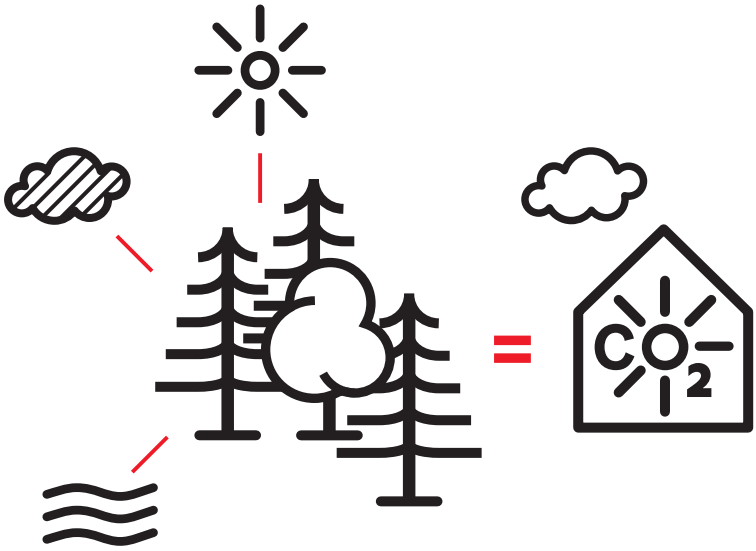

Building with wood = The active form of climate protection

Holzforschung München
Technische Universität München

Forests = Habitat,
stable ecosystem and a renewable
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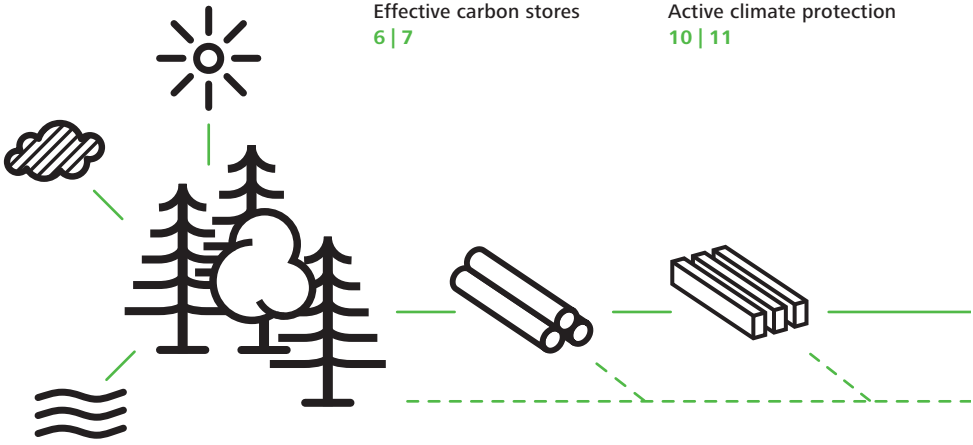
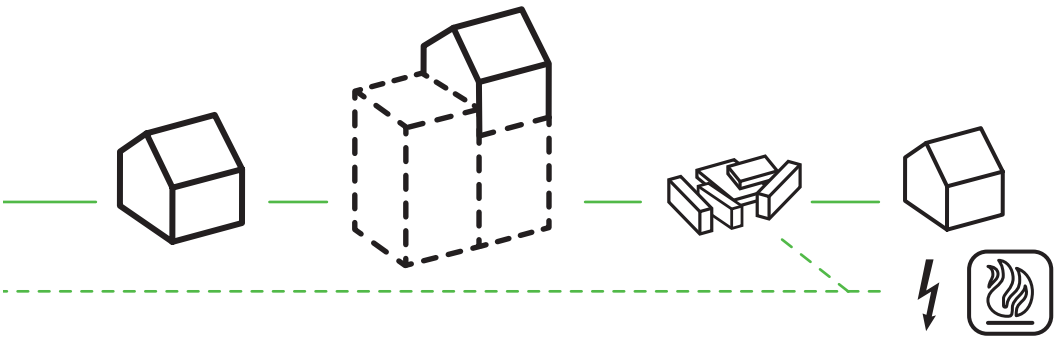


A guide

HFM
Holzforschung München, Center of Life and Food Sciences Weihenstephan
Technische Universität München

With the collaboration of
Faculty of Architecture, Department of Timber Construction, TUM
Faculty of Civil Engineering and Surveying,
Chair for Timber Structures and Building Construction, TUM
Landesinnungsverband des Bayerischen Zimmererhandwerks
LEGEP Software GmbH
Lichtblau Architekten BDA, a member of the Association of German Architects



Foreword

The Bavarian Climate Programme 2020 contains ambitious targets for building on Bavaria's leading position and pioneering role within Germany and, more widely, Europe when it comes to climate protection measures.

In this context, the sustainable and, at the same time, energy and carbon-efficient use of raw materials and products in the construction industry is a critical issue, which has led to wood and timber materials consistently being used more and more. This is due to the fact that these building materials, with their positive energy and carbon balances, have unique qualities to offer, not only throughout their life-cycle, from the forest to product manufacture and use, but also in terms of the available options for recycling materials or energy.

