



Carbon Footprint of SLOW Spain

SLOW Spain, promoted by the American Hardwood Export Council (AHEC), aims to make visible the conscious change of the current "fast" culture towards more durable objects, with timeless design and quality.

SLOW Spain brings together the work of 17 students selected from nine design schools in Spain. The brief to the young designers was to create innovative pieces around the concept of "slow" design. The projects have been carefully chosen by their professors and, subsequently, have been mentored by Inma Bermúdez and Moritz Krefter (Studio Inma Bermúdez), Álvaro Catalán de Ocón (ACdO) and Jorge Penadés (Oficina Penadés).



Making of Todo Toca by Eli Yang, Anna Perathoner. Photo by Uxío da Vila

Together with AHEC, the renowned designers have worked with the students to refine their ideas and shape them with a selection of four sustainable American hardwoods which are abundant yet still underused in Europe: red oak, maple, tulipwood, and cherry. The prototypes have been handcrafted at La Navarra carpentry in Madrid. The designs are both aesthetic and functional, ranging from side tables to a shelf-screen, a desk and a reinvention of the chair. The collection, comprising nine works, is being exhibited for the first time from 7 February to 12 March 2023 at the Fernán Gómez Cultural Center of the Villa, as part of the official programming of the Madrid Design Festival 2023.

This carbon footprint of the nine designs has been prepared to provide insights into the environmental impacts of the individual designs at each stage of the product life cycle. It shows how good design, responsible material choices, and efficient processing ensure that these impacts can be kept to a minimum. At point of delivery to the exhibition in Madrid, the total GWP or "carbon footprint" of all nine of the SLOW Spain designs is 712 kg of CO₂ equivalent (kg CO₂e). That's equal to the carbon emissions of driving 6,600 kilometres in an average Spanish car, or, to put another way, about the same as emitted by the average Spaniard over a one month period. A large proportion of emissions associated with the designs is offset by carbon stored in the sustainable wood materials which constitute nearly nine tenths of their total weight. The emphasis on "slow" design to create durable timeless pieces means that this carbon is likely to remain stored in the furniture for many years. It also reduces the frequency of replication of environmental impacts due to product replacement.



Replacement time of harvested timber¹

2.3 seconds



Carbon footprint (kg CO₂e) *

713 kg



Equivalent distance in a family car (km)²

6600 km



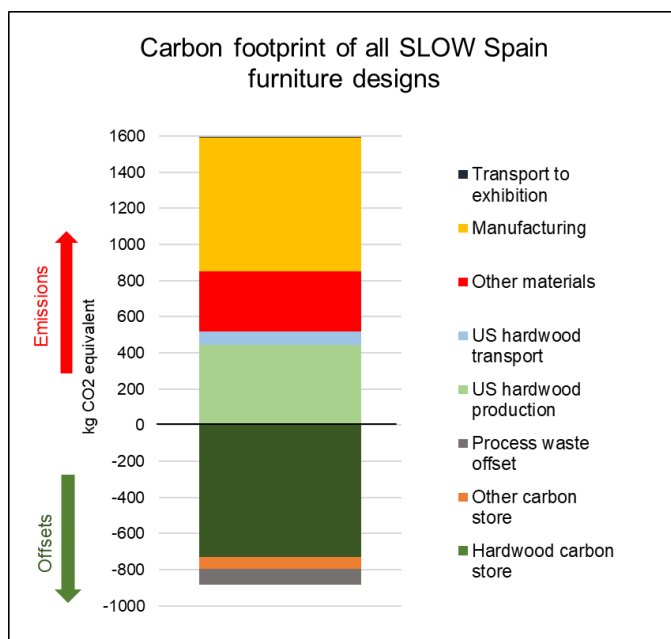
Equivalent carbon footprint for average EU citizen³

32 days

1. Time in seconds for new growth in U.S. hardwood forest to replace that required to be harvested to supply wood for the project.

