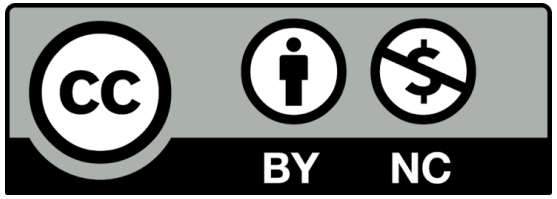

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Cárdenes, V. (2026) Natural Roofing Slates versus Synthetic Roofing Slates: A LCA comparison. Communication presented a the National Slate Association conference, Annapolis 17th-19th September 2026

Universidad de Oviedo

Natural Roofing Slates versus Synthetic Roofing Slates: A LCA comparison

A scientific analysis of the sustainability, durability and benefits of both materials

Prof. Dr. Víctor Cárdenes Van den Eynde
Geology Department, University of Oviedo, Spain

CUPA PIZARRAS

be natural® Slate - Ardoise - Pizarra - 自然板岩 - Schiefer - Ardósia

Víctor Cárdenes Van den Eynde

- Geologist, with a PhD on roofing slates
- Professor of Petrology and Geochemistry, Oviedo University
- More than 80 scientific papers published on roofing slates
- Working together with the slate sector since 1999

LITHOTYPES

Depositional conditions: Anoxic → Oxic

Metamorphic grade ↓

Petrography \ Color	Black-grey B	Green G	Purple-red R
Low-grade slate 0	B0 Black-gray low-grade slate	G0 Green low-grade slate	R0 Purple-red low-grade slate
Slate s.s. 1	B1 Black-gray slate	G1 Green slate	R1 Purple-red slate
Phyllite 2	B2 Black-gray phyllite	G2 Green phyllite	R2 Purple-red phyllite
Schist 3	B3 Black-gray schist	G2 Green schist	R2 Purple-red schist
Special roofing slates	ST Roofing Stones	R1a Variegated slates	

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Before we start, some words about the sponsors:

CUPA PIZARRAS

- CUPA Pizarras is the **world's leading company** in the production and supply of natural roofing slate.
- The company extracts **high-quality slate** from its own quarries in Spain, particularly in the north-western Iberian Peninsula.

Slate - Ardoise - Pizarra
be natural®
自然板岩 - Schiefer - Ardósia

- Be natural offers a **wide range of slate types**, formats, thicknesses and surface finishes.
- Be natural has a **strong international presence**, supplying projects in residential, commercial and heritage architecture.

Before we start, some words about the sponsors:

The National Slate Association

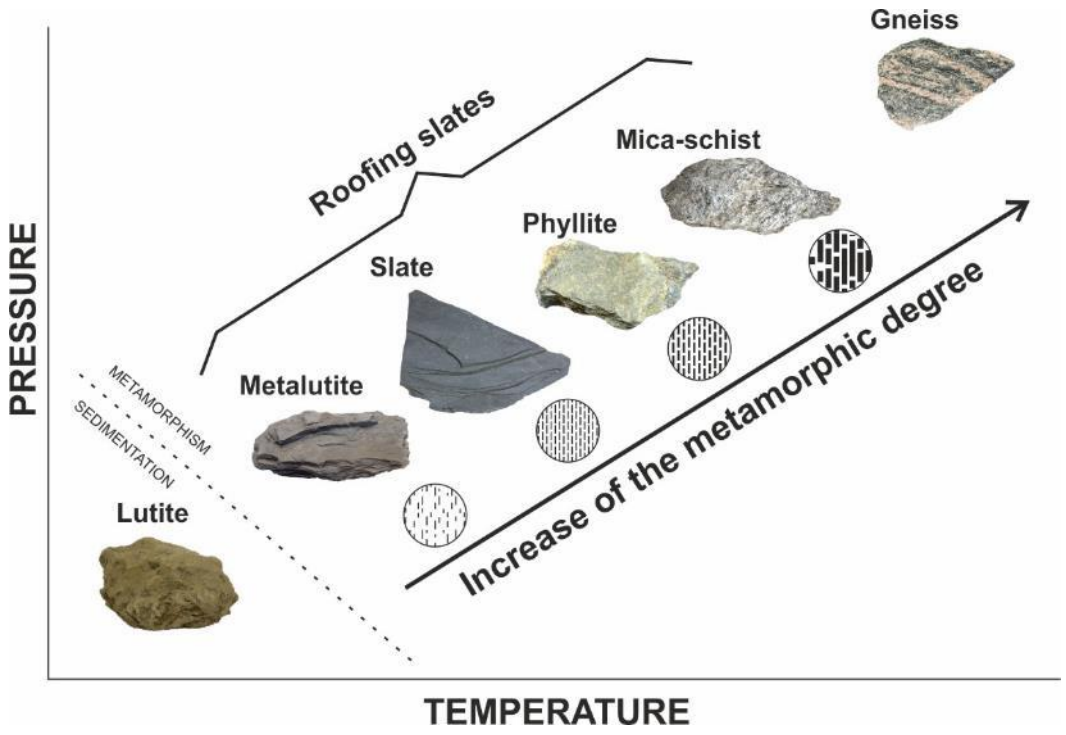
- Industry representation
- Quality and technical knowledge
- Promotion of natural slate
- Industry collaboration

Index

1. *Evolution of natural and synthetic roofing slates over time*
2. *Different materials, different performances*
3. *Sustainability, durability and economic benefit*
4. *Comparing the Life Cycle Assessment (LCA)*
5. *Some laboratory test*
6. ***Conclusions***

1. Evolution of natural and synthetic roofing slates over time

- **Roofing slates** are a group of natural stones used since (at least) the Roman Empire.
- Due to this long period of use, they are present in a large part of the world's architectural heritage.
- Their durability has been proven over centuries of use.



Old Town of Segovia, Spain. UNESCO World Heritage List

1. Evolution of natural and synthetic roofing slates over time

- **Synthetic slates** were developed by the beggining of the 20th century.
- They included asbestos in their composition, in order to **prevent fires**.
- Asbestos were eventually banned, being substituted by synthetic fibers and polymers.