This brochure presents these complex climate protection qualities and the effects they can have both now and in the future in a concise and comprehensible format. It also aims to make builders, planners, architects and decision-makers from the fields of politics and local government aware of the opportunities afforded by building with wood at both a structural and a design level when modernising and densifying, particularly when it comes to public building projects and the urban environment. Finally, added value effects relating to the economy as a whole, achieved via the social role played by forests, the regional availability of the raw materials and the safeguarding of jobs in rural areas, for example, allow bold strides to be made regarding policies aiming to increase the number of buildings being constructed from wood. The result is that efforts to create spaces to live that are fit for the future actually become an active form of climate protection.

Forests = Habitat, stable ecosystem and a renewable source of raw materials

Sustainable forestry measures safeguard the forest ecosystem. And what's more, it stays stable! The regulated management of forests preserves their variety, since only the amount of wood that will regrow during a given period is actually used during that space of time. This ensures that Germany's forests will remain stable, which is extremely important, not least in the context of climate change. Without a system of forestry management, other, more unstable forests would develop. And that would have a negative impact on the myriad demands society makes of wood in terms of the way it is used and the functions that it carries out. Already, around 70 per cent of Germany's forest area is certified, meaning it is managed in harmony with nature. The global figure is approximately 13 per cent (PEFC and FSC).

- Around 200,000 people employed in the forestry and timber industries
- High standards of training
- Over 700,000 forest owners, including over 1,800 local authorities
- In 2008, one million people with an interest in forests took part in forest education, timber marketing and other information events
- 60 % of 30 to 40-year-olds go to forests to relax

Forests in Bavaria — Growth of around 31 million solid cubic metres/year (21 million solid cubic metres in use)

Tree species in our forests

Alder, black alder, common alder, green alder, grey alder, mountain alder. **Apple tree**, crab apple, domestic ap
Cherry tree, mazzard cherry, wild cherry. **Common hornbeam**, European hornbeam. **Common walnut**. C
elm. **Fir**, European fir, noble fir, silver fir. **Horse chestnut**. **Larch**, European larch. **Lime tree**, European li
chequer tree, rowan tree, wild service tree. **Oak**, durmast oak, English oak, pedunculate oak, red oak, sessile oa
poplar, European aspen, trembling poplar, white poplar. **Robinia**, false acacia, locust tree. **Spruce**, Norway sp
Yew, English yew.

Augsburg is the largest municipal forest owner in Bavaria, being responsible for 7500 hectares – an area the size of Lake Chiemsee. Our forests, which are situated not far from the city itself, have been safeguarding the quality of our drinking water and providing a popular recreation area for centuries now. They are producing a material which will be available to our community and to the wood-processing industries and trades for the long term – and which has an ongoing role to play in the region's circular economy.
Hartmut Dauner, Director of Forests

The forest is a manufacturer of wood. But as well as producing timber, it also fulfils other functions, providing a diverse habitat and conditions that make human, animal and plant life possible:

- Soil, wind, erosion and avalanche protection
- Regional climate control in high density areas, but also on a global level
- Air pollution control – acts as a filter (immission control, noise control)
- Safeguarding of drinking water reservoirs
- Habitat and a place to retreat for many species of animal and plant in biotopes (Natura 2000 areas, nature reserves, natural forest protection areas, national parks)
- Forests as areas of recreation

– of which 10 million remain in forests
Total forest reserves of approximately 1,000 million solid cubic metres

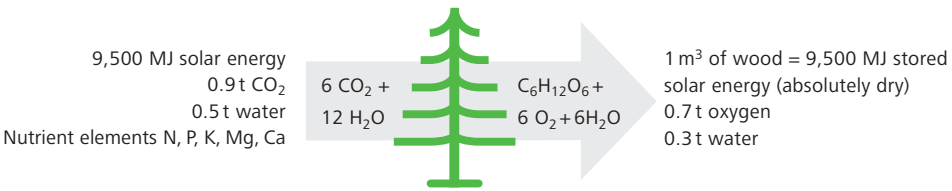
ic apple. **Ash**, common ash, flowering ash. **Beech**, copper beach, European beech. **Birch**, downy birch, silver birch.
t. **Common whitebeam**. **Douglas fir**. **Elm**, English elm, European white elm, field elm, wych elm, fluttering elm, spreading
n lime, large-leaved lime, small-leaved lime. **Maple**, field maple, hedge maple, Norway maple, sycamore. **Mountain ash**,
le oak. **Pear tree**. **Pine**, arolla pine, European black pine, Scots pine, Swiss pine, Weymouth pine. **Plum tree**. **Poplar**, aspen, black
y spruce. **Sweet chestnut**, European chestnut. **Thuja**, arbor vitae. **Willow**, goat willow, osier, purple willow, white willow.

Forests and wood = Effective carbon stores

The sustainable use of wood restricts the rise in CO_2 levels in the earth's atmosphere, thus acting as a brake on the greenhouse effect. Trees absorb CO_2 and store it within their wood for a long period of time as biogenic carbon. Every trunk used creates space for new trees and increases the amount of carbon (C) storage available in the wood. If wood is not used, as in an unutilised forest, for example, the stored carbon is released unused back into the atmosphere in the form of CO_2 when trees decompose.