2. The distance travelled in a typical mid-sized family car to produce the same carbon footprint.

3. The number of days for the average EU citizen to produce the same carbon footprint.



A large share of carbon emissions of the finished SLOW designs occurs during manufacturing in Spain. Emissions due to use of grid electricity during manufacturing of the nine designs were 740 kg CO₂e. Around one third of this is needed for dust extraction in the factory, one third is during 72 hours of CNC machining operations – mainly on the Scaffold and Todu Toca designs – and the remaining third for other machines such as saws, lathes, drills, planes, and presses.

The impact of electricity use during manufacturing in Spain is mitigated to some extent by the country's relatively high dependence on renewable energy sources. In 2021, renewables generated nearly 47% of Spain's electricity needs, the largest part of it from wind power (23%), followed by hydroelectric (11%), solar (10%), and other renewables (2%). An additional 20% derives from nuclear power with only about one third from fossil fuels.

Wood's dual role as a material for product fabrication and as biomass for energy production has implications for the carbon footprint. Of 800 kg of wood used to produce the designs at the factory in Spain, 504 kg (63%) is incorporated in the final product, while 10 kg (1%) is estimated to be lost as dust or shavings, and the remainder (36%) is collected by a specialist waste management company. The majority of this waste wood is shredded for energy recovery. Carbon emissions for the project are therefore partially offset by 89 kg CO₂e resulting from substitution of fossil fuels through incineration of this wood waste.

The quantity of non-wood materials used for the SLOW designs is small relative to wood but has a relatively large impact on the the overall carbon footprint. Non-wood components - including steel, leather, cloth, twine, glues and coatings - together made up 11% of the total weight of the finished designs while contributing 292 kg CO₂e (41%) to the total carbon footprint.

Variation between the Slow designs

A benefit of the SLOW Spain project is that it allows comparison of the environmental impacts of different design decisions. This is facilitated by use of a comparable base material – American hardwood - for all the individual designs and by manufacturing at a single location at La Navarra carpentry in Madrid.

Emissions associated for individual designs range from a high of 165 kg CO₂e (Blas) to a low of 5 kg CO₂e (Toei). The variable footprint of individual designs is due to the differing balance between the offset due to carbon sequestration in the wood, on the one hand, and the emissions associated with supply of the U.S. hardwood and other materials and with manufacturing in Spain on the other (see Chart below and Table 1).

The low carbon footprint of the Toei design – which is close to carbon neutral – is due to a combination of positive environmental features including: a relatively high proportion of American hardwood compared to non-wood materials (96% of the design is of American hardwood); high (79%) wood conversion efficiency so that most of the sequestered carbon



