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**SUSTAINABLE, HIGH-PERFORMANCE  
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**MAPPING THE TIMBER CONSTRUCTION SECTOR – THE BIG PICTURE**

Aída Santana Sosa  
14.03.2023



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**Mapping the timber construction sector**

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**CONTENT**

1. Background
2. Problematic
3. Methodology
4. Findings

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### BACKGROUND – CHALLENGES

1. Urbanisation: Global population growth

75% population will live in cities by 2050

40% population will need new buildings by 2050

|      |           |
|------|-----------|
| 2050 | 2.137.034 |
| 2025 | 1.918.303 |
| 2020 | 1.853.846 |
| 2014 | 1.767.898 |

➤ Cost efficient housing in short time

|          | Population as of 1 Jan. 2018 | Change 2008 – 2018 in % |
|----------|------------------------------|-------------------------|
| Vienna   | 1,888,776                    | 13.0                    |
| Munich   | 1,456,039                    | 11.0                    |
| Hamburg  | 1,830,584                    | 3.4                     |
| Warsaw   | 1,761,298                    | 3.0                     |
| Budapest | 1,749,734                    | 2.8                     |

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### BACKGROUND – CHALLENGES

2. Environmental assessment: CO2 Emissions

33% global CO2 emissions

40% energy consumption

60% electricity consumption

Total Carbon Emissions of Global New Construction from 2020-2050  
Business as Usual Projection

Embodied Carbon

Embodied Carbon

Embodied Carbon

Operational Carbon

Embodied Carbon

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### BACKGROUND – CHALLENGES

#### 3. Resource scarcity and waste

40% global resource use

30% EU waste Annually in the EU

12% Water consumption

- Scarcity of resources
- Rising material costs
- **Higher pressure on construction sector**
- Renewable materials
- Circular economy: maintain and repair, refurbish, disassemble and reuse, recycle
- Resource efficiency: Optimal resource use, less waste, shorter transports

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### BACKGROUND – CHALLENGES

#### 3. Productivity growth

Global productivity growth trends<sup>1</sup>

Real gross value added per hour worked by persons engaged, 2005 \$  
Index: 100 = 1995

Compound annual growth rate, 1995-2014

Hourly rate

|               |      |
|---------------|------|
| Construction  | \$25 |
| Total economy | \$37 |
| Manufacturing | \$39 |