CO_2 emissions in tons, primarily from fossil fuel sources

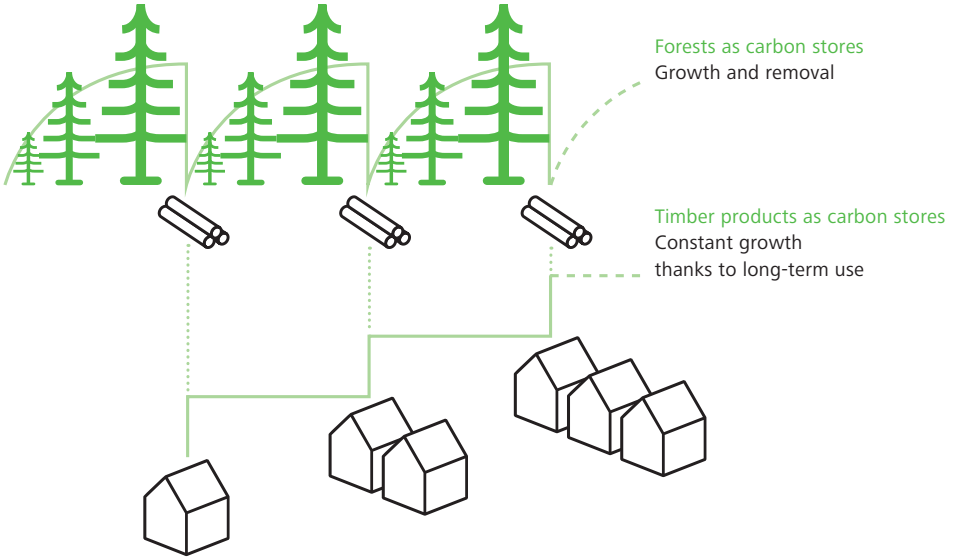
Driving a car for a year	1.5 t CO_2
A return flight from Munich to New York	1.5 t CO_2
Power consumed by a 3-person household (4,100 kWh/year)	2.5 t CO_2
Oil heating (2,000 litres/year)	5.6 t CO_2



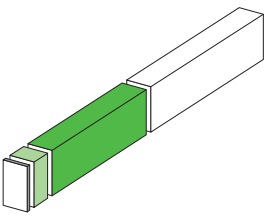
1 m³ of wood absorbs
almost 1 ton of CO_2 as carbon

1.000 million tons of CO_2 emissions/year
in Germany from fossil fuels

Many nature-lovers protest against every tree we cut down here, although doing so creates space for younger trees. I have to do a great deal of work explaining these issues, because the widespread assumption amongst the general population is that the best forest is one that is left to its own devices. That may sometimes be the case as far as species conservation is concerned, but the exact opposite is true when it comes to climate protection, where the best thing to do is to preserve the forest whilst harvesting and using as much wood as possible at the same time. This enables houses and furniture to be built and paper to be produced, with the wood retaining the carbon it has absorbed and not releasing it back into the atmosphere over a long period of time.
Jens Meier, District Forest Official



1 m³ of wood contains
(absolutely dry)



250 kg carbon (≅ 0.9 t CO_2)
215 kg oxygen
30 kg hydrogen
5 kg other elements

27 million tons of CO_2 are fixed each year by the annual forest growth in Bavaria

14 million tons of CO_2 are fixed each year through the use of timber products manufactured from this forest growth

Wood = Stored solar energy

More energy is contained within timber products than the amount of energy needed to actually manufacture them. Take a glued laminated timber beam (glulam), for example. The process of cutting and drying the raw material, then manufacturing the glulam, consumes less energy than that which has been previously absorbed into the product. And what's more, it is possible to gain access to the energy contained in the excess cut-offs (residual timber) and in the product itself, once it reaches the end of its life-cycle, by burning them in a climate-neutral manner. You see, products made from wood are not called "positive energy products" for nothing.

Only a fraction of the energy contained in wood and timber products is consumed in transporting them from their region of origin.

The energy required to manufacture timber products is only ever half as much as that contained within them, at the very most.

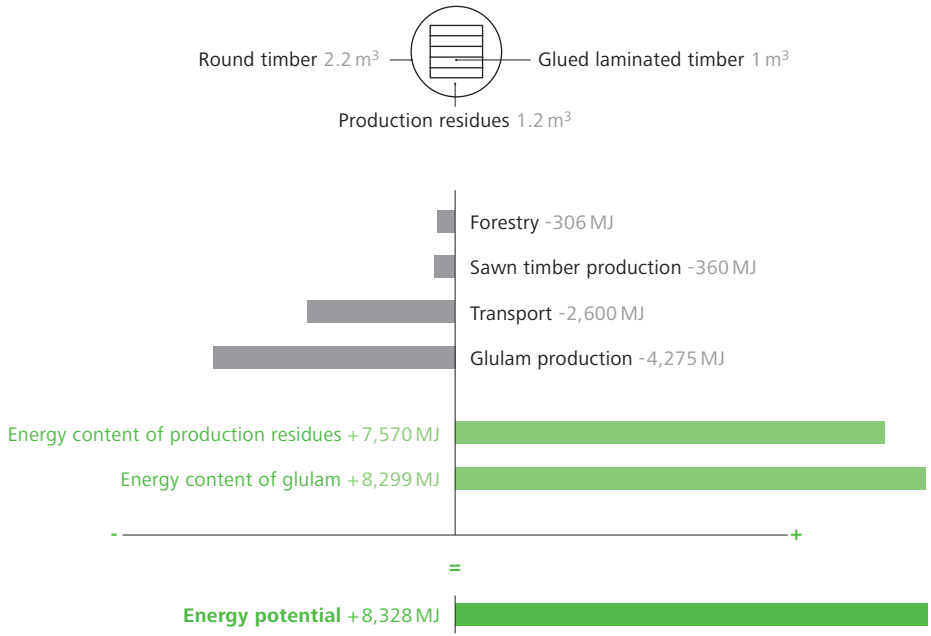
Over half of the solar energy stored in the wood is retained throughout the product's life-cycle and can be obtained once more, with no losses, and used in the form of thermal energy or electricity once the end of the life-cycle is reached.