Unknwon location, USA

Definitions

Slate: *An ultrafine- or very fine-grained rock displaying slaty cleavage. Slate is usually of very low metamorphic grade, although it may also occur in low-grade conditions (Fettes et al. 2011).*

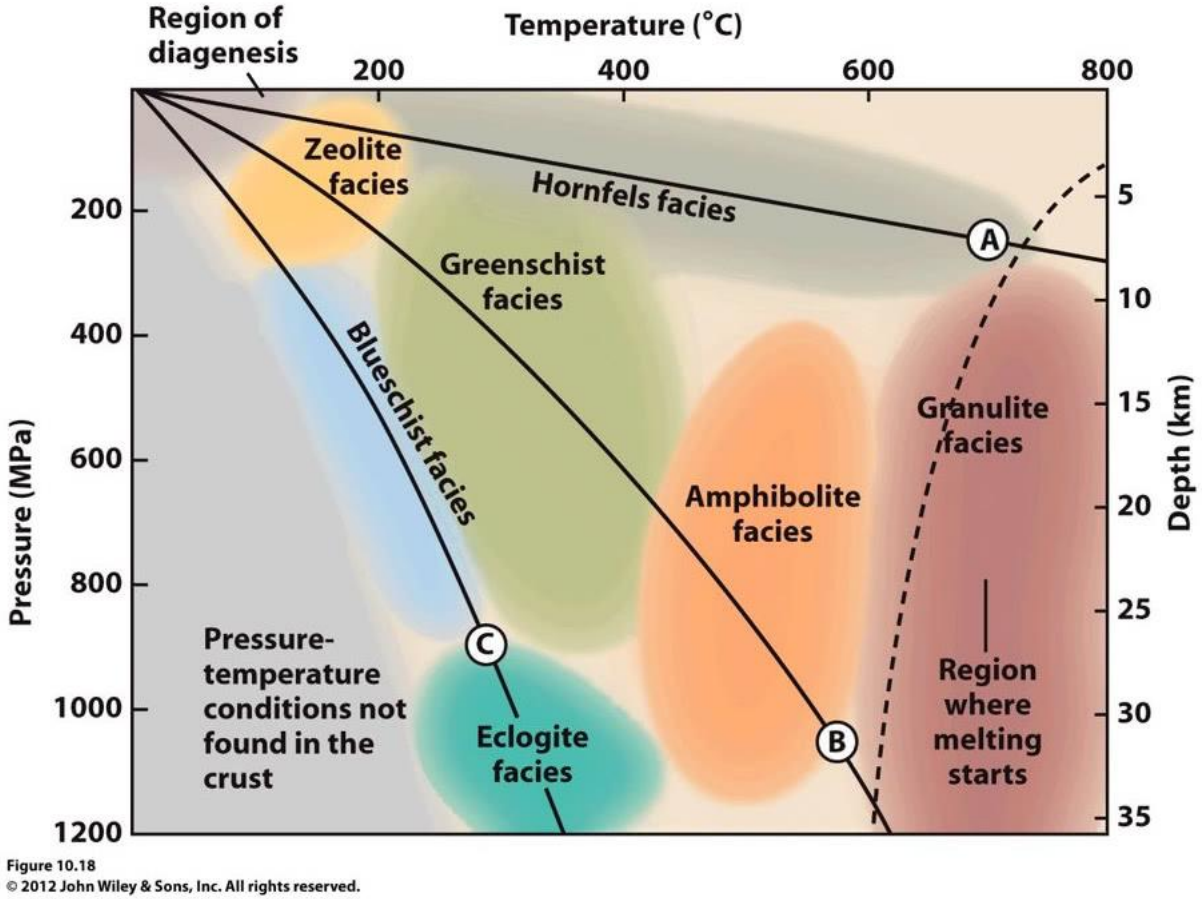


Figure 10.18
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D.J. Fettes, J. Desmons, P. Árkai, Metamorphic rocks: a classification and glossary of terms. Recommendations of the International Union of Geological Sciences Subcommission on the Systematics of Metamorphic Rocks, Cambridge University Press, 2011.

Definitions

Synthetic Slate: *A factory-produced roofing tile designed to reproduce the appearance and installation characteristics of natural slate, but made from polymeric materials rather than natural stone. (OpenAI 2026).*

2. Different materials, different performances

- **Natural slate →** mineral composition: quartz, feldspars, mica, and chlorite
- **Synthetic slate →** polymer/resin matrix, mineral fillers, pigments, performance additives

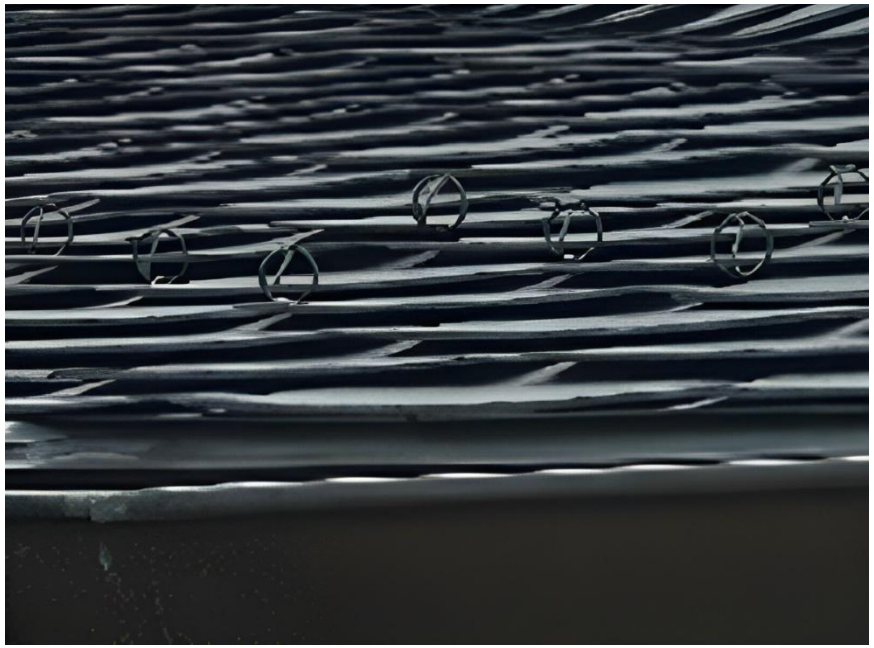
RIGID, HIGH BS	**← BENDING STRENGTH →**	DEFORMABLE WITH HEAT
SOME VARIETIES FADE	**← DISCOLOURATION →**	FADES
0.2-0.4%	**← WATER ABSORPTION →**	0.0-0.5%
MORE THAN 1,700 °F	**← TEMPERATURE RESISTANCE →**	AROUND 300 °F
NO	**← FLAMMABILITY →**	NO
MORE THAN 100 y	**← LIFE SPAN →**	EXPECTED 50 y