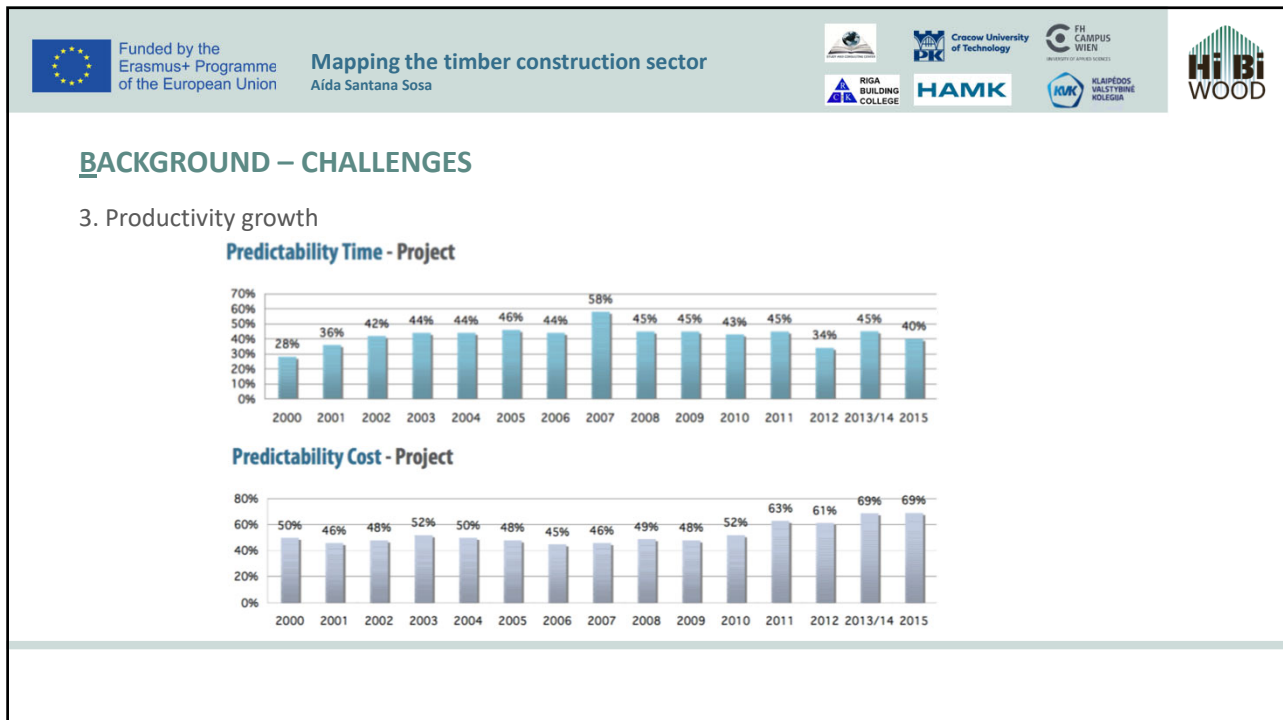
3.6 +2.6

**Manufacturing Industry**

**Construction Industry**

- Just in Germany in 2018 over 17 **billions** € were tracked back to mistakes occurred on the site.
- Fewer mistakes through higher prefabrication level and standardisation.
- Avoid follow-up costs

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### BACKGROUND – CHALLENGES

- Labour-intensive on-site
  - Too little space available in dense urban environments
  - Physically intensive work
  - Non-ergonomic working conditions (material supply, weather, short distances, repetitive tasks...)
  - In need of higher safety → Less accidents, mistakes and injuries → less insurance costs
- Financial pressure: reduced budgets
  - Material preparation, equipment, tools, machinery
  - Material saving
  - Personnel costs
  - Increased productivity (serial production of components)
  - Interchangeability or reusability of elements (Leasing)

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### BACKGROUND – CHALLENGES

- Shorter construction time
  - Parallel work on site and at the factory
  - Earlier handover
- Higher quality requirements
  - Through prefabrication in the factory (industrial production)
  - More accuracy (passive standards)
  - Less emissions, less waste
  - Less need for on-site adaptation of the elements
- More reliable cost and time estimations
  - Controlled environment → Unpredictable weather phenomena are avoided
  - Assembly site → Less work and disruption (noise, dust...)




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### BACKGROUND

- BIM
- 3D-Printer
- Robots
- ...








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### BACKGROUND – CHALLENGES

**Limit Carbon Intensive Materials**



Asphalt, Concrete and Steel are carbon intensive and major drivers

**Minimize Transportation Carbon Emissions**



**Minimize Waste & Promote Circular Economy**



**Choose Carbon Sequestering Materials**



**Minimize Construction Site Carbon Emissions**

**VolvoBunkers Electric Quay Site Reduces Energy Costs 10%**

Electric cranes, pumps and other equipment at the VolvoBunkers site have reduced energy costs by 10%.


**First fully electric crane in the UK plugs in on Skanska site**

Skanska Construction has installed the first fully electric crane in the UK on a Skanska site. The machine is a 1500kg capacity crane, which is used for lifting and moving materials on the site.









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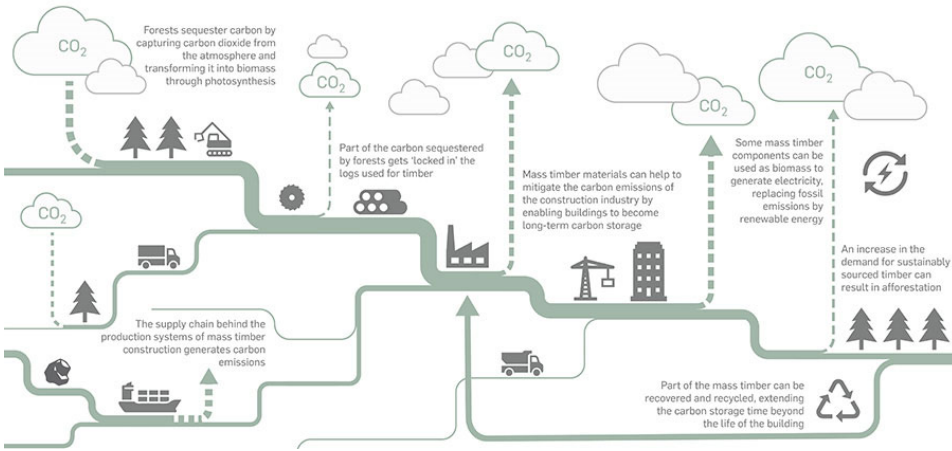
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### BACKGROUND – SOLUTION