Compared to products made from less climate-friendly materials, timber products contain exceptionally little embodied energy. This is the energy used throughout a product's entire life-cycle, including manufacture, transport, use and disposal.

The energy stored in a modern timber house would be sufficient to provide a house that meets the latest insulation standards with heat for half a century.

The most beneficial source of energy is energy which is not used. After all, buildings and materials that consume a lot of energy during production have a considerable negative impact on the atmosphere and on a building's life-cycle assessment. If these building materials are replaced by more environmentally-friendly alternatives, this reduces the consumption of embodied energy, as well as CO_2 emissions. Modern timber building materials have enormous potential for being used as substitute products in this regard, a fact which is reflected in their environmental key figures.
Holger König, Architect and Consultant on Life-Cycle Assessments

Positive energy balance Producing 1 m³ of glued laminated timber results in a useful energy potential of 8,328 MJ.



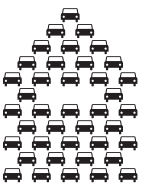
The energy contained in 1 m³ of glulam equates to the amount of energy required to light a detached house for 4 and a half years.

Building with wood = Active climate protection

50 % of all the raw materials used in Germany go into constructing and running buildings. They are responsible for 60 % of all waste materials. Particular attention must be paid to evaluating not only the technical suitability of the raw materials concerned, but also their environmental characteristics. The benefits of energy-efficient buildings are already apparent, due to the low amounts of heating energy they consume. But that does not go far enough. Buildings that are fit for the future must also be constructed from materials which do not require much energy when used to erect, refurbish, convert and demolish buildings. In this way, CO_2 emissions can be reduced not only during the time in which the building is in use, but also throughout the entire product life-cycle. Using wood in the supporting structure too has the greatest effect in terms of climate protection, not least because it replaces building materials which consume a lot of energy during manufacture.

44 % of citizens support the use of wood as the primary construction material for new public buildings. It is already the case that no building is built without wood, whether it is in the supporting structure, on the surface as a decorative feature, for the interior finish or as formwork boards – wood is everywhere.

Effects	Wood as a building material
C storage effect	+
CO_2 prevention effect due to substitution	+
Heating energy/CO_2 savings thanks to insulation	+
Energy gain at the end of the life-cycle	+

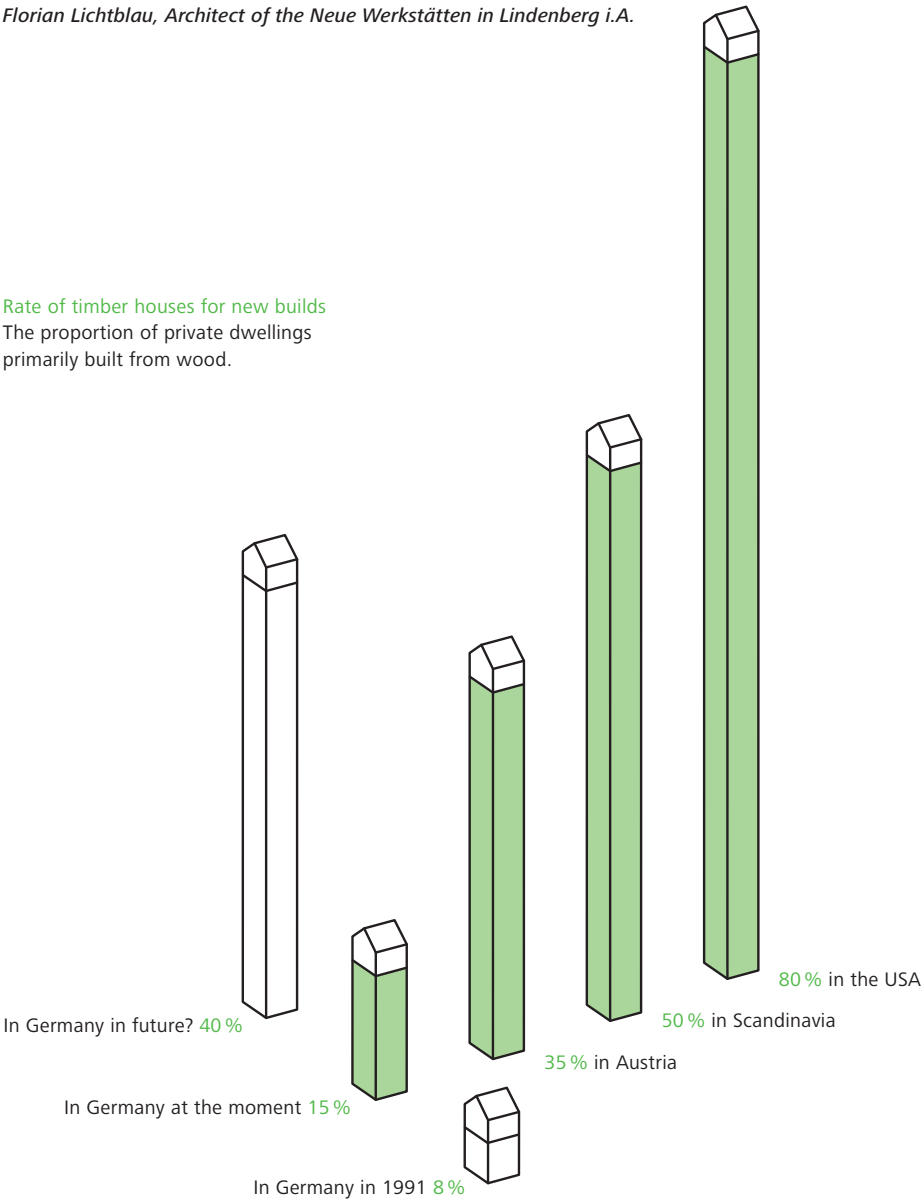


A modern car emits around 1.5 tons of CO_2 per year*.
A modern detached timber house contains as much CO_2
as would be emitted over the course of 40 years of driving a car.