2. Different materials, different performances

NATURAL SLATE

← **BENDING STRENGTH** →

SYNTHETIC SLATE

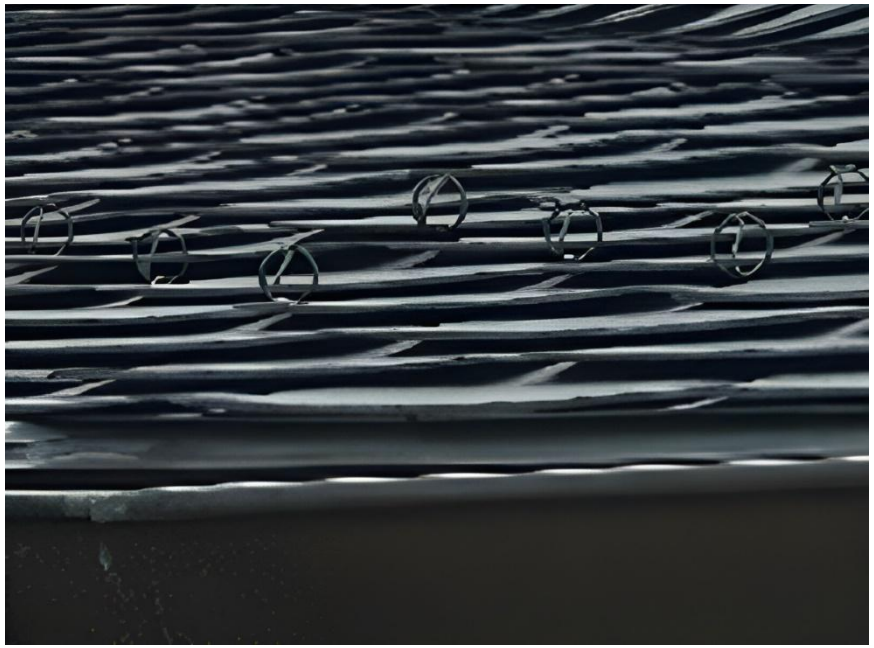


2. Different materials, different performances

NATURAL SLATE

← **BENDING STRENGTH** →

SYNTHETIC SLATE



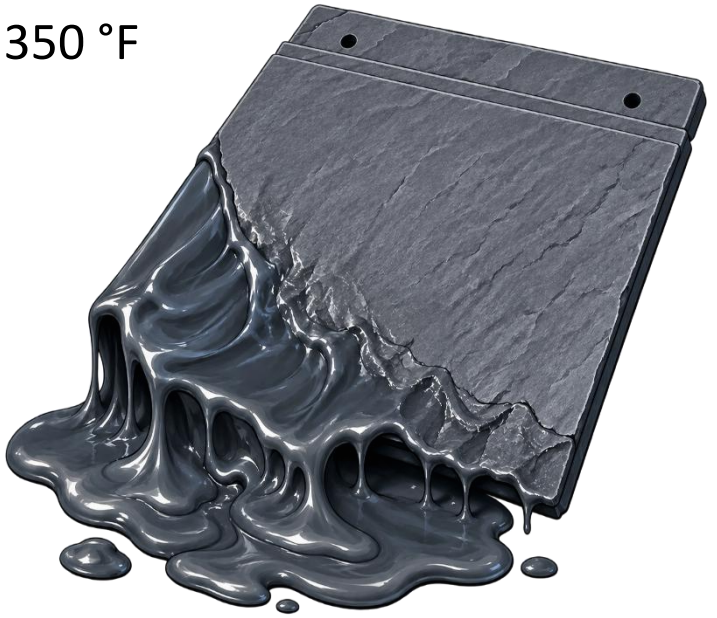
2. Different materials, different performances

NATURAL SLATE

← **TEMPERATURE RESISTANCE** →

SYNTHETIC SLATE

350 °F



AI-generated image

Fire resistance of roofing slates: Mechanical, mineralogical and aesthetic changes alongside temperature increase
V. Cárdenes, A. Rubio-Ordóñez and J. García-Guinea
Construction and Building Materials 2023 Vol. 368 Pages 130376

3. Sustainability, durability and economic benefit

- **Sustainability** is the ability to maintain or support a process, system, or condition over time without depleting finite resources.
- **Durability** is the ability to withstand wear, pressure, or damage.
- **Economic benefit** refers to any gain, advantage, or positive financial impact that can be measured and quantified in money.

Natural slate vs. Synthetic slate: which offers better values?

