Training Handbook: Building Material Cleaner Production Auditing and Green Building Material Evaluation

For Policy Makers

Imprint

Title: Training Handbook: Building Material Cleaner Production Auditing and Green Building Material Evaluation - for policy makers

Authors: Wuppertal Institute - Gokarakonda, Sriraj; Shrestha,Shritu; Xia-Bauer, Chun

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Contact: Chun Xia-Bauer
Doeppersberg 19
42103 Wuppertal (Germany)
e-mail: chun.xia@wupperinst.org

Content

List of Tables

List of Figures

1. Labels and Environmental Product Declaration of Sustainable Building Materials /Components in Europe

In Europe, there are various information tools that intend to inform customers (users, downstream manufactures, retailers, etc.) about the environmental impacts from manufacturing and using the products. They are operated by governments, private companies, and other non-governmental organizations. Some of them are tested independently. Others are declared by manufacturers, importers, and distributers themselves. These independently verified information tools can be categorized into two types: eco-labeling and environmental product declaration.
This chapter will mainly focus the first type. It starts with an overview on various eco-labels of sustainable building materials/components and then presents how various green buildings schemes and these materials/components labels are linked. Important tools that facilitate the selection of sustainable building materials/components will also be highlighted. Finally, the chapter will briefly introduce the second type, i.e. environmental product declaration and its principles.

1.1 Ecolabels of sustainable building material and components

Those are developed in Europe (such as the Blue Angel and EU Ecolabel) or internationally (such as Cradle-to-Cradle (C2C) and Forest Stewardship Council (FSC)). Their rating system also varies according to the scheme and they are valid for one to five years. Product certification includes limited products (such as wood products in FSC) to a wide range of products (such as insulation, floorings, plasters and wall panels etc.). The criteria of these certification lables include various sustainability features, such as environmental, climate, health, resource efficiency, ethics, etc. The certification bodies can be government agency (such as RAL for the Blue Angel) or accredited third party (such as in EU Ecolabel and FSC).

1.1.1 European and German labels of sustainable building materials

Three European and German sustainable building labels, i.e. The Blue Angel, EU Ecolabel, and The Passive House Components Label, and their features are presented in the tabular form below.

The Blue Angel	
Label Description	Organization structure
The Blue Angel, a type I Eco-label, is designed to promote goods and services that have – based on the entire life cycle – reduced environmental and health impacts compared to the market average. Combined with other environmental policy instruments, eco-label initiatives can play their part to restructure	Established in 1978
	Awarding body: Umweltbundesamt (German Federal Environment Agency), RAL – German Institute for Quality Assurance and Certification)
	Type: In line with the international standard for eco-labelling, ISO 14024
	Ratings:

the economy towards sustainable development.	Validity:
	Webpage: http://www.blauer-engel.de/index.php
Scope and Range	
Products for home and living (such as recycled cardboard, paper and plastics, and textile floorcoverings etc.), construction (such as composite Wood Panels, Wood products, Low-Emission Internal Plasters and Thermal Insulation Material etc.), electric devices, office, energy and heating, and garden.	
Criteria determination	
Criteria under product groups and services: - protects environment and health - protects climate - protects water - protects resources	
Certification bodies	
- German Federal Environment Agency (Umweltbundesamt) which develops the technical criteria - Expert hearings involving representatives from industry and other expert groups - Environmental Label Jury composed of representatives from HDE (Central Association of German Retail Trade), BUND (Friends of the Earth Germany), BDI (Federation of German Industries), NABU (Nature and Biodiversity Conservation Union), DGB (Confederation of German Trade Unions), vzbv (Federation of German Consumer Organizations), SWR (South West German Broadcasting Corporation) as well as Stiftung Warentest (Foundation for comparative product testing), churches, state ministries of the environment, local authorities and science, decides on the award of a Blue Angel - RAL which organizes the award with the label users - German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, the supporting organization of the Blue Angel	
Certification procedure	
<u>A. for existing basic award criteria</u> 1. The supplier submits their application - In order to use the environmental label, verification of compliance with the requirements is sent to the awarding body RAL. 2. RAL checks the application for the use of the environmental label for compliance with the stipulated requirements. 3.German Federal Environment Agency submits statement 4.RAL concludes the contract on the use of the environmental label with the supplier/manufacturer 5.Advertising by the supplier using the environmental label based on the contract on the use of the environmental label concluded with RAL <u>B. for the development of new Basic Award Criteria</u> 1.Anybody can submit a new proposal including comprehensive information on the product to the German Federal Environment Agency 2.Specialist evaluation by the Federal Environment Agency 3.The Environmental Label Jury decides on the investigative order 4.Federal Environment Agency Expert preparation and proposals for the Basic Award Criteria 5.RAL - Organization of the expert hearing	

6.Expert hearing Participants - RAL (Chair), UBA, Sector supplying the product/service (BDI), Consumer associations (BVZV/StiWa), and Environmental associations, Trade unions, Other experts (if required)

Recommendations for the Environmental Label Jury

7.Environmental Label Jury ratify the Basic Award Criteria

8.Announcement of the decisions by the BMUB

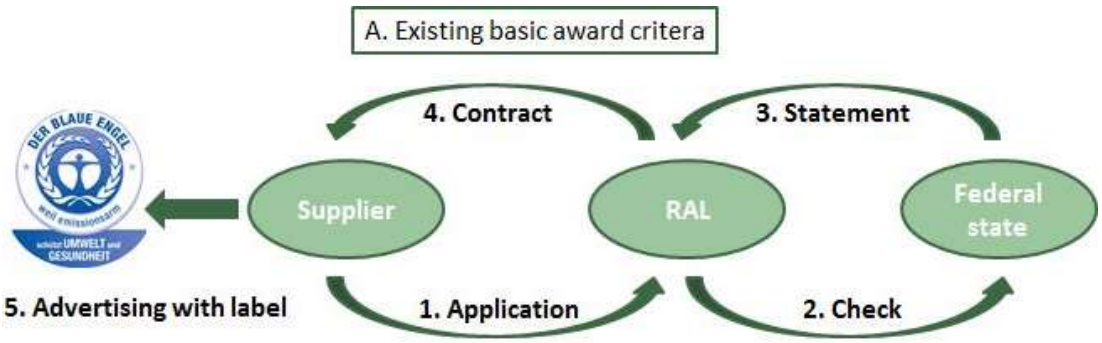


Figure 1: Certification procedure for existing basic award criteria.

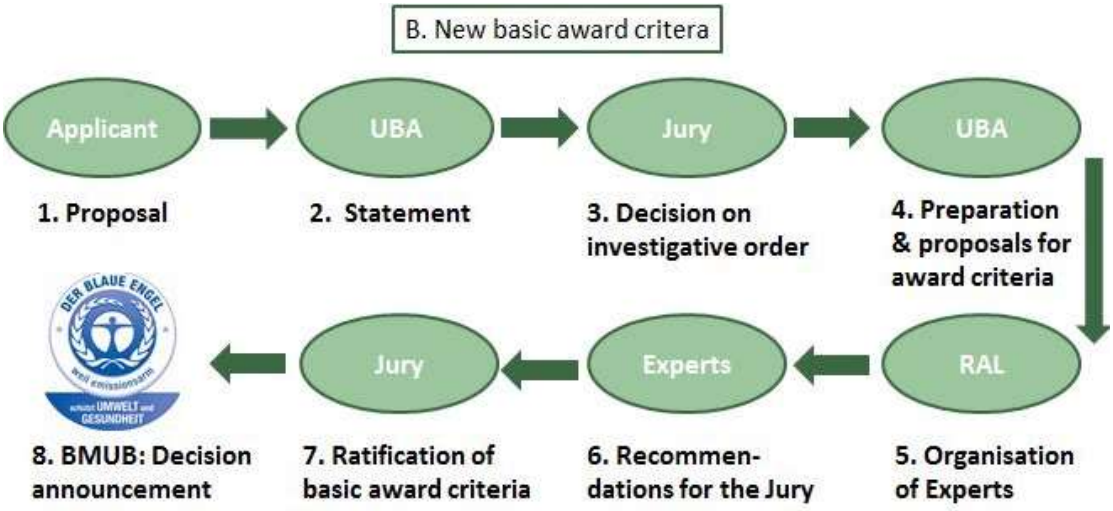


Figure 2: Certification procedure for new basic award criteria.