* EU guide value: 120 g CO_2/Km; annual mileage of a car: 11400 Km

Wood is a high-performance material with outstanding technical properties and long-term beneficial effects in terms of both energy and carbon. It stands for innovative, flexible, high-quality and efficient construction. When someone builds a timber house, he cancels out his entire CO_2 balance for the next eight years.
Florian Lichtblau, Architect of the Neue Werkstätten in Lindenberg i.A.

Rate of timber houses for new builds
The proportion of private dwellings primarily built from wood.



An appropriate combination of materials
Even increasing the proportion of wood used in each building is an active form of climate protection.

Modernising and urban densification with wood = A second chance for climate protection

The challenges of the future affect everyone: Over the next few years, almost 30 million residences will need to be renovated in Germany. That equates to around 75 % of all residential buildings, most of which were constructed before 1985. Practically every single one needs to be improved in terms of the way it uses energy. The building methods of the past are also putting pressure on local authorities, whose schools, public halls and administration buildings cost an enormous amount of money to run. If the costs are compared over the long term, it often makes more sense to refurbish a building than to keep running it in its current state. But it does depend on how this refurbishment work is carried out. Prefabricated, highly-insulated timber elements, which can be installed on site in next to no time, represent an alternative to standard systems of modernisation that is fit for the future and meets all the requirements of a modern building. The corresponding energy balance really shows the benefits of using wood as a building material.

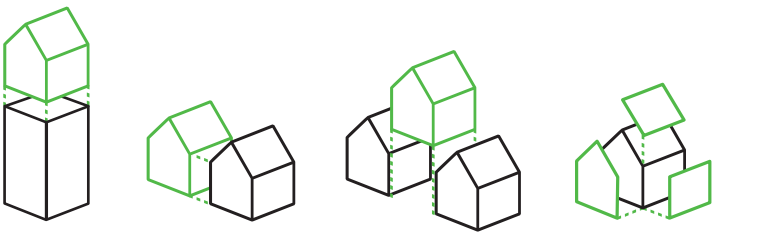
Carbon storage
Increasing the use of wood raises the amount of carbon storage available in the long term and has a direct positive effect on the climate.

Lightweight
Wood is particularly well suited to adding storeys to existing buildings, since its low gross density (for coniferous wood, around 450 kg/m³) means there is often no need to reinforce the supporting framework of the primary structure.

Natural insulation
Due to its low thermal conductivity of just approximately 0.13 W/mK, wood really lends itself to the creation of designs without thermal bridges and the construction of a highly-insulated building envelope. As such, it is logical that many passive houses are built from wood and feature timber-based insulating materials.

By modernising the building envelope of the Realschule Buchloe school with prefabricated timber construction systems, we were able to reduce the building's annual energy requirements by 80 %. In addition, the wood now integrated into the school contains 160 tons of CO_2, which would be damaging to the environment if released. The short construction period was also absolutely fantastic: The prefabricated timber façade elements were attached during the long school holidays, in just six weeks. So there was no need for contingency plans as to where to teach the just under 900 pupils. With this project we were seeking to break new ground in timber construction and climate protection and to provide a template for others across the administrative district to follow.
Johann Fleschhut, Ostallgäu District Commissioner

Innovative timber construction systems really impress by the flexible way they can be combined with other materials and are the perfect way to extend and add storeys to existing buildings. Prefabricated timber elements that use dry mortarless construction are lightweight building materials and are particularly well suited to buildings which could not support heavy extensions and loads, for example. So existing buildings can be retained or even extended in a cost-effective manner, without any need for demolition and rebuilding work.



Adding storeys | Extending | Filling a gap | Adding an envelope

Intelligent timber engineering solutions for modernising and urban densification

More space
Walls made of timber are not as thick as conventional ones. Up to 10 % more living space can be achieved and marketed with wooden walls than solid ones for the same size floor area.

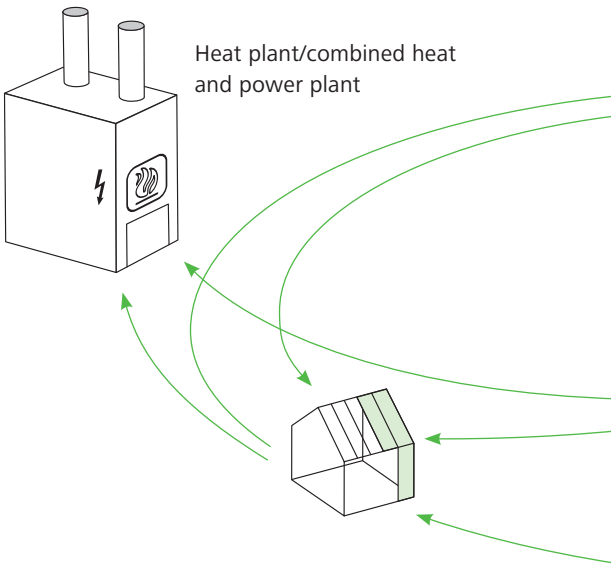
Fire protection
The point at which built-in wood will be destroyed during a fire can be calculated exactly, which is a highly-prized advantage over other building materials (burn rate of 0.7 mm/min). So modern timber houses even score highly when it comes to insurance premiums.