AI-generated image

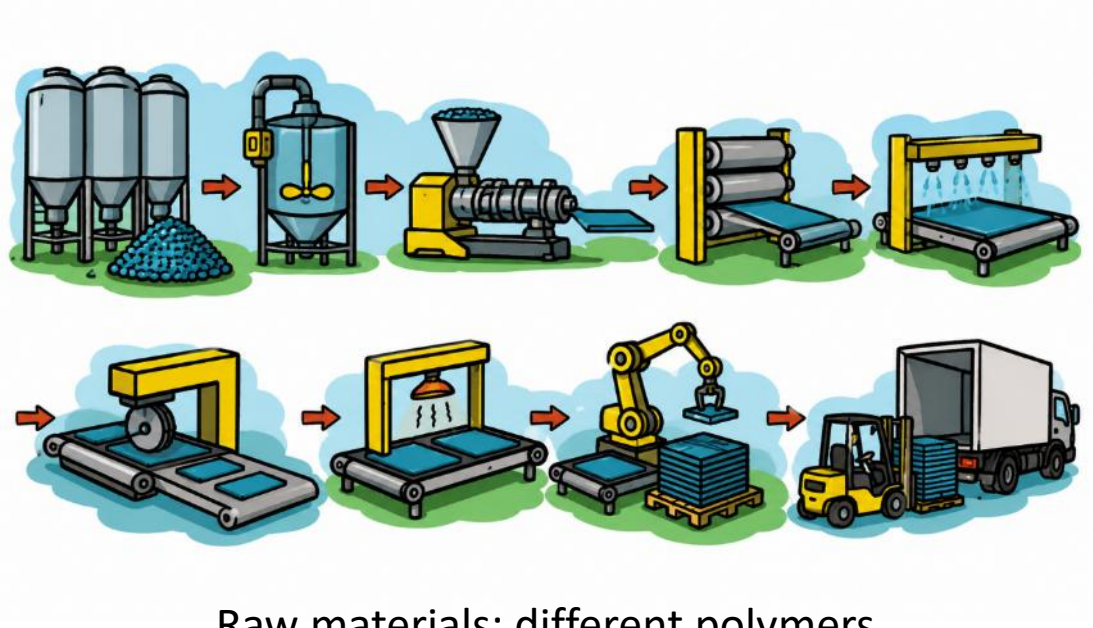
3. Sustainability, durability and economic benefit

Sustainability

Natural slate

Raw materials: slate rock

Synthetic slate



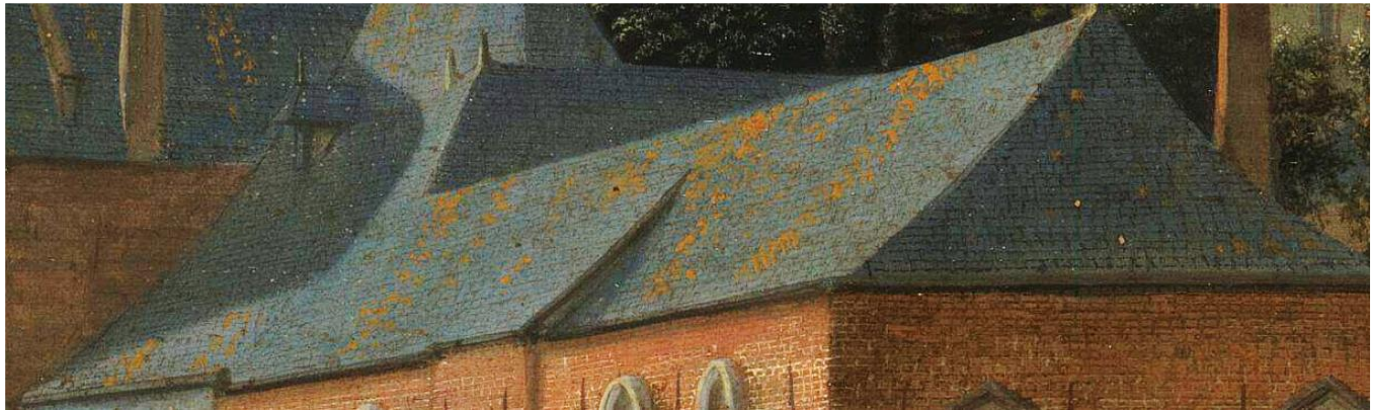
Raw materials: different polymers and plastics derived from petroleum

Both are finite resources

3. Sustainability, durability and economic benefit

Durability

Natural slate has been used for millennia. Its durability (100 to 300 years) is more than proven.



A view on Cologne (1660) - Jan van der Heyden.
National gallery of London

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3. Sustainability, durability and economic benefit

Durability

Synthetic plastic slate only from the beginning of this century. The warranties state 50 years, but this figure is not verified on the ground.

3. Sustainability, durability and economic benefit

Durability

The way these materials weather matters¡

Natural slate slowly decompose into small fragments → sand.

Synthetic plastic slate breaks down rapidly into **microplastics**, which pose a serious danger to environmental health.

3. Sustainability, durability and economic benefit

Economic benefit

Cost component	Synthetic slate (US$/m²)	Natural slate (US$/m²)
Roofing slate material	**$29–58**	**$41–81**
Battens, underlay and fixings	**$17–29**	**$17–29**
Installation labour	**$35–58**	**$52–87**
Total installation cost	**$81–146/m²**	**$111–198/m²**
Average reference cost	**≈ $114/m²**	**≈ $155/m²**
First installation		

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3. Sustainability, durability and economic benefit

Economic benefit

Material	Cost per installation (US$/m²)	Installations in 100 years	**Total 100-year cost (US$/m²)**	**Average cost per year (US$/m²/year)**
Synthetic slate	$114	2	**$228**	**$2.28**
Natural slate	$155	1	**$155**	**$1.55**

Taking into account a 100-year period, natural slate becames cheaper tan synthetic slate

YOU GET WHAT YOU PAY FOR

(CHEAP IS EXPENSIVE, in Spanish)

3. Sustainability, durability and economic benefit

Economic benefit

Material	Cost (€/m²)	Lifespan	Average annual cost (Cost/Lifespan)
Asphalt shingle	25,18	5 – 15	5,03 – 1,68 €
Concrete tile	29,12	30 – 40	0,97 – 0,72 €
Ceramic tile	31,27	30 – 40	1,04 – 0,78 €
Copper roofing	104,93	20 – 80	5,24 – 1,31 €
Sheet metal roofing	30,33	20 – 40	1,51 – 0,76 €
Zinc roofing	59,00	20 – 80	2,95 – 0,73 €
Slate roofing	36,70	70 – 120	0,52 – 0,30 €