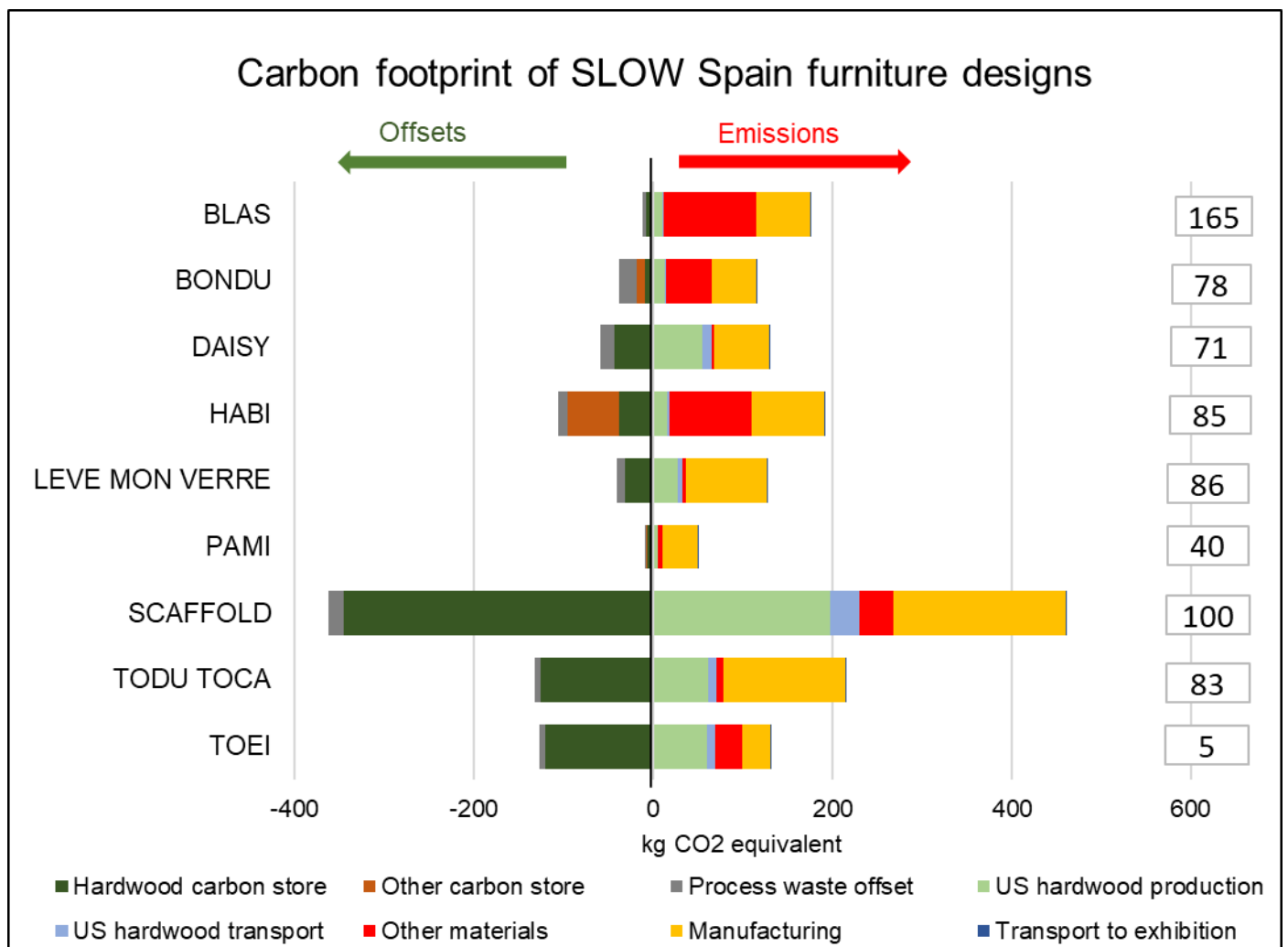
*Blas by Sheila Valle García.
Photo by Uxío da Vila*



remains in the finished product and is not lost during manufacturing; and use of the wood largely in its natural state and without a large energy input during manufacturing.

The relatively higher carbon footprint of the Blas design is due to the comparatively low proportion of American hardwood contained in the finished product relative to the other materials, mainly comprising twine for the seat and steel fixings. The carbon footprint for this design may be an overestimate. Due to lack of data on the type of twine used, it is assumed to comprise a synthetic (oil-based) material. Use of a natural or recycled fibre instead of a synthetic material would greatly reduce the carbon footprint of this design.

The Scaffold design is notable for being by far the largest of the nine pieces on display in Madrid, weighing in at 235 kg, nearly three times that of the next largest (Habi at 88 kg). Despite this, the carbon footprint of Scaffold – at 100 kg CO₂e – is less than Blas and only slightly more than the other much smaller designs. Although the large quantity of American hardwood used for Scaffold results in larger emissions to supply the material and for machining in Spain, this is offset by the large amount of carbon sequestered in the finished design. The carbon sequestered in this design alone amounts to 345 kg CO₂e, over 40% of the total 794 kg CO₂e stored in all nine designs.





