Decarbonization Wedges Exercise

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LOW-CARBON BUILDING AND BUILDING ENVELOPES

1. State of the art and current development in different world regions

The major technologies associated with the envelope of low-carbon building fall into the following 3 categories:

- Air tightness
- Thermal insulation
- Windows and protection

The first category will not be assessed in this template as it is hard to associate a specific technology with air sealing. Thermal insulation technologies can be divided into three major methods: traditional insulation materials— like glass wool and mineral wool—, natural fiber insulation —from straw, hemp, linen, lamb's wool, etc. — and 'super'-insulation —vacuum insulation and aerogel.

Low-carbon building focuses on existing buildings and on thermal retrofitting. However new insulation technologies and performant windows are also crucial to the performance of new buildings.

2. Maturity level and technological perspectives

Maturity of low-carbon building and building envelopes

Methodological information:

The maturity level is the TRL, reduced to 5 levels with market deployment enclosed in the higher TRL classes; maturity level scaling: 0 = none; 1 = fundamental research; 2 = R&D; 3 = demonstrator; 4 = low deployment; 5 = large deployment.

	2015	2020	2030	2040	2050
Traditional insulation	5	5	5	5	5
Natural fiber insulation	3-4	4	5	5	5
Super insulation	2-3	3	4	4	5
Windows and protection	5	5	5	5	5

Traditional insulation materials are a mature technology.

This technology is currently quite used, notably in European countries —notably with existing buildings and heating requirements— as well as in North America and in China, though to a lesser extent. As increasing life standards led to better comfort standards, traditional insulation will gain momentum on the worldwide scale. However it will not play a significant role regarding climate change.

The asset of natural fiber insulation is its low environmental impact, especially in terms of carbon footprint. However, considering the thermal conductivity, natural fiber materials are not as performant as traditional insulation materials. Natural fiber also involves stability issues over time, especially due to moisture sensitivity.

Super-insulation materials display a high thermal performance, which is why they can be used in thin layers. However this technology is not stable yet and the involved costs are still very high. Like traditional insulation materials technology, windows have reached technological maturity and display high a thermal performance. However, installation on site is often an issue with windows.

Potential development of low-carbon building and building envelopes

Methodological information:

Potential development is measured as the percentage of the technology's contribution to environmental protection. This means evaluating, in terms of carbon emissions and of carbon emissions reduction, to what extent this new technology can contribute to limiting temperature increase to 2°C above pre-industrial level according to the time horizon considered in this study. Potential development scaling: 0 = not significant; 1 = significant (i.e. more than 1% of global emissions reduction) in some countries; 2 = significant on the global scale; 3 = very significant on the global scale (i.e. up to 3% of global emissions reduction); 4 = major technology vs. climate change (i.e. more than 3% of global emissions reduction).

	2020	2030	2040	2050
All technologies	2	3	3	3

Low-carbon buildings will have a significant role in energy transition and its effects are already visible today.

3. Technological, economic and social bottlenecks

Methodological information:

The following table ranks the bottlenecks according to their impact on the development of the technology. A bottleneck ranking at 6 on the scale will hinder or stall the deployment of the technology compared with bottlenecks ranking at 1; conversely, a bottleneck ranking at 1 will hinder the deployment of the technology much less than bottlenecks ranking at 6. Note that the ranking is relative, meaning that a bottleneck ranking at 6 is not necessarily hard to remove; conversely, a bottleneck ranking at 1 is not necessarily easy to remove. Technologies rank according to: research, finance, regulations, resources & environment, security and acceptability. The table also contains keywords associated with each bottleneck.

Technology		**Research & technological bottlenecks**	**Economy and Financial bottlenecks** (investment, risks)	**Regulation & institutional environment**	**Resources & environmental impacts** (including scarcity of raw materials, water, land, climate)	**Safety & security** (impacts on health, people and security assets)	**Socio-technical feasibility**
Traditional insulation	Rank	1	3	4	5	2	6
	Key-words	No —or very few— R&D programs	Long time of return on investment for refurbishment	Incentive role of thermal regulation	Carbon footprint	Handling of materials during mounting	Installation quality
Natural fiber insulation	Rank	6	5	3	1	2	4
	Key-words	Stability of performances over time	Overcost compared to traditional insulation materials	Thermal regulation	Low environmental impact		Specific know-how for installation
Super insulation	Rank	6	5	2	4	1	3
	Key-words	R&D programs needed	Overcost compared to traditional insulation materials	Thermal regulation	Environmental issues with some materials		Specific know-how for installation
Windows and protection	Rank	-	4	5	-	-	6
	Key-words	No —or very few— R&D programs	Overcost of very performant materials Long time of return on investment for refurbishment vs. energy bill	Thermal regulation			Mounting quality

The major bottleneck with traditional insulation materials pertains to mounting. Traditional insulation is also a technology with a high carbon footprint, which is why R&D programs are currently carried on for this technology.

Concerning new insulation technologies, R&D programs are needed to stabilize performances —i.e. ageing of components for natural fiber materials— and to reduce costs. Aspects related to R&D and economics are of foremost importance: this is why feasibility bottlenecks —i.e. mounting— seem of a lesser importance, even if they play a significant and even stronger role than for traditional insulation.

Environmental issues are crucial for insulation materials, both for traditional and for natural fiber insulation.

Finally the importance of the regulation environment should be mentioned for all technologies: indeed the regulation environment plays an essential role in the deployment of thermal regulation.

4. Potential radical and incremental innovations

<u>*Methodological information:*</u>

The following table lists the nature of innovations needed to overcome the bottlenecks mentioned earlier. There are two types of innovations: I stands for 'incremental innovation' (i.e. improving existing products and processes) and R stands for 'radical innovation' (i.e. developing new products and processes).

Technology		**Research & technological innovations**	**Economy and Financial innovations** (investment, risk)	**Regulation & institutional environment**	**Resources & environmental impacts** (including scarcity of raw materials, water, land, climate)	**Safety & security** (impacts on health, people and security assets)	**Socio-technical feasibility**
Traditional insulation	I or R						R
	Key-words						Specific know-how
Natural fiber insulation	I or R	I					R
	Key-words						Specific know-how
Super insulation	I or R	I/R					R
	Key-words	Performance, costs					Specific know-how
Windows and protection	I or R						R
	Key-words						Specific know-how

Radical innovations are expected concerning insulation materials and windows mounting. Such innovations would involve reassessing completely operations on building sites, improving training and valorizing career pathways and industrializing processes to guarantee performance during implementation processes.