Durability
Wood protection measures implemented by design mean that timber is a durable material even without the use of chemicals (DIN 68 800-2). Many modern timber houses and historic half-timbered buildings are testament to this.

Good internal climate
Thanks to its ability to regulate damp, wood creates a healthy living environment. And with its warm, natural appearance and the sheer variety on offer in terms of both look and feel, wood really speaks to the senses.

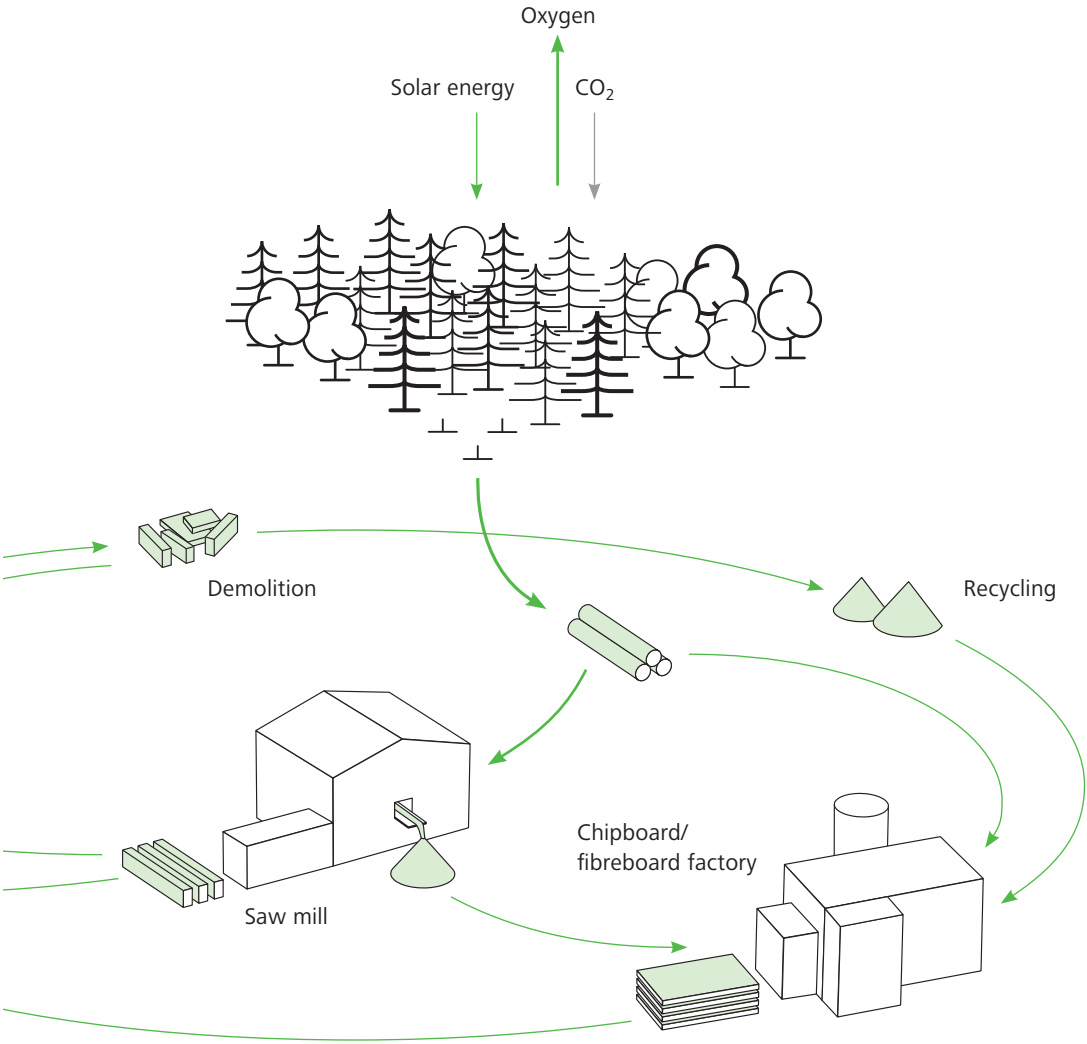
Wood as a cycle product
= Conserves resources, recyclable, energy-efficient

Unlike building materials obtained from non-renewable raw materials, timber ones conserve resources and participate in the circular economy throughout their entire period of use. Once they are no longer needed for their original purpose they can form the basis for other products and at the very end of their life-cycle they become a source of energy. Many other different products are associated with problems in terms of disposal or consume a lot of energy during the recycling process. The possibilities for and barriers to further processing are defined at an early stage of any project, in the concept and design documentation.



Paper can be recycled up to six times, incorporated as an insulating material for the long term or used to provide heat.