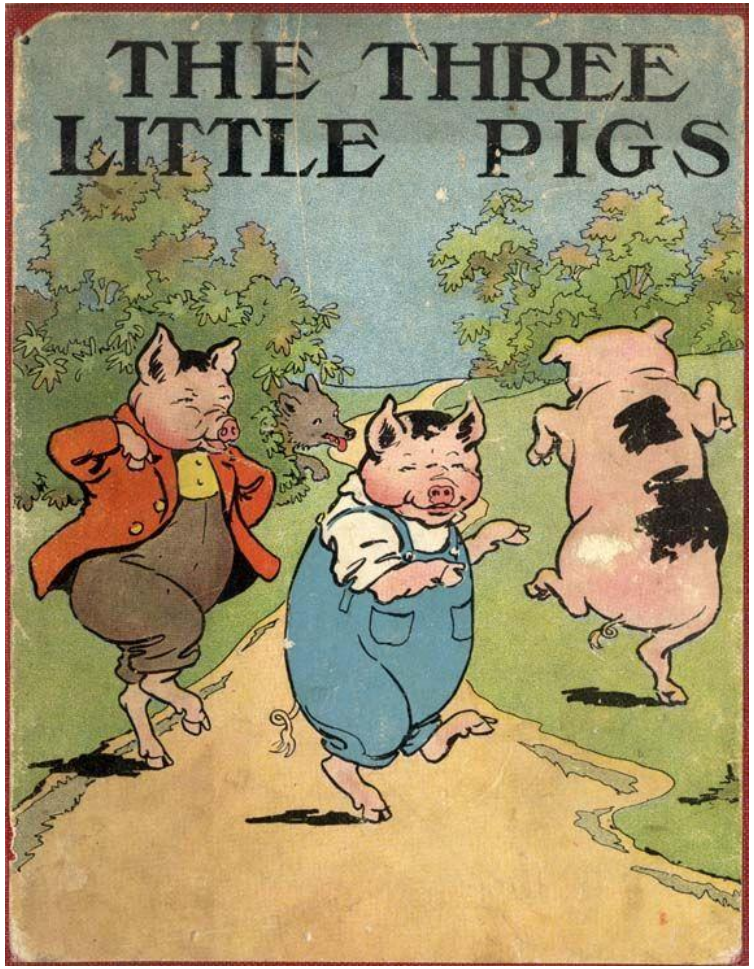
Average annual cost for different roofing materials.
Source: Spanish College of Technical Architectcs

3. Sustainability, durability and economic benefit

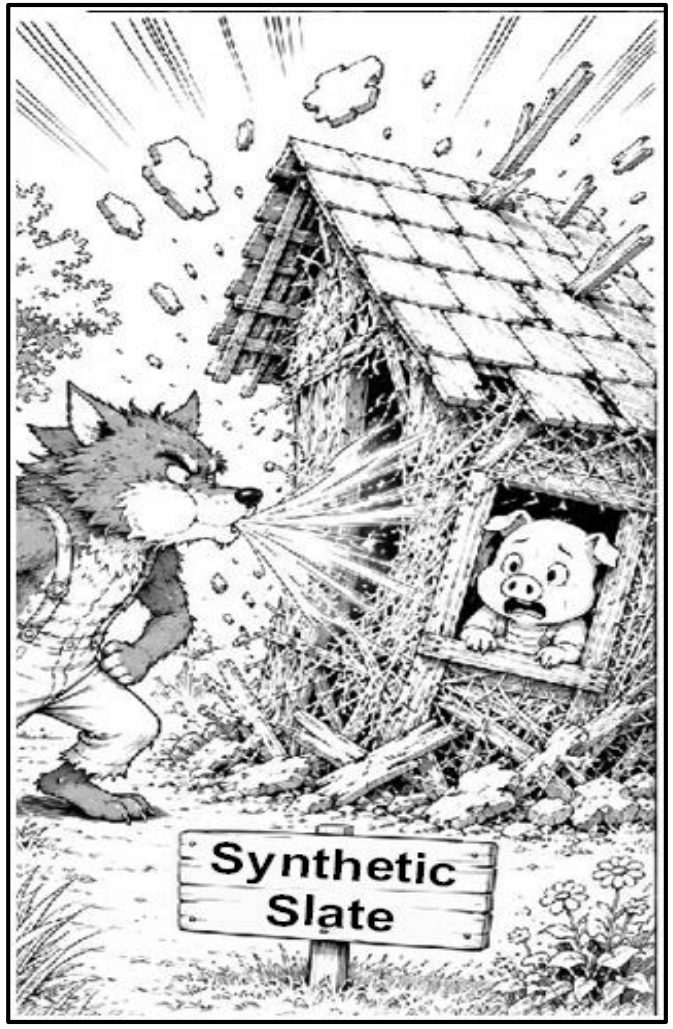
Economic benefit

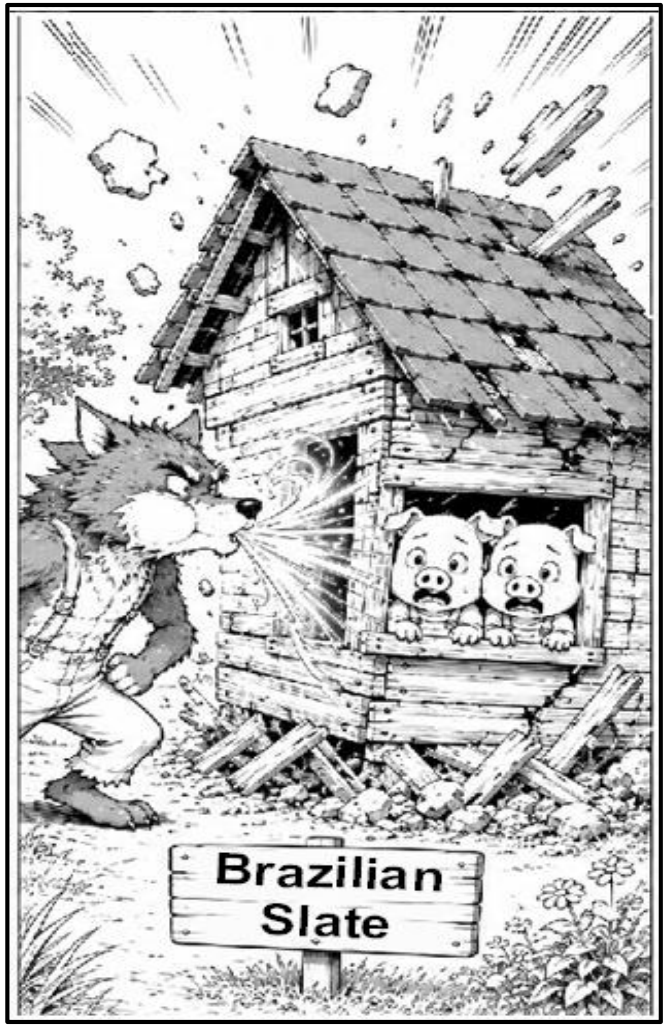
Question: How can we transmit these knowledge to our customers?