EU Ecolabel	
Label Description	Organization structure
Figure 3: Ecolabel.	Established in 1992
	Awarding body: European Eco-labelling board (EUEB)
	Type: Type I according to ISO 14020
	Ratings:
	Validity: 4 years
	Webpage: http://www.eu-ecolabel.de
Scope and Range	
- Products and services, consumer-oriented	

- Building products included: Paints, varnishes, heat pumps, wooded floor coverings, soft floor coverings and textile floor coverings
Criteria determination
- Criteria determination on the basis of lifecycle analysis and the focus on the stages (manufacturing and packaging, distribution, use and finally the 'end of life') depends on where the product has the highest environmental impact, and this differs from product to product. - Consider the most significant environmental impacts, mainly the impacts on climate change, the impact on nature and biodiversity, energy and resource consumption, waste generation, emissions to all environmental media, pollution through physical effects and use and release of hazardous substances - Substitute hazardous substances by safer substances or the use of alternative materials or designs, wherever it is technically feasible - Reduce environmental impacts due to the durability and reusability of products - Include health and safety aspects at various life stages of the products that helps to balance between environmental benefits and burden - Consider social and ethical aspects
Certification bodies
- Runs via a third party, National Competent Body (PFS Product Policy for Belgium) - Product testing by accredited laboratory
Certification procedure
<u>Getting Started</u> Which products and services are eligible? Every product or service supplied for distribution, consumption or use in the European Economic Area market (European Union plus Iceland, Lichtenstein and Norway) and included in one of the established non-food and non-medical product groups is eligible for EU Ecolabel. Discover the full list of established product groups and the related product criteria. Who can apply? Producers, manufacturers, importers, service providers, wholesalers and retailers. Retailers can apply for products placed on the market under their own brand name <u>Getting Advice</u> Start the application in the right product group and contact the Competent Body The Competent Body is responsible for evaluating the application and awarding the EU Ecolabel, and also give the applicant technical support and answer the questions about meeting the criteria. <u>Starting the application</u> To get your EU Ecolabel license, it is mandatory to apply using the online application tool, ECAT_Admin. <u>Collecting the Evidence</u> In order to prove compliance to the criteria for the product group, it is required to provide a dossier made up of the declarations, documents, data sheets and test results. The User Manual for each product group explains the requirements. The EU Ecolabel checklist is a useful tool to manage the dossier. The checklist can be downloaded. <u>Submitting the Application</u> Once the online application is submitted, the required paper files are also required to be submitted to the Competent Body.

Within two months of the initial application submission, the Competent Body will assess the product against the criteria set for it. If documentation is missing, the applicant will be informed and they will need to provide additional information.

Ecolabel awarded

Application approval:

If the criteria are met and the dossier is complete, the Competent Body will award the EU Ecolabel to the product by creating a contract with the applicant.

Once that's complete, the applicant can use the EU Ecolabel logo on all the products that have met the criteria and on the associated promotional material.

Compliance monitoring:

Once the applicant becomes a license holder, it is their responsibility to stay compliant with EU Ecolabel criteria. The Competent Body will explain how often it will need test samples of your product.

From time to time, the Competent Body may carry out factory inspections and product tests. This ensures that the environmental excellence is maintained for consumers.

The applicant (or the supplier) will need to keep a journal on the test results and all the relevant documentation. This documentation should be available at all times.

If the Competent Body receives evidence that during the validity period, the product no longer complies with the criteria, it will prohibit the use of the EU Ecolabel on that product.

Marketing their product with the EU Ecolabel

Once the EU Ecolabel is awarded to the products, it is the applicant's responsibility as the license holder to register the products and services on the ECAT Product Catalogue and Tourist Accommodation Catalogue via ECAT_Admin.

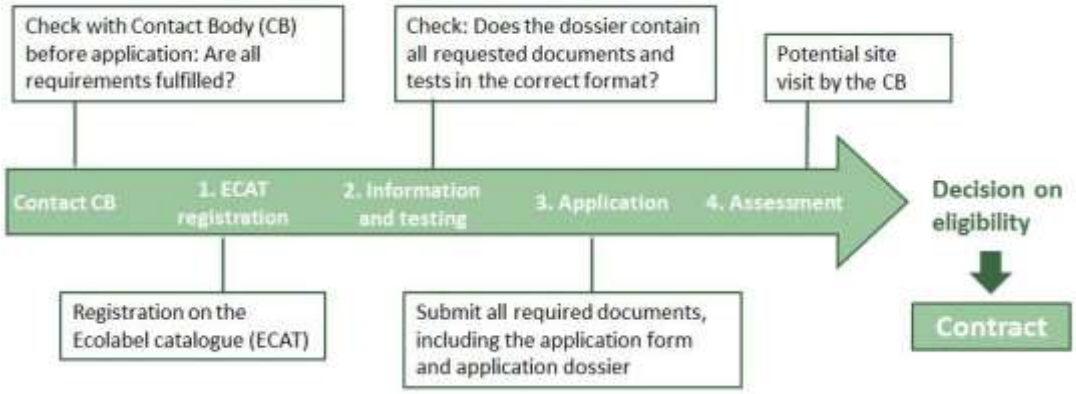


Figure 4: Certification procedure for EU Ecolabel.

The Passive House Components Label	
Label Description	Organization structure
The use of Passive House components simplifies the planner's task significantly and contributes significantly to ensuring the proper functioning of the resulting passive house.	The Passive House Institute (PHI) is an independent research institute which developed the Passive House Standard.
	Validity: Each certificate has a validity of year after which it can be re-certified by the Passive House Institute. With each new validation the previous certification loses validity.

 Figure 5: Passive House Label.	Webpage: http://database.passivehouse.com/de/components/
Scope and Range	
These are defined depending on the category of the component. These being divided into three categories: - Opaque Building Envelope: Wall and building systems, Façade anchors, Ground slab, Roof parapet, Flue and exhaust systems, Balcony thermal break technology, Attic steps and ladders, Airtightness systems. - Building Technologies: Heat Pumps, Ventilation system, Waste water heat recovery system. - Transparent Building Envelope: Windows, Roof windows, Skylight, Mullion and transom, Glass roof, Opening elements in glass roof, Roller shutters, Entrance doors, Sliding doors, Glazing, Spacers (windows). The components are also declared according to a specific climate zone: - Arctic Climate - Hot Climate - Temperate Climate	
Criteria determination	
PHI certifies high energy-efficient materials and components according to their international criteria for Passive House. The criteria are divided into two groups, comfort criteria (including residential health and comfort) and thermal criteria (relevant to the thermal balance of a building). All criteria can be specified by ascertainable physical or physiological criteria and verified by measurements with established practices and tested according to standard criteria with respect to their characteristics. If possible, there is a climate-independent formulation of the criteria. However, this is usually less clear for the user - therefore applicable criteria to define climates are also specified.	
Certification bodies	
PHI as an independent body test and certifies products as to their suitability for use in passive houses.	
Certification procedure	

Cradle to Cradle	
Label Description	Organization structure
The Cradle to Cradle Certification framework focuses on using safe materials that can be disassembled and recycled as technical nutrients or composted as biological nutrients. Unlike single-attribute	Established in 2005
	Awarding body: MBDC (McDonough Braungart Design Chemistry)
	Type: Not classified i.e. it can't be regarded as an environmental declaration type I, II or II according to

eco-labels, the Cradle to Cradle Certification takes a comprehensive approach to evaluating the design of a product and the practices employed in manufacturing the product	the ISO 14020 standard.
	Ratings: Basic, Bronze, Silver, Gold and Platinum
	Validity: 1-2 years
	Webpage: http://www.c2ccertified.org/

Scope and Range

The products include building materials, interior design, paper and packaging, textile and fabric and other products

Criteria determination

Criteria in 5 categories:

-Material Health

-Material Reutilization

-Renewable Energy and Carbon Management

-Water Stewardship

-Social Fairness

Figure 6: Cradle to cradle certified product scorecard.

Certification bodies

- Runs via MBDC and possibly EPEA

Certification procedure

1. Determine if the product is appropriate for certification: Is it within the scope of certification? Does it comply with the Banned Chemicals Lists? Is there a commitment to continuous improvement and product optimization? Does your product meet eligibility requirements in the Cradle to Cradle Certified Product Standard?

