

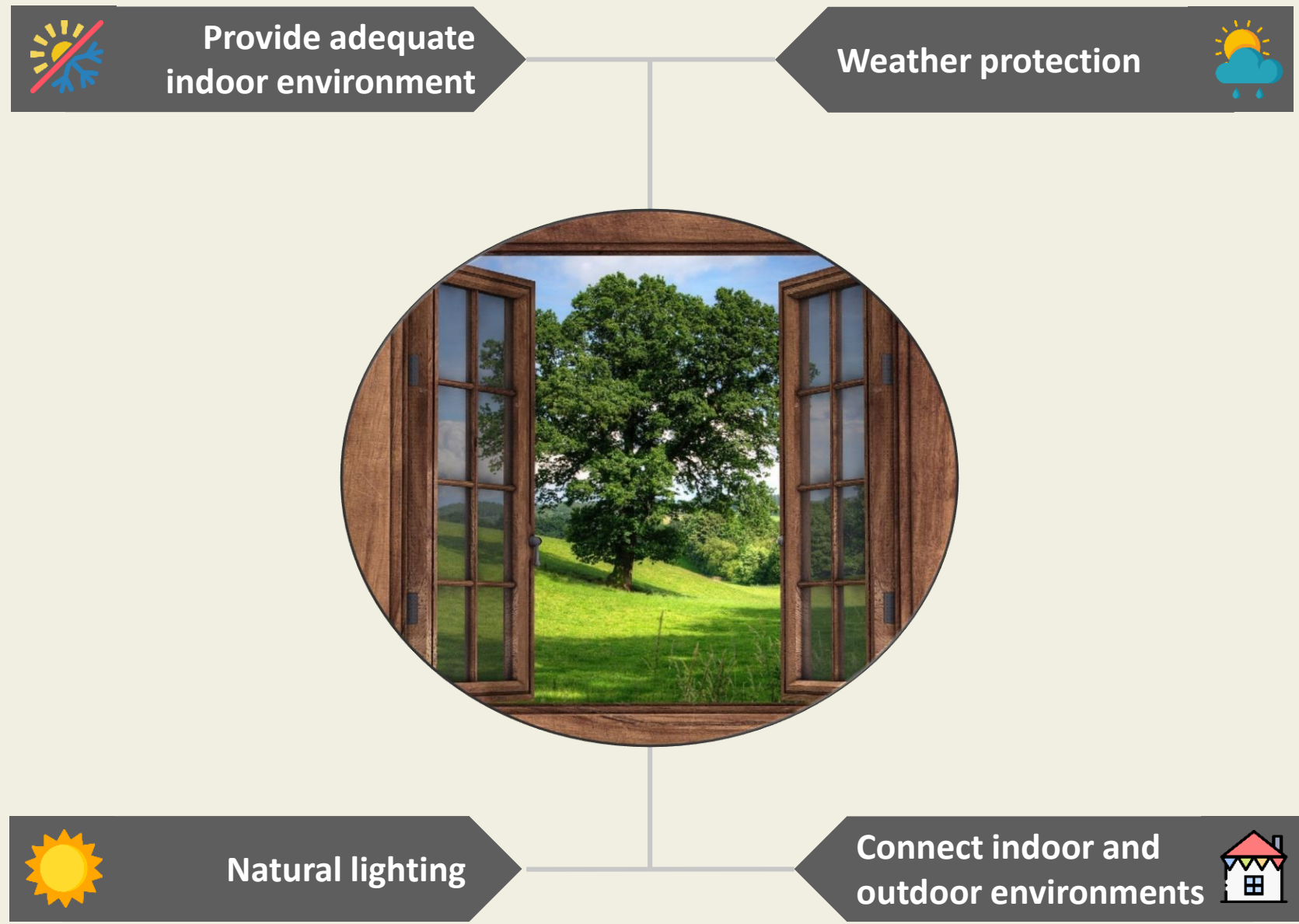
*The 10<sup>th</sup> International Conference on  
Life Cycle Management*