Forests sequester carbon by capturing carbon dioxide from the atmosphere and transforming it into biomass through photosynthesis

Part of the carbon sequestered by forests gets 'locked in' the logs used for timber

Mass timber materials can help to mitigate the carbon emissions of the construction industry by enabling buildings to become long-term carbon storage

Some mass timber components can be used as biomass to generate electricity, replacing fossil emissions by renewable energy

An increase in the demand for sustainably sourced timber can result in afforestation

The supply chain behind the production systems of mass timber construction generates carbon emissions

Part of the mass timber can be recovered and recycled, extending the carbon storage time beyond the life of the building

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### BACKGROUND – SOLUTION


**Structural performance?**

| Building Name                   | Year                           | Height (m) | Storeys | Architects                               |
|---------------------------------|--------------------------------|------------|---------|--|
| Toji Temple                     | Japan, 988                     | 57         | 5       |  |
| Pura Besakih Temple             | Bali, 19th century             | 44         | 11      |  |
| Hippsteadt stave church         | Norway, 1130                   | 27         | 4       |  |
| Ogu Ten                         | China, 1420                    | 25         | 3       |  |
| "Alter Bau" granary             | Germany, 1445                  | 21         | 7       |  |
| Damaschke housing estate        | Germany, 1996                  | 9          | 3       | Architects: Firk + Jocher                |
| H 8                             | Germany, 2012                  | 25         | 8       | Architects: Schenkula Architekten        |
| Fortis Tower                    | Australia, 2012                | 32         | 10      | Architects: Landbase                     |
| Student residence               | Canada, 2017                   | 63         | 18      | Architects: Acton Osby Architects        |
| Hydro timber high-rise building | Austria, in the planning stage | 84         | 24      | Architects: RLP Rüdiger Lainer + Partner |



Sources: Kaufmann 2018



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### BACKGROUND

Attractive ecological, social and economic(?) solution



**Weight and design load**

|  |   |   |
|--|---|---|
| <p><b>Benchmark</b></p> <div style="display: flex; justify-content: space-around;"> <div style="width: 15px; height: 15px; background-color: #808080; margin: 0 auto;"></div> <div style="width: 15px; height: 15px; background-color: #d3d3d3; margin: 0 auto;"></div> </div> <p>1.00<br/>Dead load</p> <p>1.00<br/>Design load</p> | <p><b>Option 1<br/>CLT</b></p> <div style="display: flex; justify-content: space-around;"> <div style="width: 15px; height: 15px; background-color: #808080; margin: 0 auto;"></div> <div style="width: 15px; height: 15px; background-color: #d3d3d3; margin: 0 auto;"></div> </div> <p>0.30<br/>Dead load</p> <p>0.38<br/>Design load</p> | <p><b>Option 2<br/>CLT RP and TF</b></p> <div style="display: flex; justify-content: space-around;"> <div style="width: 15px; height: 15px; background-color: #90ee90; margin: 0 auto;"></div> <div style="width: 15px; height: 15px; background-color: #90ee90; margin: 0 auto;"></div> </div> <p>0.26<br/>Dead load</p> <p>0.35<br/>Design load</p> |
|--|---|---|

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**BACKGROUND**

Transport comparison

**Benchmark**  
Mineral based

**Option 1**  
CLT

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**BACKGROUND**

Construction schedule

**Design phase (14 months)** M 0 to M 14

| Option                             | End Date | Potential Savings     |
|------------------------------------|----------|-----------------------|
| Benchmark_ standard mineral based  | M 29     | -                     |
| Option 1_ CLT massive wood frame   | M 26     | -13 weeks<br>115 kEUR |
| Option 2_ CLT rib and timber frame | M 26     | -11 weeks<br>100 kEUR |

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## BACKGROUND – MAIN QUESTION



### Why is Timber not widely Implemented in Large Volume Constructions?

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## PROBLEMATIC

- Planning and building with timber is **different**
- Lack of common **understanding** about interdependences



- **Inefficient** collaboration and large conflicts
- Higher costs, time overruns, tension and dissatisfaction