2.Select an Accredited Assessment Body for the testing, analysis, and evaluation of your product: Select from the list of Accredited Assessment Bodies, and develop a certification plan including cost, timeline, and necessary resources

3. Work with the assessor to compile and evaluate data and documentation: Work with assessor

and supply chain to collect data. Assessor evaluates data based on Standard criteria and develops optimization strategies. Submit an Assessment Summary Report, assembled by the assessor, to the Institute for final review. 4. Receive certification for the product: The Institute reviews Assessment Summary Report to ensure completeness and accuracy. Applicant signs a Trade-mark License Agreement, and pays the certification fee to the Institute. The Institute makes the final certification decision, conferring a certificate and the use of the Cradle to Cradle Certified mark, considering the requirements of the Trademark Use Guidelines. Work with the Institute to post the products on the product registry. 5.Work with Institute and the marketing teams: Make the customers aware of the innovation and certification story 6. Report the progress: Every two years, work with the assessor and supply chain to gather new data for re-certification. `The Assessor evaluates the data and progress on optimization strategies. Submit the Re-certification Assessment Summary Report to the Institute for review.
Additional measures: Cradle to Cradle has a website providing simple and clear information of labelling and its application process. This website also includes an online certified product registry, which facilitates project developers to choose these products; These Assessors are accredited by the Institute based on the experience, qualifications, and training of organization's staff; With the launch of the new LEED v4, Cradle to Cradle Certified products are written into LEED. Choosing certified products can earn project teams up to two points for Materials & Resources Credit, Building Disclosure and Optimization—Material Ingredients. In addition, BREEAM-Netherland— the 'Environmental Assessment Method' -is now rewarding the use of Cradle to Cradle Certified Products; Cradle to Cradle also provide training courses to leading companies in the building sector by exploring design methodologies, material health programs, product and systems innovations, and a new definition of waste.

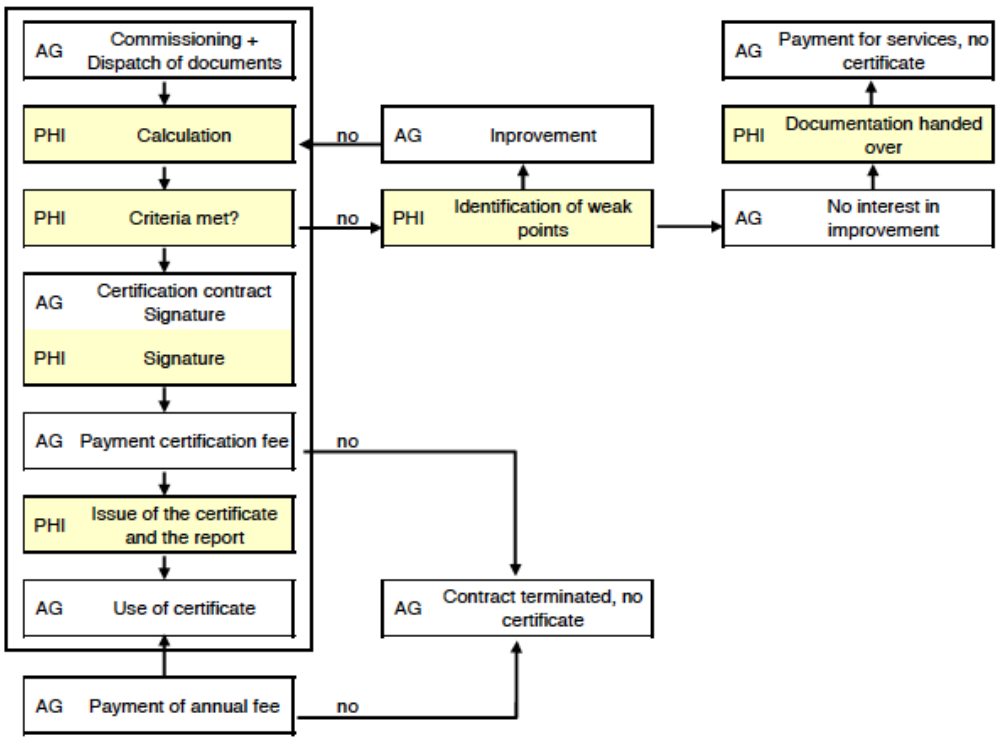


Figure 7: Certification procedure for Cradle to Cradle.

1.1.2 International labels of sustainable building materials

Two sustainable building labels (Cradle-to-Cradle and Forest Stewardship Council) and their features are presented in the tabular form below.

Forest Stewardship Council (FSC)	
Label Description	Organization structure
The Forest Stewardship Council mission promotes environmentally sound, socially beneficial and economically prosperous management of the world's forests. FSC-certified products ensure environmental protection, community engagement and access to markets. There are 3 types of the FSC certificate: Forest Management Certification, Chain of Custody Certification and Controlled Wood Certification.	Established in 1993
	Awarding body: FSC accredited certification bodies. Accreditation Services International (ASI) is responsible for checking the certification bodies.
	Type: Type I according to ISO 14020
	Ratings:
	Validity: 5 years, conduct annual surveillance audits to verify the continued compliance with FSC certification requirements
	Webpage: https://ic.fsc.org/
Scope and Range	
The FSC promotes environmentally appropriate, socially beneficial, and economically viable management of the world's forests: • Environmentally appropriate forest management ensures that the harvest of timber and non-timber products maintains the forest's biodiversity, productivity, and ecological processes. • Socially beneficial forest management helps both local people and global society to enjoy long	

term benefits and also provide strong incentives to local people to sustain the forest resources and adhere to long-term management plans. • Economically viable forest management means that forest operations are structured and managed so as to be sufficiently profitable, without generating financial profit at the expense of the forest resource, the ecosystem, or affected communities. The tension between the need to generate adequate financial returns and the principles of responsible forest operations can be reduced through efforts to market the full range of forest products and services for their best value. • The FSC Principles and Criteria is applied to the entire geographic space inside the boundary of the forest management unit which is being submitted for evaluation of the quality of forest management; FSC-POL-10-004 (Scope of application of the FSC Principles and Criteria for Forest Stewardship, June 2005) backed by FSC-DIS-01-001
Criteria determination
10 principles/new proposed titles: 1. Compliance with laws and FSC Principles/ Compliance with legal requirements 2. Tenure and use rights and responsibilities/ Workers' rights and employment conditions 3 Indigenous peoples' rights/ Indigenous and traditional peoples' rights 4. Community relations and worker's rights/ Community relations and development 5 Benefits from the forest 6. Environmental impact/ Ecosystem functions 7. Management plan/ Management planning 8. Monitoring and assessment 9. Maintenance of high conservation value forests 10. Plantations/ Management activities
Certification bodies
Organizations listed in http://www.accreditation-services.com/archives/standards/fsc
Certification procedure
1. Contact one or several FSC accredited certification bodies (CB): To give the applicant a first estimate regarding cost and time demands, the certification body will need some basic information about your operation. The, the certification body will provide the applicant with information about the requirements for FSC certification. 2. Auditing: A certification audit takes place to assess the applicant's qualifications for certification. 3. Certification: After working with a CB towards achieving full FSC requirements compliance, the applicant's operation will receive its FSC Certificate.

1.1.3 Sustainability building schemes and their requirements of sustainable building products and components

In highly efficient or even plus energy buildings – the buildings of the future, the lifetime operational energy consumption is much lower compared with conventional new buildings, while the share of embodied energy is higher due to additional sophisticated construction materials, energy production and recovery systems (Dutil, Rousse & Quesada, 2011), along with the use of renewable technologies. Therefore,

it is necessary to select building materials carefully, with low embodied energy to minimize the adverse effect on the environment. Beyond the energy dimension, sustainable buildings require construction products that are sustainable in terms of health and material efficiency.
In order to fulfil these criteria, specific materials should be used which are listed in various database such as greenbuildingproducts.eu for DGNB and LEED and greenbooklive.com for BREEAM. This section discusses on how material efficiency is achieved in green building certificates used in Europe. Different sustainable building material certificate schemes are also discussed with their certification process. A number of building material database are accessible online in Europe and some of them are listed and discussed in this chapter.

Green building certification systems evaluate the green performance of a building and confirm its green building status (Nelson et al. 2010) by rating and certifying it by an independent third party. Some of the certifications used in Europe are BREEAM (Building Research Establishment's Environmental Assessment Method) from the UK, DGNB (Deutsche Gesellschaft für Nachhaltiges Bauen e.V./German Sustainable Building Council) from Germany, LEED (Leadership in Energy and Environmental Design) from the USA and HQE from France. The rating systems and weightings for criteria differ between these schemes and they are either limited to their country of origin or used internationally (e.g. LEED in the USA and Europe). To date, these systems are voluntary and have been developed through non-governmental or governmental organizations. Figure 3 shows the evolution of these green building certification systems in different countries.
A short overview of some of the green building certificates are given in the tabular form below with the information gathered from the individual websites. Regarding material efficiency in the selected green building certificates, all consider life cycle impact reduction, along with the emphasis on reusing and recycling the materials in order to reduce waste generation and to dispose. Material efficiency is further enhanced by the use of green products from the green material schemes. The FSC products are suggested by all green building certificates, and some green material schemes are country specific. The product list is also suggested by the various database which shows the product details as well as their suppliers.