# **Assessing Environmental Impacts of Construction Products: The Role of Embedded and Operational Impacts in the Environmental Performance of Wooden Windows**

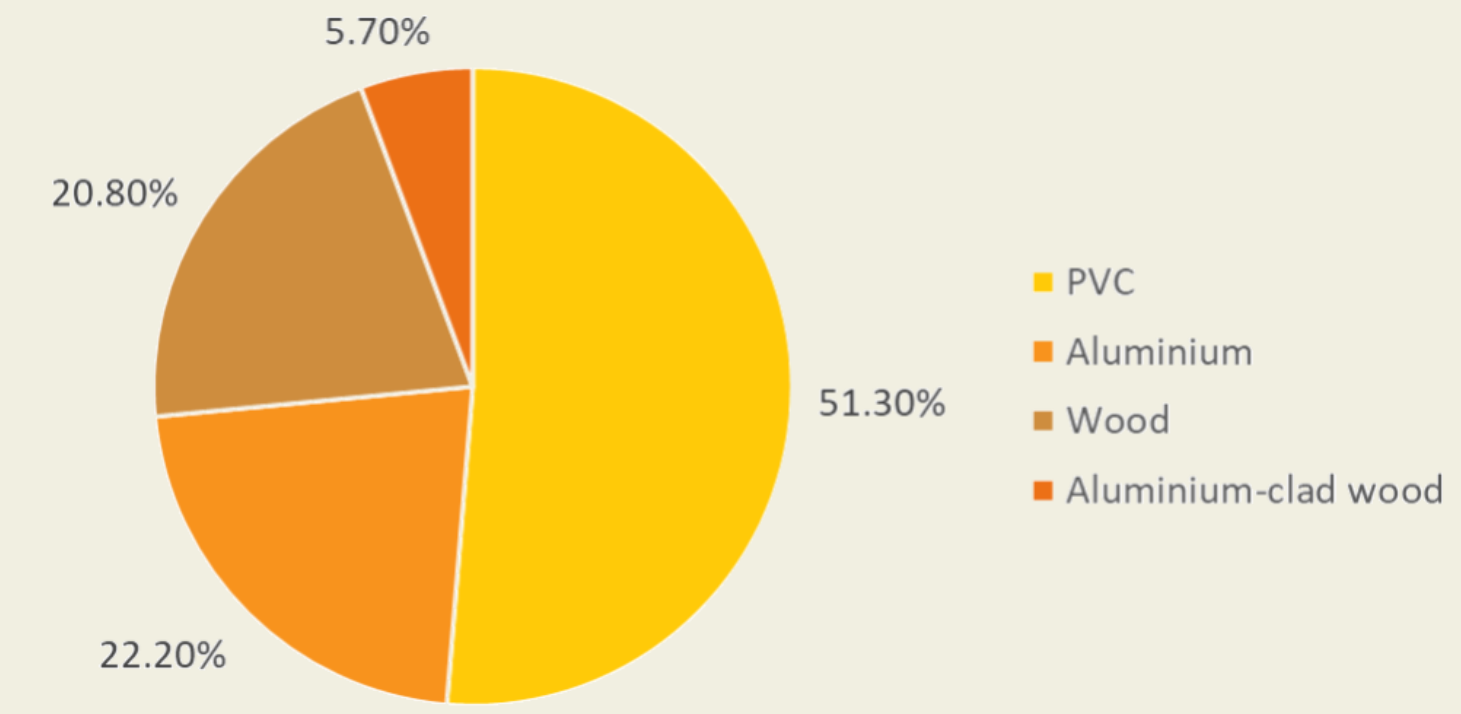
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Elisabetta Palumbo  
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What Gets Measured, Gets Improved –  
Impact Assessment and Environmental  
Labeling Along the Production Chain II