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## PROBLEMATIC

What the customer describes

What the project manager understands

What the architect designs

What the developer elaborates

How the consultant presents

How the project was documented

What the plumber installed

What was calculator for the customer

How the solution was expected

What the customer actually wanted


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## PROBLEMATIC


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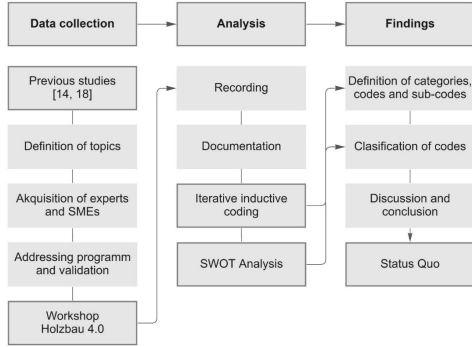
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### METHODOLOGY – HOLZBAU 4.0

- Analysis of factors affecting the design and production of multi-storey timber buildings
- Visualize barriers and opportunities with dependencies and impacts allowing a better management by simulating possible scenarios and developing strategies.



```

    graph TD
      subgraph DC [Data collection]
        P[Previous studies [14, 18]]
        D[Definition of topics]
        A[Akquisition of experts and SMEs]
        V[Addressing program and validation]
        W[Workshop Holzbau 4.0]
      end
      subgraph AN [Analysis]
        R[Recording]
        DO[Documentation]
        ICI[Iterative inductive coding]
        SA[SWOT Analysis]
      end
      subgraph FI [Findings]
        DCAT[Definition of categories, codes and sub-codes]
        CC[Classification of codes]
        DCC[Discussion and conclusion]
        SQ[Status Quo]
      end
      DC --> AN
      AN --> FI
      W --> DC
      W --> AN
      W --> FI
      W --> SQ
  
```

**STATUS QUO OF TIMBER CONSTRUCTION SECTOR AND OPPORTUNITIES FOR SMEs**

Aida Santana Sosa<sup>1,2</sup>, Martha Akkibohor<sup>1,3</sup>, DA

**ABSTRACT:** Timber construction is considered an eco-constructive industry. Nevertheless, it is mainly reserved for residential low-rise buildings. Contemporary high performance building design planning and engineering only places beyond additional costs for planning efforts, construction, design, marketing, cooperation, production, and maintenance. The utilization of multidisciplinary professional buildings, the utilization of multidisciplinary professional construction, design and marketing planning and construction management need to be assessed. Hence, a questionnaire survey from various real practice are envisaged in a questionnaire.

**KEYWORDS:** Multi-storey timber buildings, CO2-emissions

**1 INTRODUCTION**

Construction sector has been performing better satisfactorily during decades. Timber productivity [1], digitization, profitability and customer satisfaction remain to be high. However, digitization, digitization, and high-tech will not remain until 2030. It is responsible for 25% of the world's greenhouse gas [2] and the largest producer of CO2 emissions worldwide [3]. A large part of these emissions can be traced back to energy production [4]. Due to a combination and storage of global carbon together with the introduction of new materials, the digitization of architectural and building processes is required in its early stages [5]. Industrial timber construction is not an effective ecological economic and social solution to reduce the impact and avoid the significant impact [6-10]. This design solution is going against the carbon reduction, limiting global climate to take the lead in reducing greenhouse gas emissions related to the built environment.

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<sup>2</sup>Martha Akkibohor, Department for Building and Design, University of Applied Sciences Campus West-PE Campus Wien, 1040 Vienna, Austria. [martha.akkibohor@fh-campus-wien.ac.at](mailto:martha.akkibohor@fh-campus-wien.ac.at)

<sup>3</sup>Martha Akkibohor, Competence Center for Building and Public Engineering, Applied Science Center for Building and Public Engineering, 1040 Vienna, Austria. [martha.akkibohor@fh-campus-wien.ac.at](mailto:martha.akkibohor@fh-campus-wien.ac.at)

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Building 2022, 11, 144. <https://doi.org/10.3390/building11040144> <https://www.mdpi.com/journal/building>

**Barriers, Opportunities and Recommendations to Enhance the Adoption of Timber within Multi-Storey Buildings in Austria**

Aida Santana Sosa<sup>1,2</sup> and Ina Kovacic<sup>3</sup>

**ABSTRACT:** Timber construction is considered a more energy-efficient and sustainable building construction. However, timber construction is mainly reserved for residential low-rise buildings. Contemporary high performance building design planning and engineering only places beyond additional costs for planning efforts, construction, design, marketing, cooperation, production, and maintenance. The utilization of multidisciplinary professional buildings, the utilization of multidisciplinary professional construction, design and marketing planning and construction management need to be assessed. Hence, a questionnaire survey from various real practice are envisaged in a questionnaire.