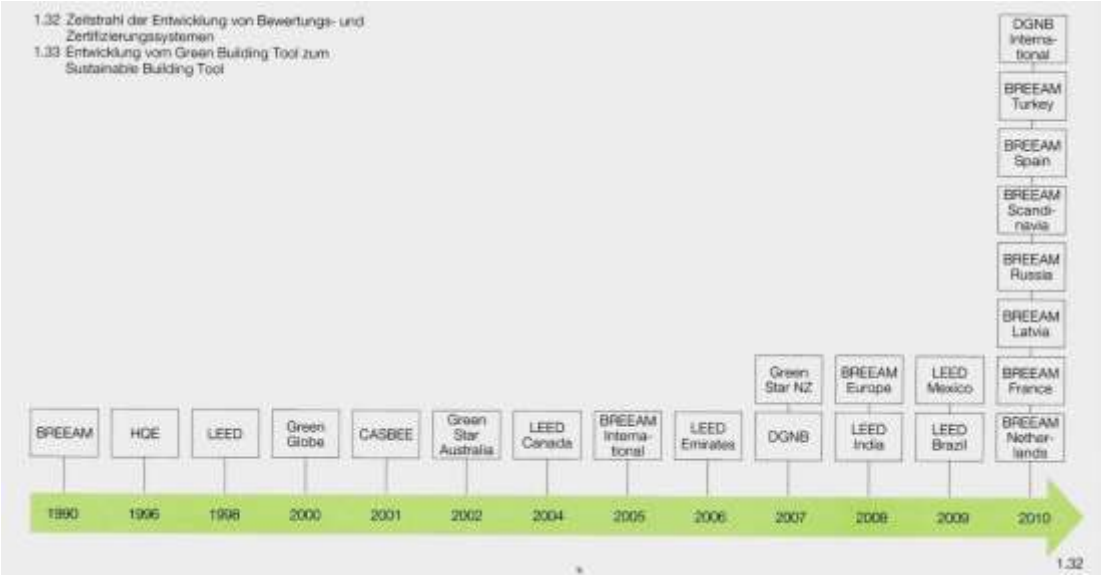


Figure 8: Evolution of Green building certification (Source: Ebert et al. 2011).

DGNB (CORE 14 scheme)	
Label Description	Organization structure
DGNB is a meritocratic rating system that covers all relevant topics of sustainable construction. It was developed to respond for a society that faces a wide range of challenges such as climate change, resource scarcity, as well as the financial crisis. It includes ecological, economical and socio-cultural issues in the planning, construction, and operation of buildings for sustainable buildings (DGNB 2012).	Established in 2007
	Country of Origin: Germany
	Responsible: DGNB together with BMVBS (German Federal Ministry of Transport, Building, and Urban Affairs)
	Criteria: Environmental Quality, Economic Quality, Sociocultural and Functional Quality, Technical Quality, Process Quality and Site Quality
	Ratings: Bronze (35%)/ Silver (50%)/ Gold (65%)/ Platinum (80%)
	Regulation: Voluntary
	Webpage: http://www.dgnb.de/en/
Material efficiency	
DGNB focuses on avoidance of construction waste by the design that are ease of deconstruction, recycling and dismantling; use environment friendly materials that have Green Product Certification; and design alteration with resource saving.	
Material sub-criteria	Environmental quality ENV 1.1 Life Cycle Impact Assessment ENV 1.2 Local environmental impact ENV 1.3 Responsible Procurement
Certification requirement	A Project Certification Query (PCQ) process must be completed (in general)
Certifier	DGNB Auditor (650 DGNB auditors till date) or DGNB Consultant (400 DGNB consultants till date)
Material schemes	The Blue Angel, timber from FSC or PEFC certified sources, stones with

suggested (voluntary)	Xertifix, Fair Stone certificates, Gut (Gemeinschaft umweltfreundlicher Teppichböden e.V.) -signet label for textile floor coverings
Material database suggested (voluntary)	LCA data in ESUCO database must match the methodological standards, quality and completeness set by ESUCO database and this must be documented comprehensively for verification, GISCODE/product code: Safety data sheet, technical information, www.wingis-online.de, greenbuildingproducts.eu

BREEAM 2014	
Label Description	Organization structure
BREEAM is the world's leading sustainability assessment method for master planning projects, infrastructure and buildings. It inspires developers and creators to excel, innovate and make effective use of resources. The focus on sustainable value and efficiency makes BREEAM certified developments attractive property investments and generates sustainable environments that enhance the well-being of the people who live and work in them. BREEAM has 80% market share and is applied in over 70 countries worldwide.	Established in 1990
	Country of Origin: UK
	Responsible: BRE Global (under BRE Trust)
	Criteria: Energy, Health and Wellbeing, Innovation, Land Use, Materials, Management, Pollution, Transport, Waste and Water
	Ratings: Pass (≥ 30%), Good (≥ 45%), Very Good (≥55%), Excellent (≥ 70%) and Outstanding (≥ 85%)
	Regulation: Voluntary
	Webpage: http://www.breeam.com
Material efficiency	
BREEAM considers life cycle impacts of building material used, the reuse of existing building facades, building structure, recycled aggregates, the minimization of construction waste and the use of low embodied and environmentally friendly materials determined by their Green Guide Rating.	
Material sub-criteria	Materials Mat 01 Life cycle impacts Mat 03 Responsible Sourcing of Materials Mat 04 Insulation Mat 06 Material efficiency
Certification requirement	During the assessment process, each category is sub-divided into a range of issues, which promotes the use of new benchmarks, aims and targets. When a target is reached, credits are awarded. Once the development has been fully assessed, depending upon the total number of credits awarded, a final performance rating is achieved.
Certifier	Licensed BREEAM assessors
Material schemes suggested (voluntary)	Cradle to Cradle, FSC and PEFC certificates, BRE Environmental Profile methodology, (As a licensed BREEAM/EcoHomes/Code for Sustainable Home Assessor, you may now use the Green Guide Calculator online tool to model a new bespoke element using available Green Guide Components.) Green Guide rating?
Material database	a list of products approved to BES6001 and additional information in

suggested (voluntary)	www.greenbooklive.com/

LEED 2013	
Label Description	Organization structure
USGBC's LEED green building rating system has been a significant driver for market transformation since its debut in 2000. Even if some progress is already achieved, urgency to improve our built environment still exists. LEED v4, the next version of LEED, was released in 2013 and redefines leadership in green building. It includes many new concepts and more rigorous requirements to continue the transformation of our construction industry. Until 2016, nearly 3,800 projects in Europe were participating in LEED.	Established in 1998
	Country of Origin: USA
	Responsible: US Green Building Council
	Criteria: Location and Transportation, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Material and Resources, Indoor Environmental Quality, Innovation and Regional Priority
	Ratings: Certified (40-49 points), Silver (50-59 points), Gold (60-79 points) and Platinum (80 and above)
	Regulation: Voluntary, consensus-based, and market driven, performance based
	Webpage: http://www.usgbc.org
Material efficiency	
LEED emphasizes on building material reuse and promotes recycling; manage the construction waste and use regional environmentally friendly materials with Green Product Certifications. It focuses on materials to get a better understanding of their compound and health and environmental impacts.	
Material sub-criteria	Materials and Resources MR Storage and Collection of Recyclables, MR Construction and Demolition Waste Management Planning MR Building Life Cycle Impact Reduction MR Building Product Disclosure and Optimization – Environmental Product Declaration, Sourcing of Raw materials, Material Ingredients MR Construction and Demolition Waste Management
Certification requirement	Third-party verified corporate sustainability reports (CSR)
Certifier	LEED Accredited Professional
Material schemes suggested (voluntary)	Wood products must be certified by the Forest Stewardship Council or USGBC- approved equivalent, Cradle to Cradle, ANSI/BIFMA e3 Furniture Sustainability Standard?
Material database suggested (voluntary)	Data sets must be compliant with ISO 14044, 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

1.1.4 Sustainable building materials and components database

Material databases with detailed information support architects and planners to find sustainable building materials and at the same time help manufacturers to present

their sustainable building materials.
Below, some of these material databases will be presented in a tabular form, including Greenbuildingproducts.eu, WECOBIS, Ecoinvent, Ökobau-dat and Green Spec. The products from the database are preferable materials to be used to get green building certification. Generally, they are online available for free, some with user registration requirement (as in Greenbuil-dingproducts.eu). Some green building certifications follow country specific database (such as Ökobaudat for DGNB and Green Spec for BREEAM), while Greenbuildingpro-ducts.eu includes products that can be used to get the building certified from DGNB and LEED.