06<sup>th</sup> September 2021

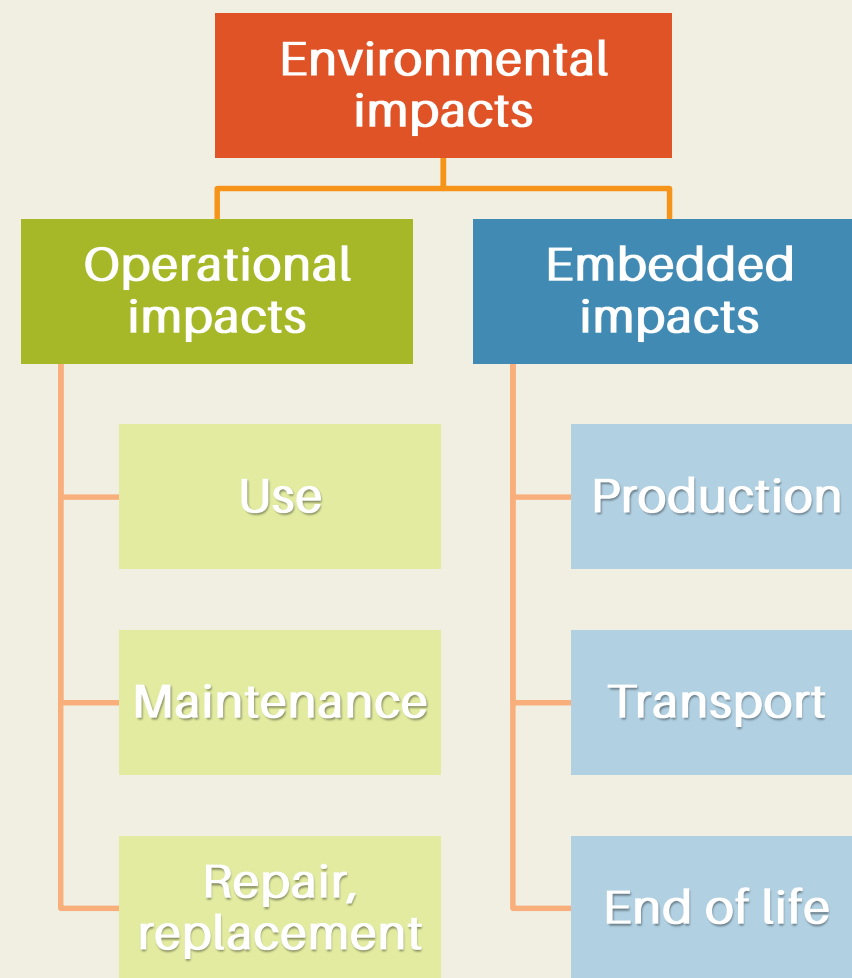


# The role of windows in buildings

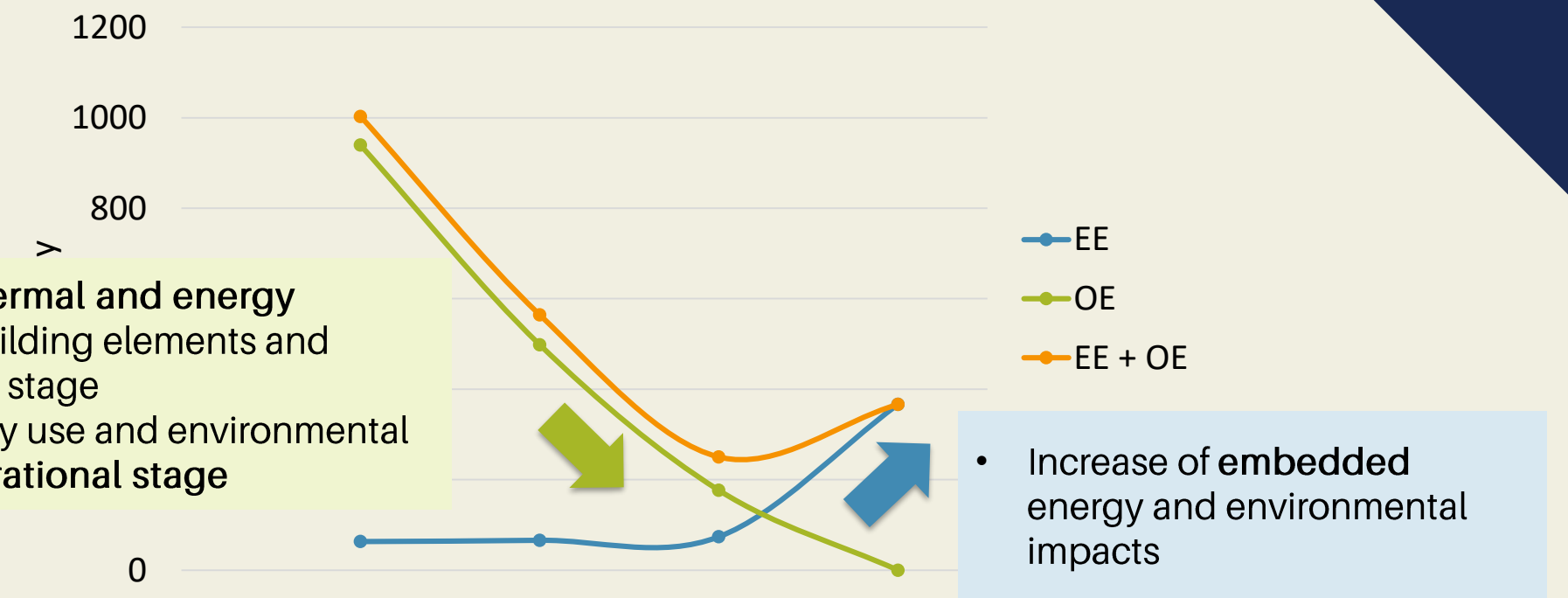


European window market: Dissemination of different window frame materials  
 Source: Own illustration, based on data from Lang, 2017

# Embedded and Operational Impacts



- Improvement of **thermal and energy performance** of building elements and materials in the use stage
- Reduction of energy use and environmental impacts in the **operational stage**



	Conventional	Low Energy Passive House	Zero Energy Building	Zero Energy Building
EE	63.31	66.1	73.79	366.32
OE	939.54	498.46	176.62	0
EE + OE	1002.85	564.56	250.41	366.32

Source: Adapted from Palumbo, E., & Politi, S. (2018).