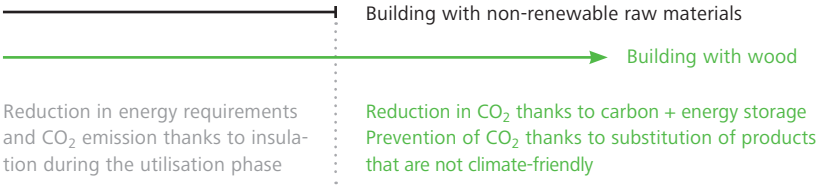
Wood is the ideal circular economy material. Timber products can be used and recycled time and time again. For example, after 30 years of use, a beam can be turned into chipboard. And once the chipboard has reached the end of its life-cycle, the energy stored within it can be obtained once more.
Martin Fink, (MdL a.D.) former Member of the Bavarian State Parliament



Timber building projects = Climate protection projects

Today's generation is responsible for the future of those coming up behind it. More and more people are calling for environmentally-friendly construction methods to be used, both in the private and the public sector. The onus is really on local authorities in this regard, since the way in which they act today will leave its mark on town and cityscapes and on local energy balances for decades to come. Town planners and approving authorities are now in a position to create incentives for sustainable construction and to make the use of wood as a building material mandatory. If you want to build in a way that will not damage the environment, you will need to strike a balance at an early stage. What will the building's impact be on an environmental and economic level throughout its entire life-cycle? Even before the planning stage starts, attention must be paid to the following:

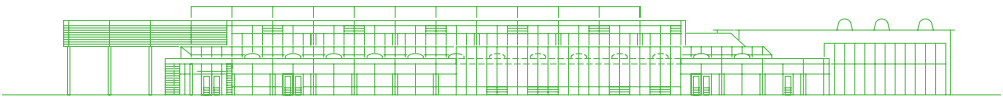
- Preferred use of regional raw and building materials, and those which are typical of the local area, as well as of construction products with a low primary energy demand
- Tendering process and presentation of environmental data relating to the construction materials that is appropriate for the materials in question
- Consideration of the capacity of the building products to store energy and carbon
- Quality of the project in terms of design
- Assessment of the building's economic and social impact, including on future users
- Evidence of the overall costs throughout the life-cycle, not just construction costs



Timber buildings are fit for the future in so many ways, not just because they reduce energy requirements during the utilisation phase.

Lebenshilfe Lindenberg i.A.

The "Neuen Werkstätten für behinderte Menschen" ("New workshops for disabled people") building in Lindenberg im Allgäu, which was completed in 2005, is playing its part in protecting the climate by using wood as a construction material. Right from the planning stage, the pros and cons of two different options were considered from an environmental and economic point of view: a solar timber construction meeting the Low-Energy Standard and a traditional solid construction meeting the standards of the 2002 Energy Saving Ordinance. The entire life-cycle was looked at during these considerations, from construction to maintenance and repair, right through to demolition. On balance, a timber design came out on top, despite the 6 % higher construction costs involved, as it demonstrated better overall efficiency due to the fact it requires less energy to run – and that was even without taking any increases in energy prices into account. At the start of construction, it was predicted that it would take 14 years to make back the additional upfront investment costs; but in reality it is now clear that this period will actually be much shorter than that forecast. Other important advantages of the timber design: a drastically reduced primary energy demand including carbon storage during manufacture and a shortening of the time needed to build the shell construction, in this case to just three and a half months, due to the fact that the modular timber structure could be prefabricated at the factory. The timber construction design used saves 117 tons of CO_2 being released into the atmosphere every year, in comparison to the reference design contained in the Energy Saving Ordinance. And one more thing: The operator Lebenshilfe, the disabled users of the building themselves and their carers are unanimous in their praise for their new timber home – their enthusiasm is infectious to the many curious and interested visitors to the building.



Local authorities pursue climate protection policies and create long-term CO_2 storage:

350 kg CO_2/m² = 1,800 t

Lebenshilfe Lindenberg i.A.
lichtblau architekten bda

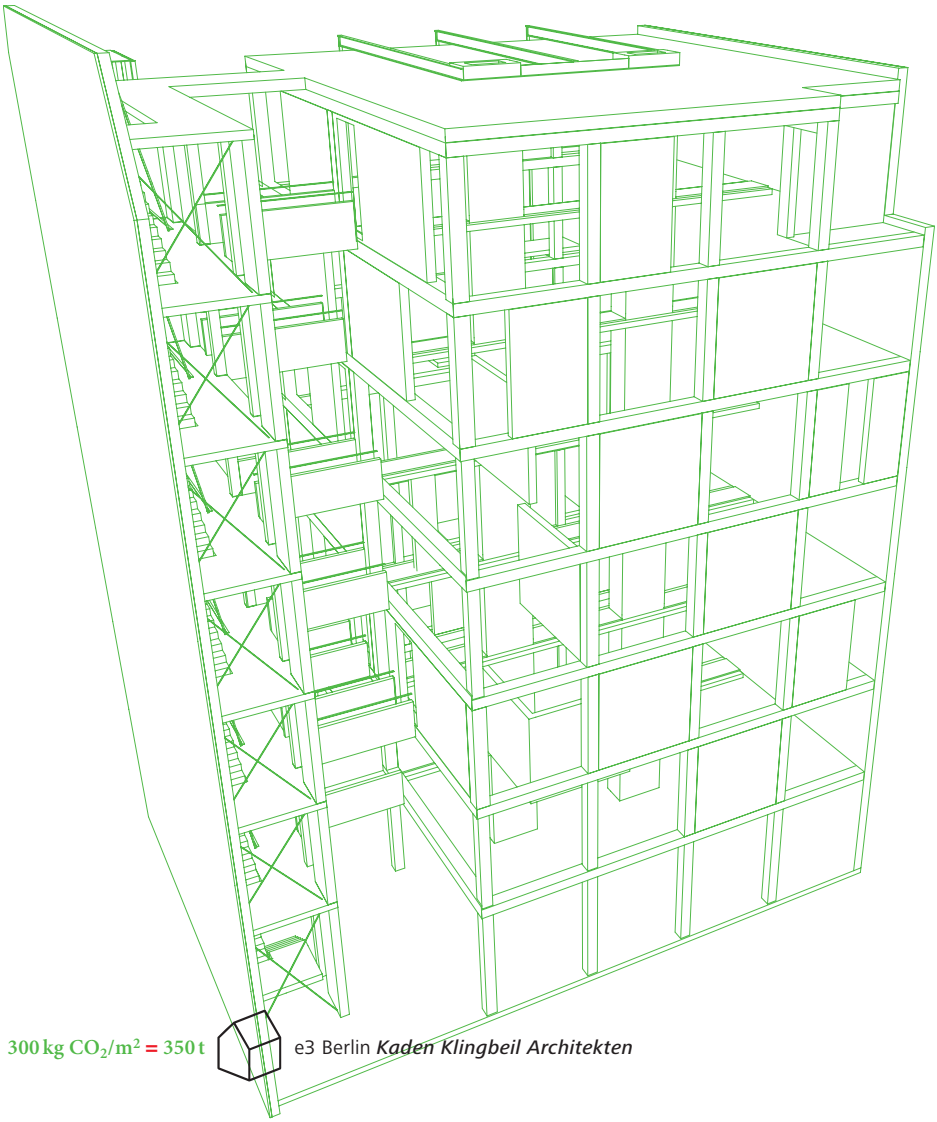
Samer Mösl

60 attractive apartments, providing homes for 200 residents and arranged across three storeys, are to be found in buildings made entirely of wood in Salzburg's "Samer Mösl" housing area. The project's stringent requirements in terms of sustainability, ecology and construction methods that save resources restricted the use of concrete to the foundations and staircase carcasses only. The rest was made of wood. Even the walls, which had to be designed to be fire-resistant, were constructed using nogging pieces, which store CO_2. The ceilings consist of cross-layered wooden panels. After a construction period of just 10 months, the operator, "Heimat Österreich", celebrated its position as the innovative and forward-looking builder of Austria's largest multi-storey passive house housing area using timber construction.

300 kg CO_2/m² = 1,800 t Samer Mösl ***sps-architekten zt gmbh***

e3 Berlin

Timber construction in the metropolis. The pioneering timber building located at Esmarchstrasse 3 is so much more than just another urban edifice. Here is wood in the middle of the city, invisibly enclosed in the supporting structure. The associated concrete stair tower provides access to the apartments via suspended walkways. The high degree of prefabrication of the wooden supports and the ceilings made from a composite timber and concrete material enabled planning and construction times to be kept short, as well as guaranteeing reasonable gross costs per square metre of between € 1,900 and € 2,400. Since the day it was completed, the building has been something of a place of interest in the Prenzlauer Berg area, a district known for its Wilhelminian style of architecture. And it has also earned a reputation as a forward-looking project. The numerous enquiries received from potential builders only go to prove this point.



300 kg CO_2/m² = 350 t e3 Berlin *Kaden Klingbeil Architekten*

Building with wood = Long-term positive effects

Building with wood is an active form of climate protection: The proof is right here in this brochure. Wood is the only building material to boast excellent levels of energy and carbon efficiency: The positive effects it brings throughout the value-added chain and its entire life-cycle are many and varied.

Forest

Wood as a raw material

Wood as a building material

Timber construction

Modernisation
Refurbishment
Urban densification

Demolition
Recycling
Energy recovery

Energy effect	Carbon effect	Value-added effect
Stores solar energy	Removes C from the atmosphere	Supplies the raw material wood; safeguards jobs in the region that are close to employees' homes
Available locally; short transport distances	C transferred into the raw material	Safeguards jobs in trades and industry; strengthens the rural area
Low-energy production; stores energy in the product	Stores C; replaces other construction materials that are damaging to the environment	Strengthens the Bavarian Forestry and Wood Cluster Initiative
Low amount of embodied energy and minimal heating requirements	Long-term C storage	Strengthens the economic power of regional enterprises; produces buildings that retain their value and provide a very healthy living environment
Low energy requirements thanks to low transport weight	Increase in C storage	High degree of prefabrication; innovative and intelligent product know-how; saves resources and retains value
Low-energy recycling or emission-neutral energy recovery	Extended C fixation due to recycling	Innovative solutions for a circular economy that is fit for the future

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A guide
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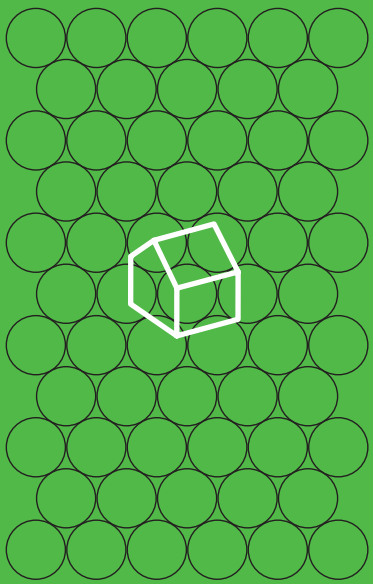
Cluster Forst und Holz in Bayern

BAYERISCHE FORSTVERWALTUNG



61 trees are harvested every minute in Bavaria
= one timber house per minute

2.6 million ha of forest area in Bavaria = 36 % of the state’s total area