Greenbuildingproducts.eu
Description
This is the 1st database for products assessed in terms of LEED and DGNB criteria. Separate database for manufacturer (construction material producer, product manufacturer and framework manufacturer) and database users (Builders, planners and planning offices, construction companies, Accredited DGNB Auditors and LEED Accredited professionals) is provided. It also offers the specific product related assessment declaration with all necessary evaluation results concerning the certification criteria and furnishing of proofs and documentation.
Database for which criteria in Green building certificates
LEED Indoor Environmental Quality: IEQ Credit 4.1 Low Emitting Materials – Adhesives and Sealants, IEQ Credit 4.2 Low Emitting Materials – Paints and Coatings LEED Materials and Resources: MR Credit 4: Recycled Content, MR Credit 5: Regional Materials, MR Credit 6: Rapidly Renewable Materials, MR Credit 7: Certified Wood DGNB Criterion 6 Risks for the local environment:
Online database contains
ID name, Product name, material provider companies, Indoor Environmental Quality (IEQ) (Adhesives, paints and coatings, flooring systems and composite fibre woods) and Materials and Resources (MR) (Recycled content, regional materials, rapidly renewable materials and FSC certified wood). The search result includes: - declaration sheet for specific product, - technical data sheet, - contact information of the manufacturer.
Published by: HOINKA GmbH
Webpage: www.greenbuildingproducts.eu
Access requirement: User registration, free access

WECOBIS
Description
The WECOBIS building material information system provides the holistic ecological selection of building materials by providing product-independent, environmental and health-related data. This information is provided for the life cycle phases of raw materials, production, processing, use and

end of life disposal.
Database for which criteria in Green building certificates
BNB criteria (Risks to the Local Environment – New Construction (BN_1.1.6), Risks to the Local Environment – Refurbishment (BK_1.1.6), Indoor Air Quality (3.1.3) and Dismantling, Separation and Utilization (4.1.4)
Online database contains
Building Products (Construction panels, Flooring, Insulation, Seals, Glue, Wood-based materials, Solid building materials, mortar and screed, surface treatments, and Glazing. Raw materials (Binders, Aggregates, Plastics and Metals)
Published by: The German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)
Webpage: http://www.wecobis.de
Access requirement: Free of charge

Ecoinvent
Description
Ecoinvent lists product databases provided by the Swiss Center for Life Cycle inventories. It holds the world's leading database with consistent and transparent, up-to-date Life Cycle Inventory (LCI) data (current version Ecoinvent version 3). The data is available in the 'ecoSpold2' data format and compatible with most of the Life Cycle Assessment (LCA) and eco-design software tools such as LEGEP Software tool (LEGEP Software GmbH, Germany), GaBi (PE International/ LBP-GaBi, University of Stuttgart, Germany) and Umberto (ifu Hamburg/ ifeu Heidelberg, Germany).
Database for which criteria in Green building certificates
Online database contains
Published by:
Webpage: http://www.ecoinvent.org/database/database.html
Access requirement: Online register for free as a guest (limited access), buy a licence for full access

Ökobaudat
Description
Ökobaudat is a German building material database for assessment of global ecological effects. As a standardized database for ecological evaluations of buildings it is made available by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety to all persons involved in building construction. Building materials, construction and transport processes are described regarding their ecological effects. ÖKOBAUDAT contains both generic datasets and specific environmental declaration datasets from diverse companies or associations. Data published in ÖKOBAUDAT is publicly available at no charge and can be used for life cycle assessment of building components and buildings. The owner of the datasets remains responsible for them (contents, values). The first database was published in 2009 and since then has been updated and expanded regularly.

Until 2016, datasets on more than 700 different building products are provided. Since September 2013, ÖKOBAUDAT has been the first life-cycle analysis database that completely complies with standard DIN EN 15804.
Database for which criteria in Green building certificates
DGNB, Bewertungssystem Nachhaltiges Bauen für Bundesgebäude (BNB)
Online database contains
1. Mineral building products 2. Insulation materials, 3. Wood, 4. Metals, 5. Coverings, 6. Plastics, 7. Components for windows and curtain walls, 8. Building service engineering, and 9. Others The first seven categories include information on production, maintenance and disposal of materials phases. Building service engineering contains further information on the use phase. The "Other" category contains information on for example transport of materials and waste disposal of materials.
Published by: the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety
Webpage: http://www.oekobaudat.de/en

Green Spec
Description
Originally set up in 2003 as a two-year project, in conjunction with the BRE (Building Research Establishment) Green Spec was funded by the UK Government with the purpose to develop information on low environmental impact building materials for architects and specifiers. Since 2006 Green Spec has been run commercially by a small group of industry professionals dedicated to disseminating information about products and building techniques which optimize the practice of Green construction. Green Spec is split into two parts – one part provides design guidance and the other is a directory of PASS (Product Assessment Screening System) endorsed Green building products. Green Spec, a UK based and in conjunction with BRE, is dedicated to disseminating information about sustainable building products and construction techniques. It identifies and endorses sustainable building products, systems and services using the PASS (Product Assessment Screening System) and includes a directory of endorsed products along with supporting environmental and specification data.
Database for which criteria in Green building certificates
BREEAM (Material)?
Online database contains
Green products such as L1 Ground treatment and retention, L2 Complete construction entities and components, L3 Structural space and division products, L4 Access, barrier and circulation products, L5 Coverage, cladding, lining, L6 Construction fabric products, L7 Services, and l8 Fixtures and

fittings
Published by: Green Spec
Webpage: http://www.greenspec.co.uk
Access requirement: Free online available?

Materialdatensammlung für die energetische Altbausanierung, MASEA ("Material Data Collection for Energy Refurbishment"
Description
This materials database contains all the necessary thermal and hygro-thermal characteristics for a wide range of typical as well as historical building materials. The database was created by the Fraunhofer IBP in cooperation with the Institute for building climate control of the Technical University in Dresden and the Centre for Environmentally Conscious Construction in Kassel, supported by the Federal Ministry of Economics and Technology within the framework of the research program EnSan. As there is little information on the building physics properties in existing building the project was started so as to offer relevant information that might be difficult to obtain. This as prediction and calculation is only as good as the knowledge of the existing materials. The information helps to make energy efficient calculations as well as hydro-thermal calculations more accurate, helping to assess energy consumption as well as potential damage risks. The materials chosen are seen as representative of the "historical" building industry in Germany.
Database for which criteria in Green building certificates
Online database contains
The database covers relevant building material information for building physics, a picture showing the building material as well as other relevant information with notes and information on special features. The material information includes: • material density • specific heat capacity • thermal conductivity • diffusion resistance (dry) 23 ° C - 3/50% of • diffusion-equivalent air layer thickness (sd value) • sorption • free water saturation • water absorption coefficient • open porosity The materials database will be continuously expanded and updated with current materials and new building materials. Therefore, both manufacturers of building materials as well as research institutions have a secure online access. The database contains 474 materials.
Published by: Das Fraunhofer-Institut für Bauphysik
Webpage: http://www.masea-ensan.de/
Access requirement: Free online available

1.2 Environmental Product Declaration (EPD)

An Environmental Product Declaration (EPD) communicates the quantified environmental impacts of a product in a standard format. It is based on Life Cycle Assessment (LCA) and common rules known as Product Category Rules (PCR). The latter ensures that EPDs of products of the same functional use category created by different organizations apply the same data scope and metrics. Unlike the various ecolabels presented above, the EPD report does not provide judgement of products, leaving that task to consumers. It looks similar as the nutrient table of food.

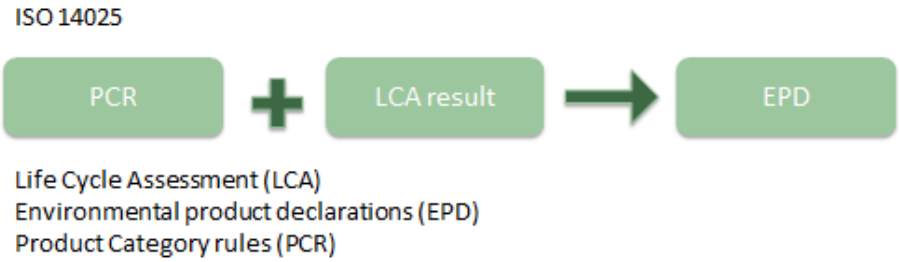


Figure 9: Compound of the Environmental product declarations (EPD).