# Estimating environmental impacts of construction products with EPDs

Environmental Product Declarations (EPDs) are a source of specific environmental data based on LCA results.

- Disclose information on potential environmental impacts, resource use, and waste generation
- When integrated into a building LCA, give understanding on the relevance of a product the overall environmental performance of a building
- Support decision-making processes

**What is the role of embedded and operational impacts in the environmental performance of wooden windows?**

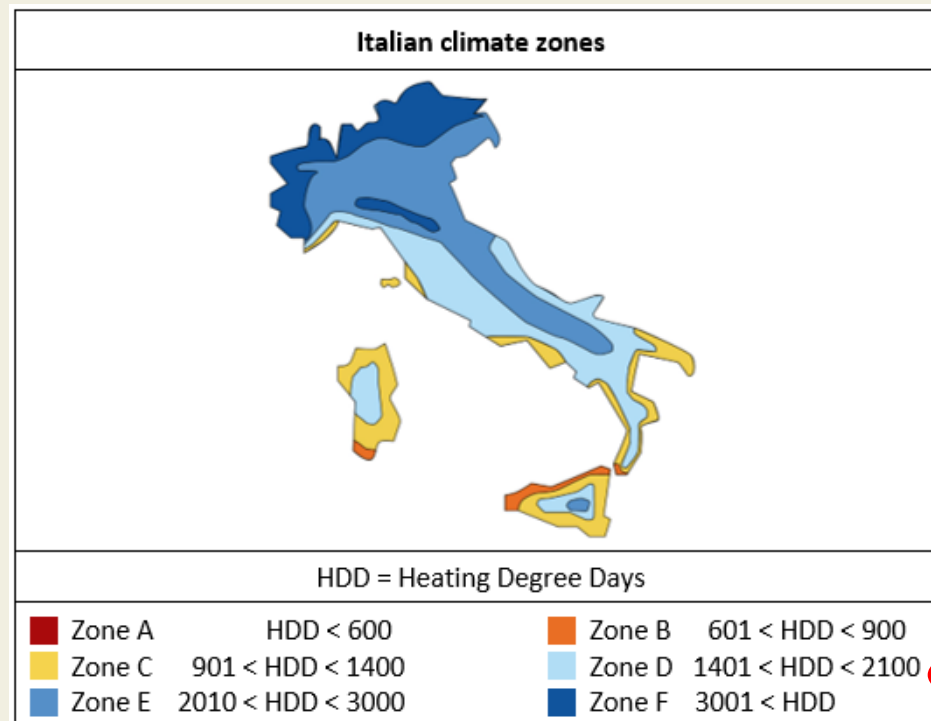
- Focus: Product and Maintenance stages
- Influence of wood type, thermal transmittance (U-value), manufacturer, service life and type of coating on environmental performance