Environmental impact of U.S. hardwood used for Spain



Leve Mon Verre by Cèlia Anglès. Photo by Uxío da Vila

The American hardwood lumber delivered to La Navarra carpentry represents a significant store of carbon. The carbon stored in the wood during growth (1111 kg CO₂e) exceeded all carbon emissions during material extraction and processing and transport from the U.S. (kg CO₂e). Of these emissions, those during processing (89% - mostly kiln drying) greatly exceeded those during transport (11%) despite the shipping distance involved (Table 2). Only around 4% of carbon emissions to deliver the American lumber to the workshop in Madrid occurred during forestry operations.

The foundation of any claim about the carbon benefits of wood products depends on their being from a sustainable source. American maple, red oak, tulipwood, and cherry are all abundant and sustainably harvested timber species. The LCA of US hardwood undertaken by PE International (now Sphera) - from which the carbon footprint data for this assessment is drawn - concludes that 'in the system under investigation the main material – wood – comes from naturally re-grown forests. The harvested areas had undergone several iterations of harvesting and re-growth. After harvesting, the land is returned to forest so there is no direct land use change to account for in the timeline of few hundred years.'

U.S. government forest inventory data shows that every year, after natural mortality and harvesting are accounted for, the volume of maple, red oak, tulipwood and cherry in U.S. forests increases respectively by 29.2 million m³, 28.7 million m³, 21.8 million m³ and 5.4 million m³. It takes just over 2 seconds for the hardwood harvested to manufacture all nine of the designs to be replaced by new growth in the US forest. Maple, red oak, tulipwood, and cherry are all under-utilised from a forestry perspective. The creation of larger markets for these timbers reduces pressure on other less abundant commercial hardwood species and enhances financial returns from sustainable use of diverse semi-natural forests.



*Making of Scaffold
by Arnau Anoro.
Photo by Uxío da
Vila*



Table 1: Carbon footprint of SLOW Spain designs from point of material extraction to delivery to exhibition in Madrid, Spain

Design	Emissions (1)	Biogenic carbon store (2)	Process waste offset (3)	Total footprint (4)	Equivalent drive (5)	Equivalent EU per capita emissions (6)
	Kg CO ₂ eq.				km	days
BLAS	175.9	-7.4	-3.8	164.7	1525	7.33
BONDU	115.6	-18.1	-19.5	77.9	722	3.47
DAISY	130.0	-43.0	-15.5	71.4	661	3.18
HABI	191.2	-95.4	-10.5	85.3	790	3.80
LEVE MON VERRE	126.8	-31.8	-8.9	86.0	797	3.83
PAMI	49.1	-7.5	-1.6	40.0	371	1.78
SCAFFOLD	462.2	-345.2	-16.8	100.2	928	4.46
TODU TOCA	214.5	-125.3	-6.6	82.6	765	3.68
TOEI	131.1	-120.6	-5.9	4.6	43	0.21
Total	1596.4	-794.4	-89.1	712.8	6600	31.72

1) Includes all emissions associated with extraction, processing, and transport of wood and non-wood materials to the workshop gate and manufacturing of the design in Madrid. Due to lack of detailed LCA data on glues and coatings, data was used for the closest surrogates that could be identified in the Sphera GABI Professional database with transport in each case of 1000 km by road (sufficient to deliver products to the factory from anywhere in the northern EU).

2) Carbon storage is calculated directly from the mass of the hardwood contained in the finished product and assumes that 46% of dry mass consists of carbon. This carbon will remain stored for the lifetime of the product, an additional benefit of durability in hardwood products (alongside reduced need for replacement).

3) The offset due to production of energy from incineration of offcuts which replaces for use of fossil fuels.

4) Carbon footprint is calculated as the balance between emissions on the one hand, and process waste offset and biogenic carbon on the other.

5) The distance travelled in an average European car to produce the same carbon footprint (a negative number is the distance in km offset by designs which are better than carbon neutral). Based on EU average carbon emissions for new passenger vehicles sold in 2020 of 0.108 kg/km (EEA provisional data).