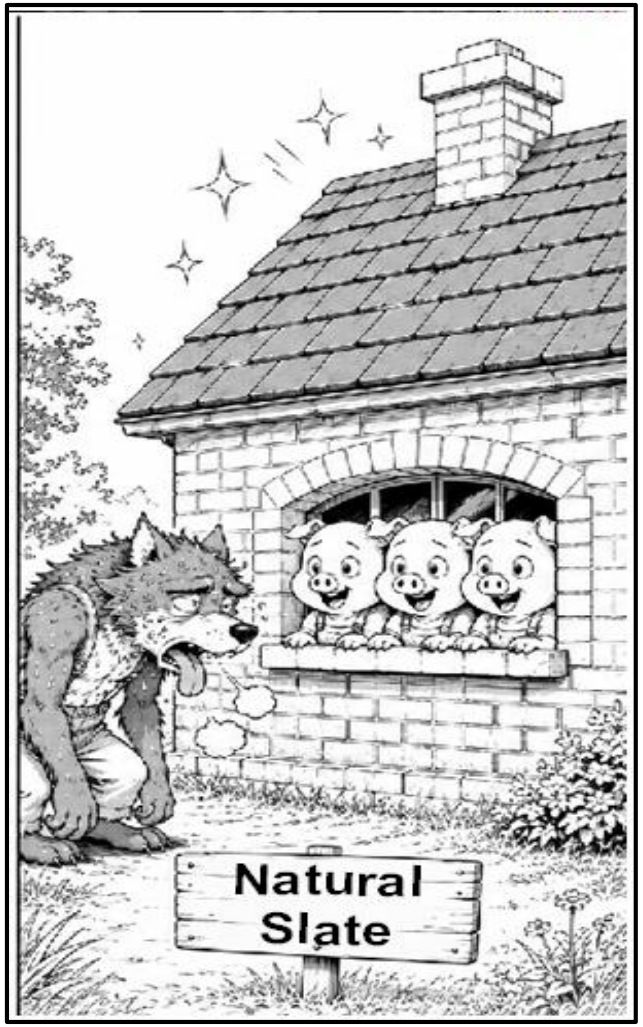
Answer: Use the old way, fables



The Three Little Pigs







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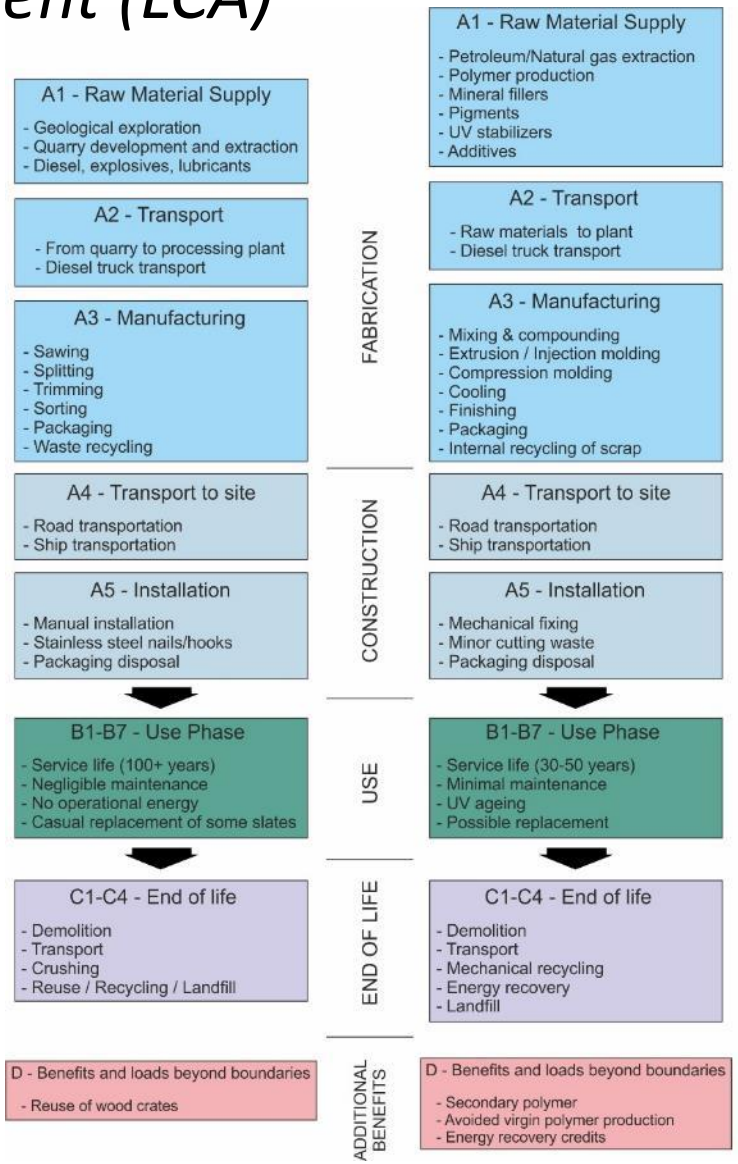
4. Comparing the Life Cycle Assessment (LCA)