RESULTS (A1 - A3) PER 1 M <sup>2</sup> WINDOW								
PRODUCT ↓	INDICATOR	GWP	ODP	POCP	AP	EP	ADPE	ADPF
	UNIT PER M <sup>2</sup>	kg CO <sub>2</sub> e	kg CFC11e	kg C <sub>2</sub> H <sub>4</sub> e	kg SO <sub>2</sub> e	kg PO <sub>4</sub> <sup>3-</sup> e	kg Sb e	MJ
Wood sidehung window 3-glass		76.7	5.2E-06	0.08	0.56	0.10	0.013	350.9
Wood/aluminum sidehung window 3-glass		90.1	6.8E-6	0.08	0.63	0.13	0.013	503.2
Wood fully reversable window 3-glass		93.4	6.4E-6	0.1	0.71	0.12	0.022	351.0
Wood/aluminum fully reversable window 3-glass		106.9	8.1E-6	0.1	0.78	0.15	0.023	503.3
Wood fixed window 3-glass		62.1	3.9E-6	0.06	0.39	0.08	0.001	353.4
Wood/aluminum fixed window 3-glass		66.7	4.4E-6	0.06	0.42	0.09	0.001	412.0
Wood/aluminum inward window 3-glass		84.6	6.9E-6	0.08	0.57	0.13	0.007	583.6
Wood/aluminum inward window 2+1-glass		90.8	8.0E-06	0.08	0.60	0.15	0.007	656.6
Wood/aluminum inward Kipp-dreh window 3-glass		89.3	7.2E-6	0.08	0.61	0.14	0.009	586.0
Wood/aluminum inward Kipp-dreh window 2+1-glass		95.5	8.4E-6	0.08	0.65	0.15	0.010	658.7

Source: EPD of Wood- and wood aluminum clad windows and patio doors (EPD International AB)

# Selecting the EPDs

EPD platform	Country	Collected EPDs
CAPEM (Cycle Assessment Procedure for Eco-Impacts of Materials)	Belgium	3
EPD-Norge	Norway	6
EPD-Italy	Italy	0
INIES	France	7
International EPD® System	Sweden	2
ITB EPD Program	Poland	3