In 2012, the European Commission published “Sustainability of Construction Work– Environmental Product Declarations – Basic Rules for the Product Category of Building Products” (often shortened to EN 15804). It is a European environmental product declaration of construction norm that ensures that all EPDs for building products, building services, and building processes are derived, verified, and represented in a uniform manner according to through PCR. The aim is to have common format and methodology underlying the environmental indicators of construction products. This standard defines the set of environmental indicators to be used, underlying calculation rules and reporting requirements for an EPD for building products and building related services. It also includes calculating rules of the life cycle inventory and the life cycle impact assessment underlying the EPD. This standard is applicable to construction products, processes and services. The product category rules specify requirements for all construction products for the intended audience (business or consumer) in accordance with ISO 21930 and ISO 14025.

Currently six mandatory impact categories shall be included in an EPD based on EN 15804 :

- Depletion of abiotic resources (elements) in kg Sb equiv. or depletion of abiotic resources (fossil).in MJ
- Global Warming Potential (GWP), in kg CO2 equiv.
- Eutrophication Potential (EP), in kg PO4 equiv.
- Acidification Potential (AP), in kg SO2 equiv.
- Ozone Depletion Potential (ODP), in kg CFC-11 equiv.
- Photochemical Ozone Formation Potential (POFP), in kg ethylene equiv.

Environmental information that is presented in an EPD consists of information

modules, based on which the LCA is conducted. Fig. 3 depicts the LCA structure, where product life cycle is divided in module A to C and recycling is module D.

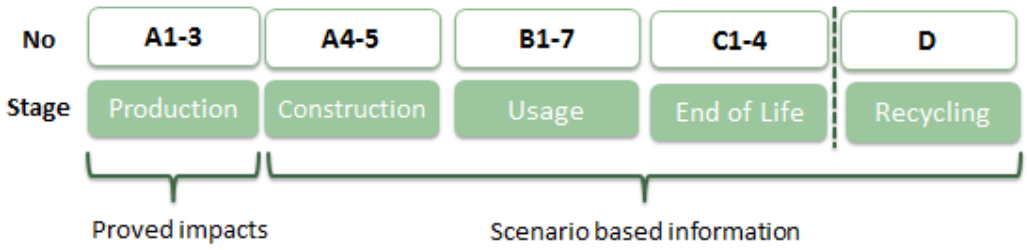


Figure 10: Module-based dissociation of the LCA.

While the production module (A1–3), i.e. cradle-to-gate, is based on existing or historical data, impacts from the downstream stages are assessed based on assumptions (i.e. scenario based information). Thus, the production module (A1–3) is the only mandatory part of the EPD.

Currently, EPD is voluntary. The third party reviews all information given. The procedure to develop an EPD and the requirements on the organisation responsible for each EPD system, the “program operator”, are defined in ISO 14025 (2006).

2. Future-oriented sustainable building materials /components in Europe

This chapter will present different future-oriented sustainable building materials and components in Europe, their energy saving and sustainable potential, and their application examples. The materials and components include insulation materials, windows, Phase Change Materials (PCMs), and Advanced Building Integrated PV (BIPV) systems.

2.1 Insulation

2.1.1 Aerogels

Aerogels are a form of translucent insulation material. Aerogels are materials that are mostly air – usually around 99 % by volume – and can be fabricated from silica, metals and even rubber. They are formed by dehydrating gels and are extremely light because of the resultant porous structure. For example, a cubic metre of silica glass would weigh about 2000 kg. A silica aerogel block of the same dimensions would weigh 20 kg. Despite this, aerogels are relatively strong. Silica aerogels consist of tiny dense silica particles of about 1 nanometre size. Aerogels are excellent insulators, having about one hundredth of the thermal conductivity of glass.
Although their high cost of production has initially limited their application to high end industrial and space applications, they are lately finding commercial applications as building insulation as well (typically in form of blanket insulation). Double glazing that replaced the air gap with an aerogel would improve the insulation value by a factor of three as against the very best current multiple glazing. It would be possible to achieve a 99% vacuum between the panes, since a solid supports them. They are best suited for applications such as skylights etc. where a clear line of sought to the exterior is not required, but only daylight is required. However, even with a thin aerogel sandwich the window would have a slightly frosted appearance. The thermal properties of aerogels also make them ideal for harvesting solar heat: Flat plate solar panels could collect heat and then radiate it back into space.

2.1.2 Vacuum insulation panels

Vacuum Insulation Panels (VIPs) are formed by creating vacuum in the hollow core between two tightly sealed rectangular panels. The walls of the panels are made of rigid, yet highly porous materials such as treated silica, perlite or glass fibre. The entire panel is then enclosed with a barrier film typically made of aluminium metalization. They are mostly used in insulating walls and roofs. Although they offer superior insulation properties compared to all other building insulation materials, their cost and handling still act as barriers to their wide spread application . They are not as

flexible as other insulation materials which can be cut on site into different sizes. They are however, best suited to use in prefabricated wall panels etc.
The following figure compares typical values of different materials used in building insulation.

Table 1: Comparison of insulation values of building materials.

Material	R-Value (mK/W)
Vacuum insulated panels	0.003-0.005
Aerogel	0.014
Extruded Polysterene (XPS)	0.025-0.04
Expanded Polysterene (EPS)	0.3-0.5
Polyurethane	0.02
Fibre glass	0.4-0.6

2.2 Advanced windows and glazing systems

Windows are the least insulating elements of the building shell. At the same time, they represent an important part of the building envelope. There is an optimum design for windows, which attempts to provide a balance between these energy flows. Advanced double or triple layered glazing systems with low-e coatings offer cooling or heating energy savings in the range of 3 % to 10% compared to typical single glazing systems.

2.2.1 Double or triple glazing systems with low-e coating

The thermal performance of windows has improved enormously through the use of multiple glazing layers, low-conductivity gases (argon in particular) between glazing layers, low-emissivity coatings on one or more glazing surfaces and the use of framing materials with much lower conductivity. Operable windows are available with heat flows that have only 25-35% of the heat loss of standard non-coated double-glazed (15-20% of single-glazed) windows (Smith, 2005). In recent years the performance of glazing design has been improved from single glazing with U-value as high as 5.6 W/m²K (undesirable), to triple or even quadruple glazing with special treatment, achieving U-values as low as 0.4 W/m²K (desirable). However, the overall window U-value depends on the window frame and thermal bridging and thus reduces the glazing U-value by a marginal factor in highly insulated frames and by considerable factor in poorly insulated metal or wooden frames. Windows frames most often have the lowest U-Value of a window and can have a large impact on the insulating properties of the window. Window rating systems such as National Fenestration Rating Council (NFRC) rates windows for their performance based on prescribed standards and testing procedures.

Table 2: Typical U-Values of glazing.

Operable windows	U-Value (W/m2K)
Single glazing	5.6
Double glazing	3.0
Triple glazing	2.1
Double glazing with gas infill and coatings	1.1 – 1.6
Triple glazing with gas infill and coatings	0.4 – 0.8

Note: The U-values refer to the glazing only; the overall window U-value will be different depending on the performance of the frame. The frame as the weakest link in window design will lead to an overall lower achievable U-value than the figures shown above; Source: Institute Wohnen und Umwelt & Hessische Energiesparaktion, 2016.

2.2.2 Smart and dynamic windows

Smart or intelligent windows are generally categorized as windows that can dynamically change their characteristics based on the surrounding optical and thermal characteristics. They are divided into two major categories: passive systems which are self-regulating and active systems which can be modulated based on user's needs.

Passive systems

Passive systems react to the natural light or heat stimuli in the immediate surroundings. They are easy to install and to maintain compared to the active systems; However, they lack the user controllability. The following table describes two key passive technologies.

Table 3: Key passive systems for windows technology.