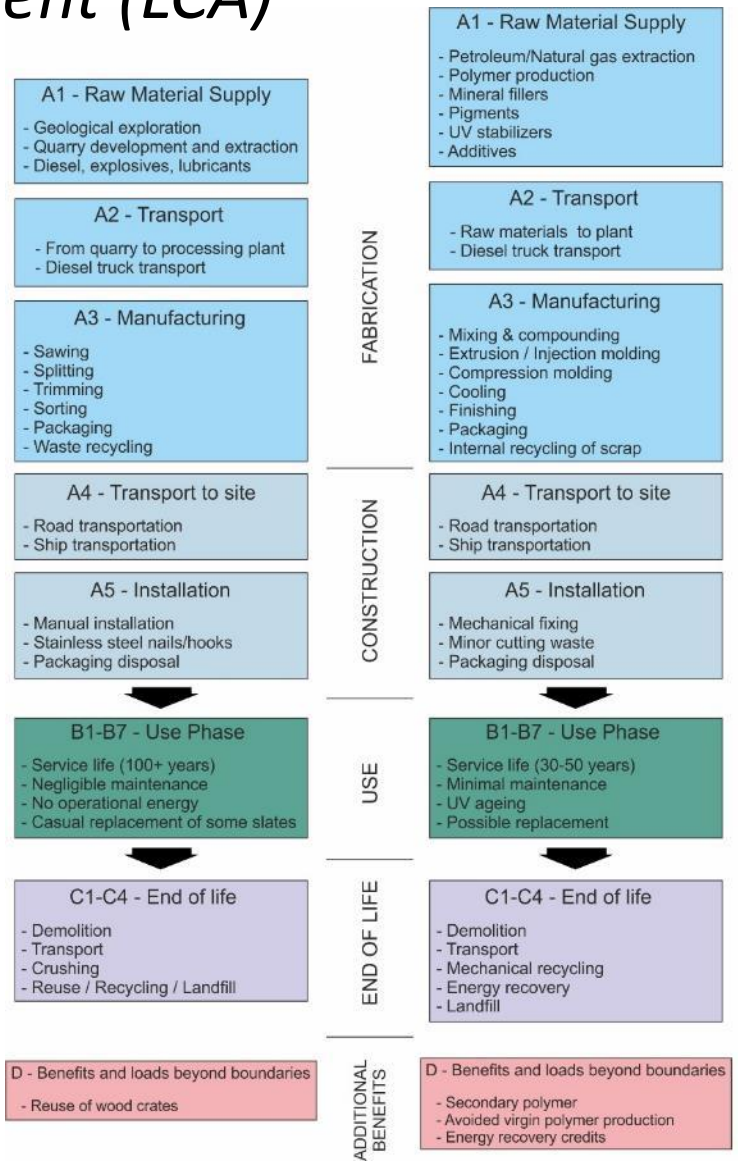
Life Cycle Assessment (LCA) is a scientific method used to measure the total environmental impact of a product, service, or process across its entire life span—from raw material extraction through production, use, and final disposal



4. Comparing the Life Cycle Assessment (LCA)

Source data: LCA reports published by
- Spanish Roofing Producers Association (AGP)
- Synthetic Slate companies

These data are freely available at the WWW



4. Comparing the Life Cycle Assessment (LCA)

Greenhouse-gas emissions by LCA stage

LCA stage	Natural Spanish slate	EcoStar synthetic slate	Main interpretation
A1–A3: Product stage - Manufacturing	**Low**	**Higher**	Natural slate requires quarrying and mechanical processing, whereas synthetic slate involves recycled-polymer processing, compounding and moulding.
A4: Transport to site	Potentially higher per tonne due to greater weight	Lower per tonne due to lower density	Transport depends strongly on the specific distance and transport scenario used in each EPD.
A5: Installation	**Low**	**Low**	Both stages make a relatively limited contribution to total GHG emissions.

4. Comparing the Life Cycle Assessment (LCA)

Greenhouse-gas emissions by LCA stage

LCA stage	Natural Spanish slate	EcoStar synthetic slate	Main interpretation
B1–B5: Use stage	Very low over 100 years	Higher when replacement is included	Natural slate can complete the 100-year period without replacement, while EcoStar requires a second product cycle under the 50-year service-life assumption.
C1–C4: End of life	Low to moderate	Potentially higher	Natural slate is inert and can be reused or recycled as aggregate; synthetic composites have more complex end-of-life routes.
D: Beyond system boundary	Potential environmental credit from reuse/recycling	Credit from avoided virgin-material production	Natural slate benefits of its high reuse potential (salvaged slate)