6) The number of days for the average EU citizen to produce the same carbon footprint (a negative number is the number of days of carbon emissions by the average EU citizen offset by designs which are better than carbon neutral). Based on EU per capita carbon emissions of 8.2 metric tonnes in 2019 (22.47 kg per day) derived from https://ec.europa.eu/eurostat/databrowser/view/t2020_rd300/default/table?lang=en.

Table 2: Quantity, forest replacement time and carbon footprint of American hardwood delivered to La Navarra carpentry in Madrid

Design	Quantity American hardwood (1)	Replacement time (2)	Carbon Emissions (3)	Biogenic carbon (4)	Carbon footprint (5)
	kg	seconds	kg CO ₂ eq.		
BLAS	17.2	0.1	12.4	-27.1	-14.6
BONDU	39.4	0.4	15.0	-62.2	-47.1
DAISY	78.9	0.1	65.0	-124.4	-59.4
HABI	38.6	0.2	17.9	-60.9	-42.9
LEVE MON VERRE	49.5	0.2	33.2	-78.0	-44.7
PAMI	8.3	0.0	5.7	-13.1	-7.5
SCAFFOLD	275.2	0.4	230.8	-433.8	-203.0
TODU TOCA	101.5	0.5	70.8	-160.0	-89.1
TOEI	96.2	0.4	69.6	-151.7	-82.0
Total	704.9	2.3	520.6	-1111.1	-590.5

1) Volume of boards delivered to La Navarra carpentry in Madrid used for manufacture. Emissions are adjusted to take account of proportion of boards of differing thickness used for each design (which affects energy required for kiln drying).

2) Replacement time is time in seconds it takes for new growth in U.S. hardwood forest of the specific species to replace that required to be harvested to supply wood for the project. It is assumed that log volume required to be harvested is double volume of delivered boards (i.e. 50% conversion efficiency from logs to boards). Hardwood forest growth data is derived from the USDA Forest Inventory and Analysis (FIA) Program (latest annual data available in November 2021, typically 2018 data for most U.S. hardwood producing states).

3) Data for carbon emissions to deliver U.S. hardwood is taken from updated LCA model developed by Thinkstep (now Sphera) as part of the LCA study commissioned by AHEC and includes all emissions from point of extraction in the U.S. through all processing stages and transport to workshop gate in Spain. It is assumed that wood is transported by the following route: by truck from the geographic central point of harvest of each species in the United States, to the leading East Coast port for each species, by container ship to Valencia port in Spain, and then 500 km to the workshop gate. Based on density of boards on site and standard industry drying practices, it is assumed that all species are dried to 7% moisture content.

4) Carbon stored in wood material during growth and is treated as a negative emission. Due to difficulties of tracing carbon flows at every stage of the life cycle, carbon storage is calculated directly from the mass of the delivered hardwood assuming that 46% of dry mass consists of carbon (where 1 kg of carbon is equivalent to 44/12 kg - i.e. 3.666 kg - of carbon dioxide).

5) Carbon footprint is calculated as the balance between emissions and biogenic (stored) carbon. A negative figure indicates carbon storage in the wood exceeds all emissions associated with delivery of the boards to the workshop gate.