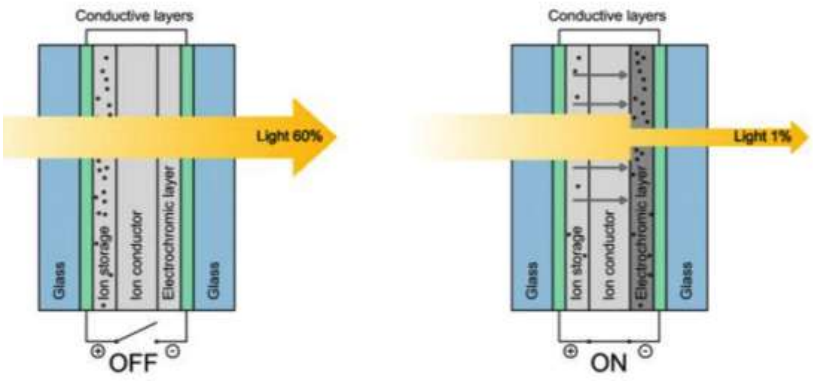
Passive system	Description
Photochromic glazing	This is a property of the window glass. Photochromic glass modulates the transparency based on the incident light intensity. This is due to the presence of organic or inorganic compounds such as metal halides that react to the ultraviolet light or due to the presence of plastics that absorb sun's energy based on the output colour spectrum variation. When subjected to direct solar radiation, the colour intensity of the glass increases in the order of few minutes and gradually reverses in about twice that time. Their application is more prominent in optical and car industry, because high costs, uniform distribution of photochromatic substances and the loss of reversibility over time are major obstacles to their application in buildings.
Thermochromic glazing	Thermochromic glazing is similar to photochromic glazing in terms of modulating the transparency. However, the change is due to the external surface temperature of the glass instead of the external radiation. It is caused either by a chemical radiation or by the inclusion of a phase transition materialconsisting of a wide range of organic and inorganic

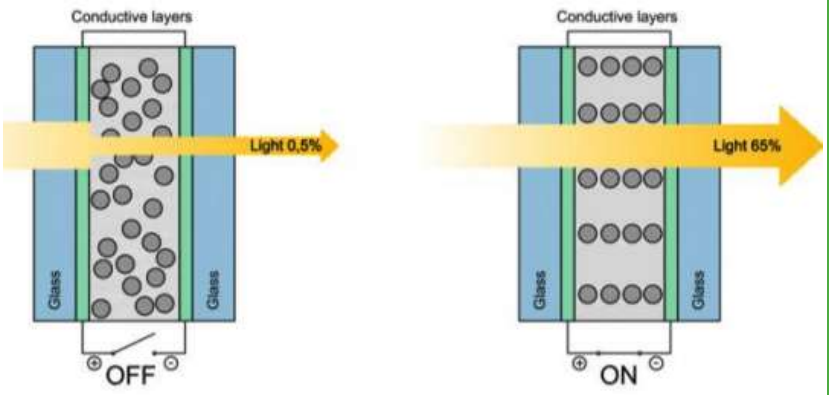
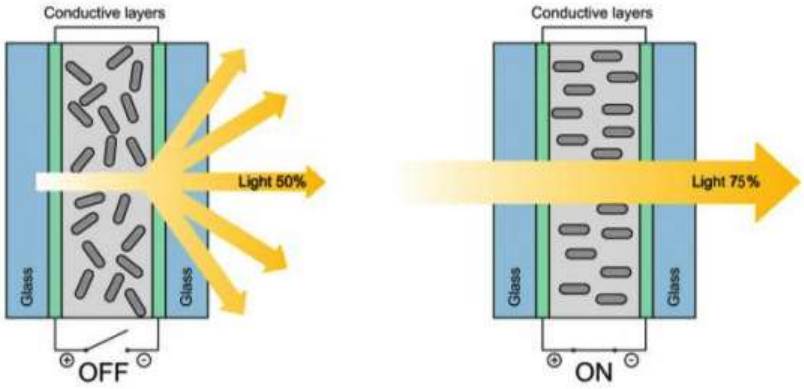
	compounds, and films of metal oxides such as vanadium oxide. The transition is made between 10 °C (maximum transparency) and 65 °C (minimum transparency). Polyvinyl butyral (PVB) is one of the most promising thermocromatic film technologies available in the market. Their application is more prevalent compared to phtochromatic glazing. However, key drawbacks of this technology include lack of user controls, disability to eliminate glare in specific situations of low temperature and high solar radiation.

Active systems

They are similar to passive systems in terms of modulating the optical properties. However, active systems differ as they can be directly controlled by the users or controlled automatically by the integration of a building automating or management system. They can be adjusted using minuscule energy, based on a variety of factors such as internal and external temperature, external radiation, natural lighting levels and user needs etc. The following table describes three key active technologies.

Table 4: Key active systems for windows technology

Electrochromic devices (EC)	Electrochromic devices work on the principle of electrolysis activated by external electrical stimuli. The transparent electrode (electrochormic film) and counter electrode (ion storage) are applied to the inside of glass panels and are separated by an ion conductor (or elctrolyte). When an electrical charge is applied the electron migrates from the ion storage through the conductor and gets deposited on the electrochromic film rendering it in dense colours. When the charge is removed the whole systems becomes transparent again. The advantage of this system is the possibility to be controlled by the user. The light transmission varies between 1% and 60%. The energy required for the transition is minimal at about 1-2-5 W_p/m^2 and requires about 0.4W/m^2 to maintain the desired tinted state.  Figure 11: Electrochimic glazing operation (Casini, 2014, p.277)
Suspended particle devices (SPD)	In SPD technology, a thin laminate of suspended particles is placed between two transparent conductor films. In their natural state, the particles are randomly oriented blocking the light. When a charge is

	applied, the particles orient themselves thereby allowing the light to pass. SPD is capable of blocking 99.4% of visible radiation, while providing a visual tight transmittance in the range of 0.5-65% and SHGC of 0.57-0.06. The system required about 5W/m^2 for switching between states and about 0.55W/m^2 to maintain the desired state.  Figure 12: Suspended particle devices operation. (Casini, 2014, p.278)
Polymer Dispersed Liquid Crystal Device (PDLC)	PLDC operates similar to that of the SPDs. However, instead of a layer of suspended particles, a layer of polymer matrix (PLDC) films is suspended between the two electrical conductors. The liquid crystals in the polymer matrix are randomly oriented in their natural state and align themselves on applying charge. The light transmission is between 50-70 and they require continuously about 5-10 W/m^2 of energy to maintain the desired state.  Figure 13: Polymer dispersed liquid crystals devices operation. (Casini, 2014, p.278)

A choice between different smart technologies is made based on various design and functional aspects such as the range of visible light allowance, ultraviolet high performance, energy consumption in natural and transitions states, tint and colour

requirements, availability and maintenance etc. Commercial glass manufactures such as Guardian, View etc., manufacture a variety of passive and dynamic smart glass systems.

Figure 14: Example of a smart glass technology. Right: more transparent, left: less transparent (Albright, p.17)

2.3 Phase Change Materials

The application of Phase Change Materials (PCMs) in building construction has been an innovative technology. PCMs work on the principle of storage and release of latent heat. PCMs typically store heat during day (or during intense heat periods) and release it during the night (or less intense heat periods), changing from solid phase to liquid phase and vice versa. The heat required for this process is known as latent heat. This latent heat absorption helps in absorbing significant amount of heat without raising the ambient temperature. The following figure shows an example of the application of a BioPCM. Enthalpy is shown on the y-axis and temperature on x-axis. As it can be seen, the rise in enthalpy is used up in the phase change without an increase in the temperature.

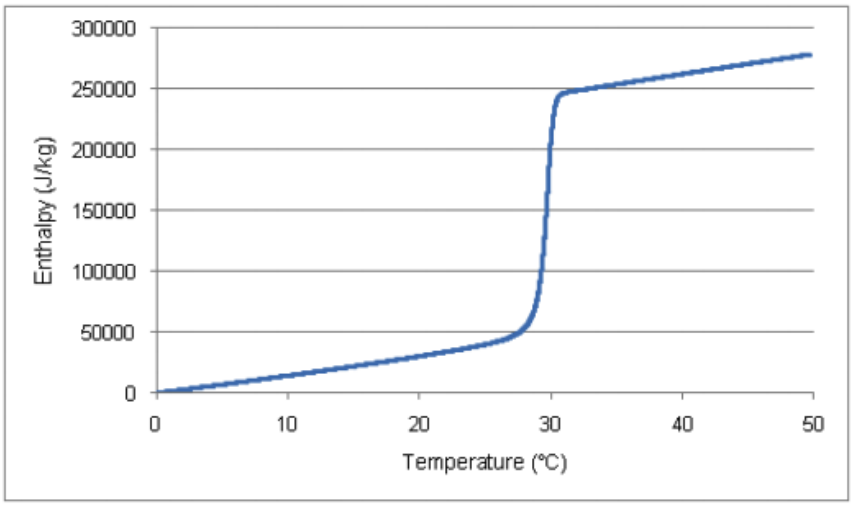


Figure 15: Enthalpy Profile of the BioPCM. (Muruganantham, 2010, p.15)

PCMs are made up of different organic, inorganic materials and also derived from agricultural sources products. For building applications, organic PCMs such as heptadecane (phase change temperature 21 °C), dodecanol (phase change temperature 24 °C), octadecane (phase change temperature 29 °C) and dodecanol (phase change temperature 24 °C) are used. PCMs could reduce the building's peak cooling loads by approximately 11% and annual cooling load by approximately 9%. Inorganic PCMs are usually salt hydrates of inorganic salts containing one or more water molecules. Some examples are $CaCl_2.6H_2O$, $LiNO_3.3H_20$ etc. They are nontoxic, non-combustible and less corrosive compared to organic PCMs. They have melting points in the range of 5 °C to 130 °C and are suitable for a range of building related applications. PCMs are capable of saving cooling energy in the range of 9-25% depending on the enthalpy of the PCMs, the PCM loading and PCM location. Biobased PCMs are typically hydrogenated hydrocarbons from various plant and animal based products such as oils from palm, coconuts and soybeans and animal fat such as beef tallow etc. They are chemically stable, they offer higher fire-resistance compared to organic PCMs and can last for decades.