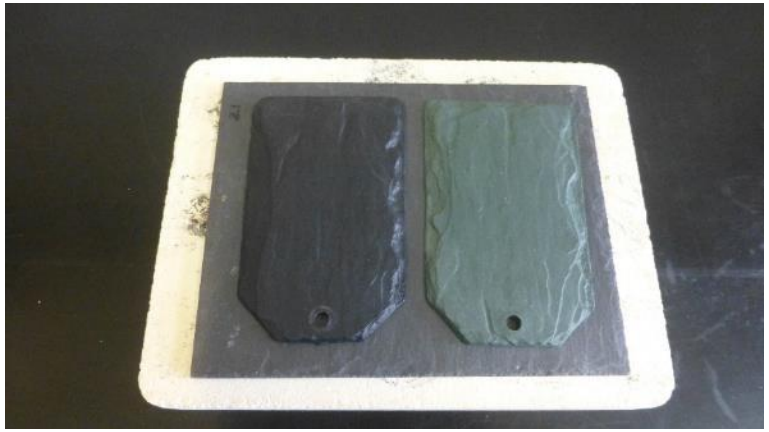
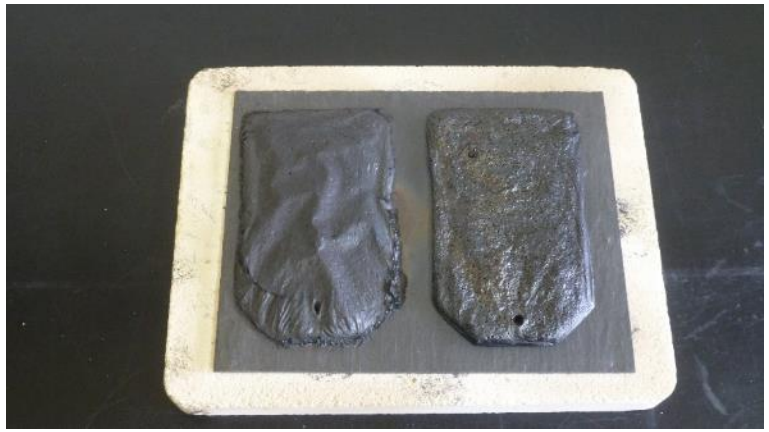
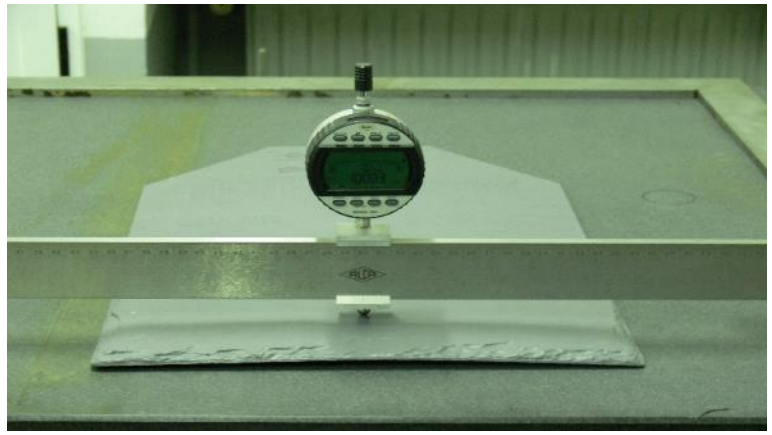
5. Some laboratory test

- Natural and synthetic slates are two very different materials
- Difficult to find tests for comparation:

Standard	Title	Purpose	Results
ISO 4892	Plastics—Artificial Weathering	UV durability	No significant changes (2000 hours)
ISO 75	Plastics — Determination of temperature of deflection under load (modified)	Durability along thermal increase / thermal expansion	Similar thermal expansión for both materials
EN 12326 (9)	Determination of the deviation from flatness (modified)	Deformability and service temperature resistance	Synthetic slates showed severe failure at 350 °F / deformation at 140 °F
EN 12326 (14)	Sulfur dioxide exposure	Resistance to acid environment	No significant changes

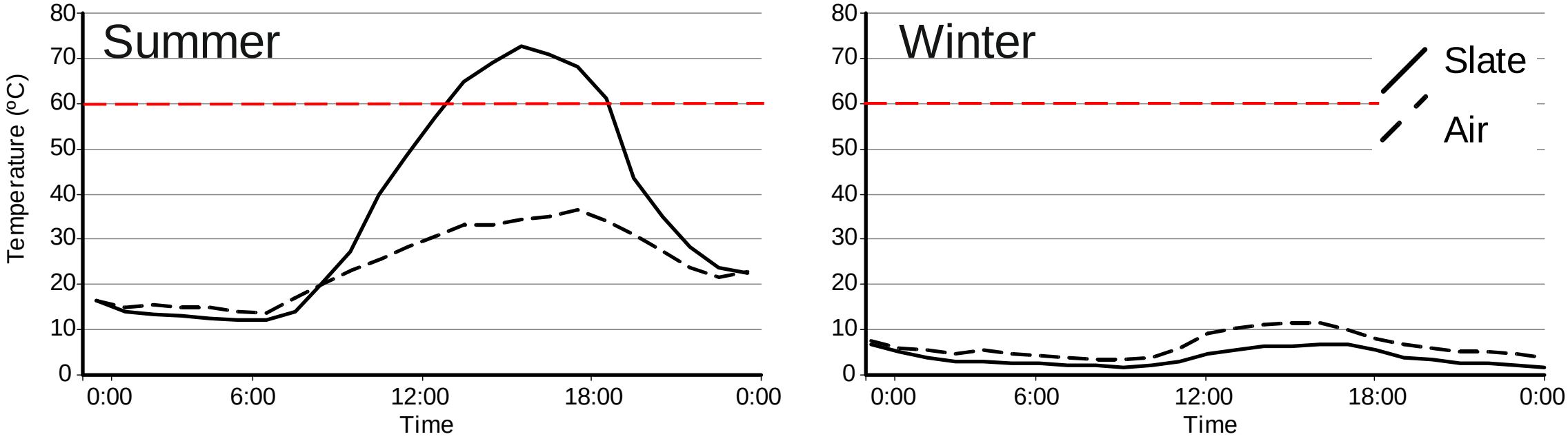
5. Some laboratory test

Thermal response test

	Before	After
350 °F		
140 °F		

5. Some laboratory test

Daily temperatures on a slate cover



Petrography of roofing slates
V. Cárdenes, Á. Rubio-Ordóñez, J. Wichert, J. P. Cnudde and V. Cnudde
Earth-Science Reviews 2014 Vol. 138 Pages 435-453
DOI: 10.1016/j.earscirev.2014.07.003

6. Conclusions

- **Sustainability** depends on both **environmental impacts** and **long-term durability**.
- LCA: Natural slate has lower environmental impact than synthetic slate.
- Thermal performance: Natural slate is significantly more thermally stable than synthetic slate.
- Durability: Longer service life substantially reduces the cumulative environmental impact of roofing materials.
- Reuse potential: Reusing salvaged slate could further improve its environmental performance.
- **Natural slate offers the strongest combination of low impact, durability, and reuse potential**.

Natural slate vs. Synthetic slate

Any Questions?

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