are currently in development
 EN 15978:2011: “Sustainability of construction works – Assessment of environmental performance of buildings – Calculation method” provides calculation rules for the assessment of the environmental performance of buildings based on EN 15643-1 and EN 15643-2 guidelines as well as using data for construction products coming from EN 15804 compliant EPDs when available.
 These standards have been developed in accordance with the ISO standards so that they do not contradict main issues.
- 184 Page 175. OECD (2012), Sustainable Materials Management: Making Better Use of Resources, OECD Publishing. <http://dx.doi.org/10.1787/9789264174269-en>
- 185 For example, as stated in the U.S. LEED Homes rating system introduction: <http://www.usgbc.org/Docs/Archive/General/Docs7982.pdf>
- 186 www.passivhaus.de
- 187 www.ashrae.org/standards-research--technology/standards--guidelines
- 188 www.minergie.ch
- 189 <http://www.minergie.ch/>
- 190 Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste quoted in “End-of-Waste Criteria”, authors: Luis Delgado, Ana Sofia Catarino, Peter Eder, Don Litten, Zheng Luo, Alejandro Villanueva JRC Scientific and Technical Reports, 2009. ftp.jrc.es/EURdoc/JRC53238.pdf

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The Committee on Forests and the Forest Industry is a subsidiary body of the United Nations Economic Commission for Europe. It constitutes a forum for UNECE member states to consult with each other and work together on issues related to forestry, the forest industry and forest products. All countries in Europe, the Commonwealth of Independent States, the United States, Canada and Israel are members of the UNECE and participate in its work.

Working towards achieving sustainable development, the Committee provides member states with the information and services they need for policy- and decision-making regarding their forest and forest industry sectors, including the trade and use of forest products and, when appropriate, formulates recommendations addressed to governments and interested organizations. To this end, it makes the following commitments:

1. With the active participation of member states, to undertake short-, medium- and long-term analyses of developments in, and having an impact on, the forest sector, including those offering possibilities for the facilitation of international trade and for enhancing the protection of the environment.
2. In support of these analyses, to collect, store and disseminate statistics relating to the sector, and carry out activities to improve their quality and comparability.
3. Provide the framework for cooperation e.g. by organizing seminars, workshops and ad hoc meetings and setting up ad hoc groups for the exchange of economic, environmental and technical information between governments and other institutions of member states for developing and implementing policies leading to the sustainable development of the forest sector and to the protection of the environment in their countries.
4. Carry out tasks identified as being of priority, including the facilitation of subregional cooperation and activities in support of the economies in transition of central and eastern Europe.
5. To keep under review its structure and priorities and cooperate with other international and intergovernmental organizations active in the sector, and in particular with the Food and Agriculture Organization of the United Nations and its European Forestry Commission, and with the International Labour Organization, to ensure complementarity and avoid duplication, thereby optimizing the use of resources.

You can get more information about the Committee's work by writing to:

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