Source: Giordano et al., 2016

Italian climate zones	U-value [W/m²K]
A-B	3.0
C	2.0
D	1.8
E	1.4
F	1.0

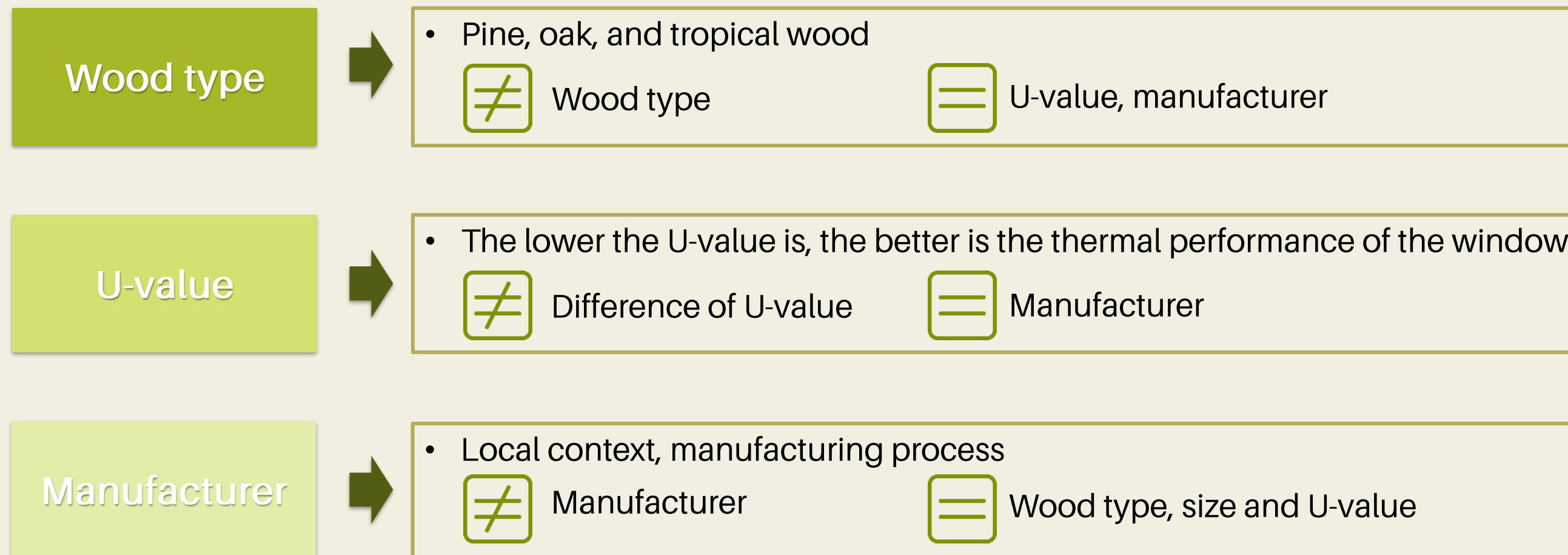
Source: Hermelink et al., 2017

EPD ID	Life cycle stages															Benefits and loads beyond the system boundaries Reuse – Recovery – Recycling potential	
	Product stage			Construction process stage		Use stage							End-of-life stage				
	Raw material supply	Transport	Manufacturing	Transport	Construction – Installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Deconstruction/Demolition	Transport	Waste processing		Disposal
1	X	X	X	X	X	X	X						X	X	X	X	X
2	X	X	X	X	X	X	X						X	X	X	X	X
3	X	X	X	X	X	X	X						X	X	X	X	X
4	X	X	X	X			X							X		X	X
5	X	X	X	X			X							X		X	X
6	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	X	X	X	X			X							X		X	X
8	X	X	X	X			X							X		X	X
9	X	X	X	X			X							X		X	X
10	X	X	X	X			X							X		X	X
11	X	X	X														
12	X	X	X														
13	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14	X	X	X	X	X		X							X	X	X	X
15	X	X	X	X	X		X							X	X	X	X
16	X	X	X	X	X		X							X	X	X	X
17	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
18	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
19	X	X	X														
20	X	X	X														
21	X	X	X														



# Assessing the product stage

Influence of the following aspects on environmental impacts of the product stage:





# Assessing the use stage

Defining maintenance scenarios, main aspects to consider:

- Location and climate
- Quality of the components
- Treatment of the wooden window
- Maintenance frequency
- Service life

**Influence of coating type and climate conditions:**

- The lack of maintenance products leads to more frequent inspections.
- Opaque coating is preferable over translucent → Better wood protection and extension of service life

EPD ID	Cleaning	External maintenance		Internal maintenance	
		Description	Cycles	Description	Cycles
4	3 washes per year and a yearly consumption of 3 L of water and 1.50 dL of detergent for 1.82 m <sup>2</sup>	Wood painted every 5 years	7	Wood painted every 20 years	1
6		Wood painted after 10 years and then every 6 years	5		
8		Wood painted every 8 years	4		
9					
13	No cleaning process	Wood painted every 5 years and includes the transport of the painter	4	N/A	N/A
14	Consumption of 360 L/m <sup>2</sup> , but the detergent is not included	Wood painted every 10 years	2		
15					
16					