Table 3: Wood utilisation and conversion efficiency of SLOW Spain designs

Design	Wood input (1)	Design weight	Wood in design			Process waste wood (3)			
			Quantity	Share of design mass	Conversion efficiency	Total (2)	of which Incinerated	of which to landfill	of which dust (emitted)
	kg	kg	kg	%	%	kg	kg	kg	kg
BLAS	17.2	15.0	4.7	31%	27%	12.5	10.4	1.7	0.4
BONDU	76.5	13.0	11.5	88%	15%	65.0	54.2	8.7	2.2
DAISY	78.9	28.0	27.3	98%	35%	51.6	43.0	6.9	1.7
HABI	95.5	88.0	60.5	69%	63%	35.0	29.2	4.7	1.2
LEVE MON VERRE	49.5	21.0	20.2	96%	41%	29.3	25.1	4.0	1.0
PAMI	10.0	6.2	4.8	77%	48%	5.2	4.3	0.7	0.2
SCAFFOLD	275.2	235.0	219.0	93%	80%	56.2	46.6	7.5	1.9
TODU TOCA	101.5	82.0	79.5	97%	78%	22.0	18.3	2.9	0.7
TOEI	96.2	80.0	76.5	96%	79%	19.7	16.5	2.6	0.7
Total	800.5	568.2	504.0	89%	63%	296.5	247.6	39.6	9.9

1) Quantity of wood materials delivered to La Navarra carpentry in Madrid needed for the project. The actual delivery volume was 999 kg, however 198 kg of offcuts are assumed to have been reusable and allocated for other products not associated with the project. All wood input comprised U.S. hardwood lumber except 37 kg of MDF in BONDU, 57 kg of plywood in HABI, and 1.6 kg of plywood in PAMI. MDF and plywood originated from within the EU.

2) Total weight of process waste wood is not measured directly but is calculated as the difference between measured wood input weight and the weight of the finished design less the weight of non-wood materials.

3) It is assumed that 2% of waste wood comprises small dust particles which is emitted, 8% is destined for landfill, while the remaining 90% is destined for a standard municipal waste incinerator.

Carbon footprint Q&A

What is a carbon footprint?

A carbon footprint quantifies the greenhouse gas emissions during the lifecycle of a product. It is the sum of all gases emitted (including CO₂, methane and water vapour) which influence the energy balance of the atmosphere leading to increased temperature. It is expressed in kilograms of carbon dioxide equivalent (kg CO₂e)

A negative carbon footprint (i.e. less than zero indicating “better than carbon neutral”) is possible for products made of wood. During growth, trees absorb CO₂ from the atmosphere which is locked in the product (and therefore no longer warming the planet) for as long as it is in use.

Wood waste created during manufacturing of the product may also be incinerated generating additional energy for heating or other industrial processes which would otherwise use fossil fuels.

When wood originates from a renewable source, both the carbon stored in the wood and the offset due to energy generated from incineration of wood waste is treated as a “negative emission” in the carbon footprint calculation.

What is included in the carbon footprint?

The assessment covers all processes from extraction of wood and other raw materials, transport of materials to processing location, all processing steps (notably sawing and kilning in the case of wood), transport of processed products to the workshop in Spain, and manufacture of the finished designs.

Due to lack of specific information on durability, maintenance and disposal at end-of-life, the carbon footprint is not a full “cradle-to-grave” assessment, and instead determines the environmental impact of the design when delivered to the exhibition in Madrid.

Who prepared the carbon footprint?

The LCA is commissioned by the American Hardwood Export Council (AHEC) and prepared by Rupert Oliver, Director of Forest Industries Intelligence Ltd, a U.K. based consultant with thirty years' experience of sustainability issues in the forest products sector.

How is the assessment carried out?

The assessment draws on a two-year Life Cycle Assessment (LCA) study, commissioned by AHEC and undertaken by PE International (now Sphera), to assess environmental impacts of delivery of U.S. hardwood into world markets¹. This involved a wide-ranging assessment of hardwood forestry practices and a survey of hundreds of U.S. hardwood companies. Information from the LCA of U.S. hardwoods is combined with the latest U.S. government forest inventory data and data gathered during manufacturing at the workshop in Madrid². It is also combined with Sphera's existing life-cycle inventory database which covers an expanding range of non-wood materials and products.

Notes:

1. The PE International LCA study of U.S. sawn hardwood is available at <https://tinyurl.com/y4azrssl>

2. U.S. forest inventory data is derived from the Forest Inventory and Analysis Database and compiled by AHEC in May 2020 using the most recent state inventory available (2018 for most states).