The PCMs are packaged in pouches, plates, balls etc. depending on their area of application. They can either be flat or tubular in shape. PCMs are integrated into buildings as extended layers on walls and roofs, or can be added in the interiors on to the ceilings and floors. PCMs can also be integrated with materials (mixed within the material): insulation materials such as fibreglass insulation, finishing materials such as plasters and also with interior partition and ceiling systems such as gypsum board etc. The advantage of PCM technology is that they can be added to existing buildings as sheets, blocks, and layers with minimum invasion in the structure. The choice of the PCM material and application depends on factors such as usage, space design, temperature profile of the space and PCM material, and fire rating etc. The following figures show different applications of PCMs in buildings.

Figure 16: Passive working delta cool ceiling panels containing inorganic PCM (Kośny, 2015, p.41).

Figure 17: Installation of the active-chilled ceiling system containing PCM-enhanced plaster and plastic micro-tubing (Fraunhofer ISE, Germany). (Kośny, 2015, p.43).

Figure 18: Construction details of a roof assembly containing, reflective insulation, and subventing air channels, followed with two PCM insulation systems produced by Outlast, USA. (Kośny, 2015, p.46).

Figure 19: Experimental attic module containing microencapsulated PCM blended with cellulose insulation, ORNL, USA, testing facility. (Kośny, 2015, p.48).

Figure 20: Installation of the test wall containing PCM-enhanced fibreglass insulation. (Kośny, 2015, p.37).

Left side presents wall cavity instrumentation with array of thermocouples installed across the wall cavity. Right side Cavity finish task, after blowing in fibreglass

Figure 21: Installed BioPCM Mat in the Ceiling. (Muruganantham, 2010, p.16)

2.4 Advanced Building Integrated PV (BIPV) systems

Modern PV systems offer customization to be integrated into building façade as an external finish. Building elements such as shading devices like fixed shades and louvers could be replaced with PV panels to serve dual purpose of shading and

energy generation. Sunspaces and sky roofs can be replaced with modern transparent/translucent PV panels instead of plain glass.
Two main aspects of Solar Photovoltaics in current and future building integration would be the panel technology and mounting technology. The efficiency of the panel technology lies in the transparency levels that can be achieved while producing the maximum energy possible. Mounting technology should enable smooth integration into the building and at the same time allow for smooth operation and maintenance. Mouting the PV glazing systems can be done using the regular architectural glass mounting technologies such as linear mouting (mullion and transom facades, and structural glazing systems) or point fixing systems such as spandrel glazing systems. However, the installation required proprietary technology based on the PV glass panel to interconnect the panels with each other and with the balance of systems such as inverters, storage and distribution systems.

2.4.1 Panel technology improvements for transparent panels

Commercial organizations such as Polysoalr, Onyxsolar etc. offer proprietary technology based on transparent solar photovoltaic glass technologies (typically a transparency of up to 40% can be achieved). They can be customized for their transparency, thickness, color and size. Transparency is typically achieved by encapsulating the photovoltaic cell in an encapsulation material and then sandwiching it between two layers of glass. The cells are spaced depending on the transparency that needs to be achieved. Although technically these are not clear glass photovoltaic systems, the future generation polymer solar cells could be designed to capture light in visible and non-visible spectrum to create actual transparent PV glass. Color tint could also be added to these modules by using color glass or by applying coatings, although it comes at some expense of the efficiency.

Figure 22: Example of BIPV, PV panels as canopies. (Polysolar Limited, 2015, p.19)

An EU-funded project called B-first (fibre reinforced solar technology) focuses on "development and demonstration of a set of standardized multifunctional photovoltaic products for building integration based on a recently developed technology for solar cells encapsulation within glass fibre-reinforced composite materials".

Some of the key objectives of the programme are:

- Design and development of BIPV products based on composite materials, yet at par with the efficiency levels of traditional modules.
- Increasing light transmission properties
- Demonstration of these innovative BIPV products
- Development of product catalogues and datasheets

Products that have been developed during the course of the project are integration of BIPV in:

- Ventilated façade
- Roof shingle
- Curtan wall
- Skylight
- Shading elements

A demonstration building has also been erected under B-first programme using advanced photovoltaic triple glazing system curtain wall based on fibre reinforced composite materials developed within the project. A total of 10 PV modules will be installed covering an area of approximately 18m^2, with a total power of 1.28kWp and generating an estimated annual energy of 1,229 kWh/year.

Figure 23: Demonstration building from B-first programme. (BFIRST-FP7)

Advanced BIPV is another EU funded project aimed to increase the architectural

application of photovoltaic panel in buildings with a concept, more glass, more transparency and more complex geometries. One of the work package involves developing a BIPV vision glass of high quality and stable photovoltaic performance showing light transmission (LT) as high as 50%. This project is also linked with the Small and Medium-sized Enterprises instrument for promoting the manufacturing of the developed technologies.
Typical applications of such transparent PV glass in atria glazing systems, corridor glazing, staircase glazing systems, double glazed facades, roofing, canopy roofs, green houses etc. where high level of visual light transmittance (VLT) (>50%) is not required. They can also be used in window systems where high VLT is not required.

Figure 24: Example of transparent PV glass application. (Sapa Solar)

Living Tomorrow Brussels, Belgium. PV panels in atrium. 33 see through panels each with a rated power of 136W_p have been used in the project along with 14 opaque panels with a rated power of 100 W_p each.

2.4.2 Panel technology improvements for opaque panels

Instead of mounting photovoltaic panels on building envelope, it offers both economic and convenience in construction when the building components are integrated with photovoltaic cells. PV panels can be typically integrated into building cladding systems, roofing systems etc.
Construct-PV is a European Commission funded project with an objective to develop and demonstrate customizable, efficient and low cost BIPV for opaque surface of buildings with partnership in research and industry.

Two pilot projects are being undertaken in this initiative. One project is integrating PV into façade cladding systems as planned in Züblin campus in Stuttgart.

Figure 25: Integrated PV into façade cladding systems in Stuttgart – model. (Construct PV)

Another example of the Construct-PV are BIPV roof shingle modules for school buildings of Mining and Metallurgical Engineering, which arelocated in Zografou campus of the National Technical University of Athens (NTUA).

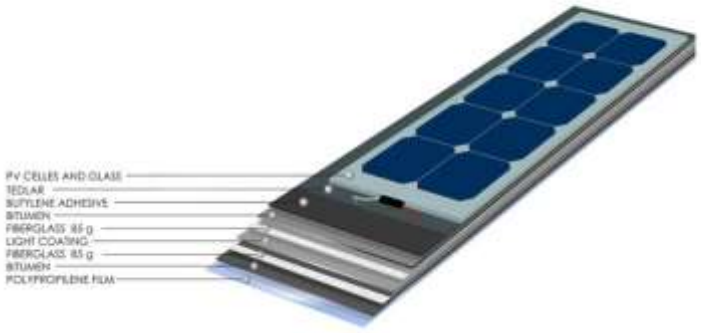


Figure 26: BIPV roof shingle modules in Athens. (Fraunhofer ISE)

Key objectives of the project is to replace typical shingles with PV shingle modules ensuring leak-tightness and other physical characteristics that a can be achieved by using a typical shingle. The PV shingle modules used glass-glass modules containing high-efficient crystalline heterojunction solar cells and are electrically connected using many thin wires in “smart wire” technology making them invisible from a distance.

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