# Influence on environmental impacts – Product stage

## Wood type



- European oak vs tropical wood
- Window made of tropical wood presents higher environmental impacts

## U-value



- Small  $\Delta$   $\rightarrow$  Both triple-glazed units; Bigger  $\Delta$   $\rightarrow$  Double-glazed vs triple-glazed unit
- Increase in environmental impacts
- Non-linear correlation observed

## Manufacturer



- Lowest change in the environmental impacts
- Similar technology in European context(?)





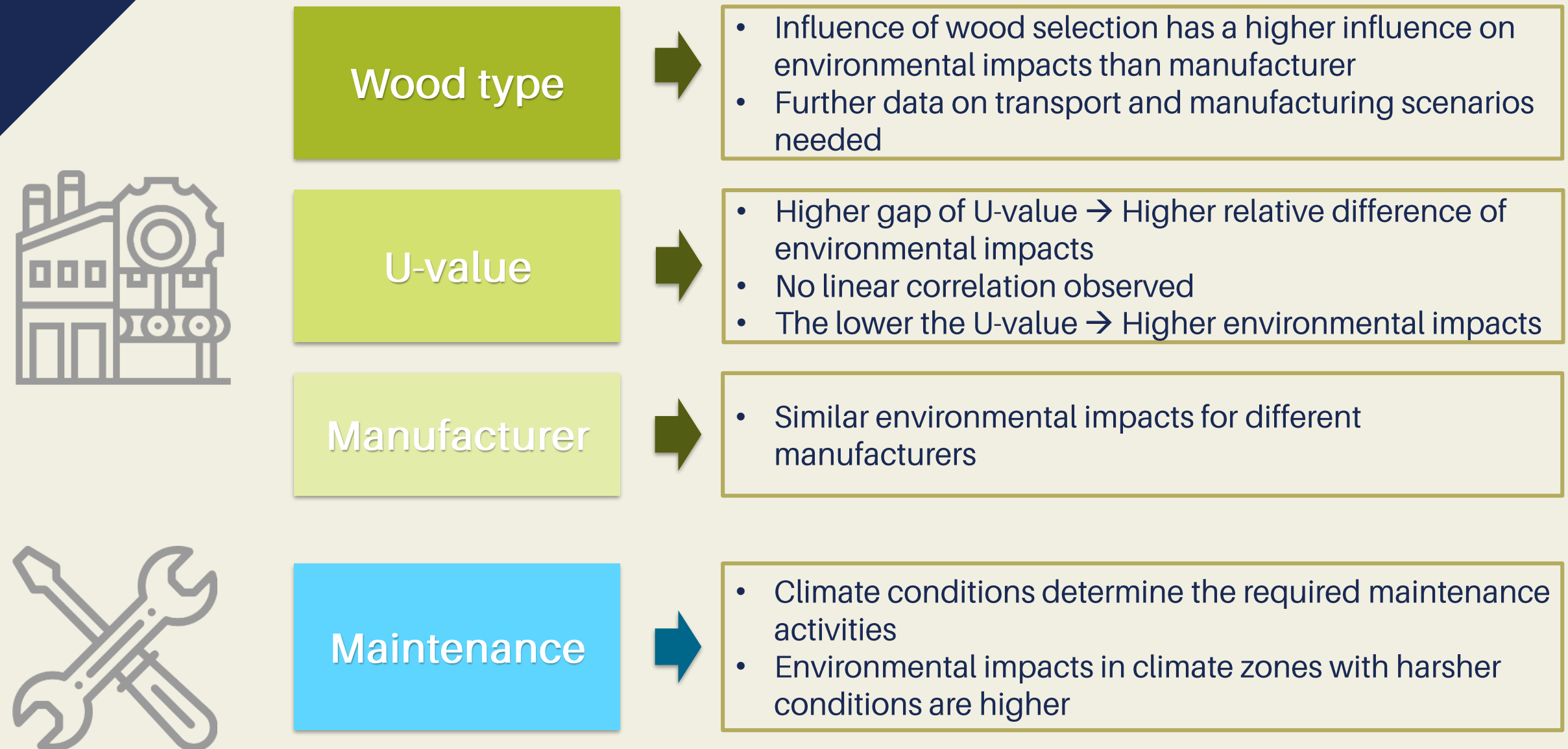
# Influence on environmental impacts – Maintenance

## Influence of location and coating colour

- Climate zone B (protected weather), climate zone D (normal weather), and climate zone F (heavy weather).
- Coating colour: Light, medium, dark
- Maximum environmental impacts are three times higher than minimum environmental impacts

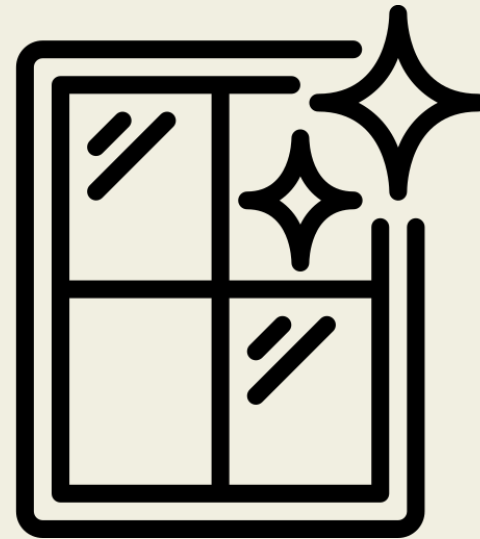
Italian climate zones	Colour	Maintenance cycles	Environmental indicators							
			GWP [kg CO2-eq.]	ODP [kg CFC-11-eq.]	POCP [kg C2H4-eq.]	AP [kg SO2-eq.]	EP-fw [kg PO43--eq.]	ADP-e [kg Sb-eq.]	ADP-f [MJ]	
B	Light	3	2.70E+00	2.63E-07	1.20E-03	1.60E-02	2.82E-03	2.85E-05	5.17E+01	MIN
	Medium	3	2.70E+00	2.63E-07	1.20E-03	1.60E-02	2.82E-03	2.85E-05	5.17E+01	
	Dark	4	3.60E+00	3.50E-07	1.60E-03	2.14E-02	3.76E-03	3.79E-05	6.89E+01	
D	Light	3	2.70E+00	2.63E-07	1.20E-03	1.60E-02	2.82E-03	2.85E-05	5.17E+01	
	Medium	4	3.60E+00	3.50E-07	1.60E-03	2.14E-02	3.76E-03	3.79E-05	6.89E+01	
	Dark	4	3.60E+00	3.50E-07	1.60E-03	2.14E-02	3.76E-03	3.79E-05	6.89E+01	
F	Light	5	4.50E+00	4.38E-07	2.00E-03	2.67E-02	4.70E-03	4.74E-05	8.61E+01	
	Medium	7	6.30E+00	6.13E-07	2.80E-03	3.74E-02	6.57E-03	6.64E-05	1.21E+02	
	Dark	9	8.10E+00	7.88E-07	3.60E-03	4.81E-02	8.45E-03	8.54E-05	1.55E+02	

# Conclusions



# Outlook

Consideration of  
further window  
characteristics



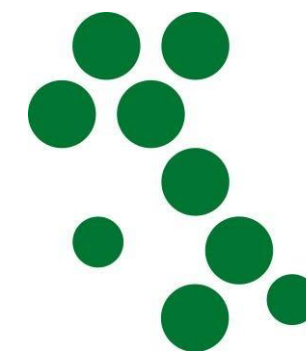
Other data sources



More locations



# Thank you for your kind attention!



**LIFE  
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\*The authors thank the European Union, which co-financed the project "LIFE MAGIS (MAde Green in Italy Scheme)" through the LIFE programme (LIFE18 GIE/IT 000735).

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