**KEYWORDS:** barriers, opportunities, recommendations, multi-storey timber buildings, qualitative analysis, expert surveys



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### METHODOLOGY – HOLZBAU 4.0



- Topics

**Participants**

| Area of expertise      | N° participants |
|------------------------|-----------------|
| Research               | 3               |
| Architectural design   | 5               |
| Specialist consultants | 2               |
| SMEs employees         | 9               |

**Exercise**

|                   | Project A     | Project B    |
|-------------------|---------------|--------------|
| Approach          | Private       | Public       |
| Focus             | Individuality | Fixed budget |
| Quality           | High-Tech     | Low-Tech     |
| Process model     | Cooperative   | Traditional  |
| Time of tendering | Irrelevant    | Fixed        |

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## METHODOLOGY – HOLZBAU 4.0

### Holzbau 4.0

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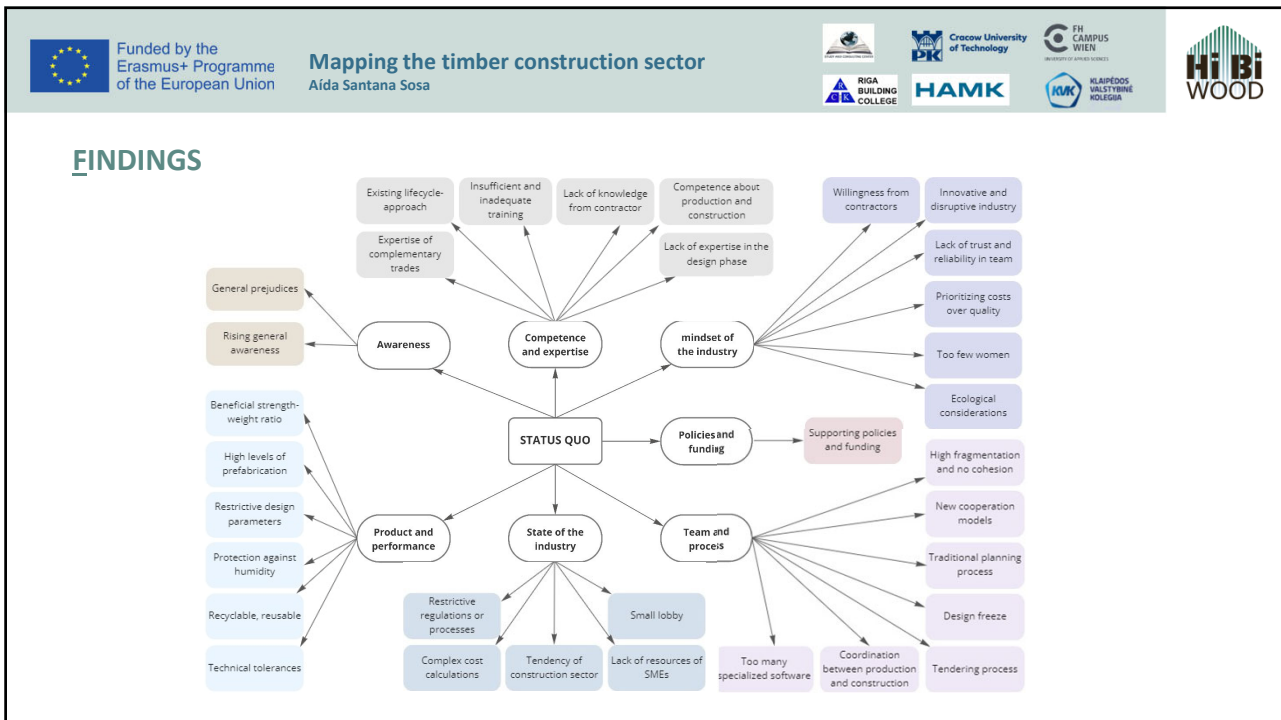
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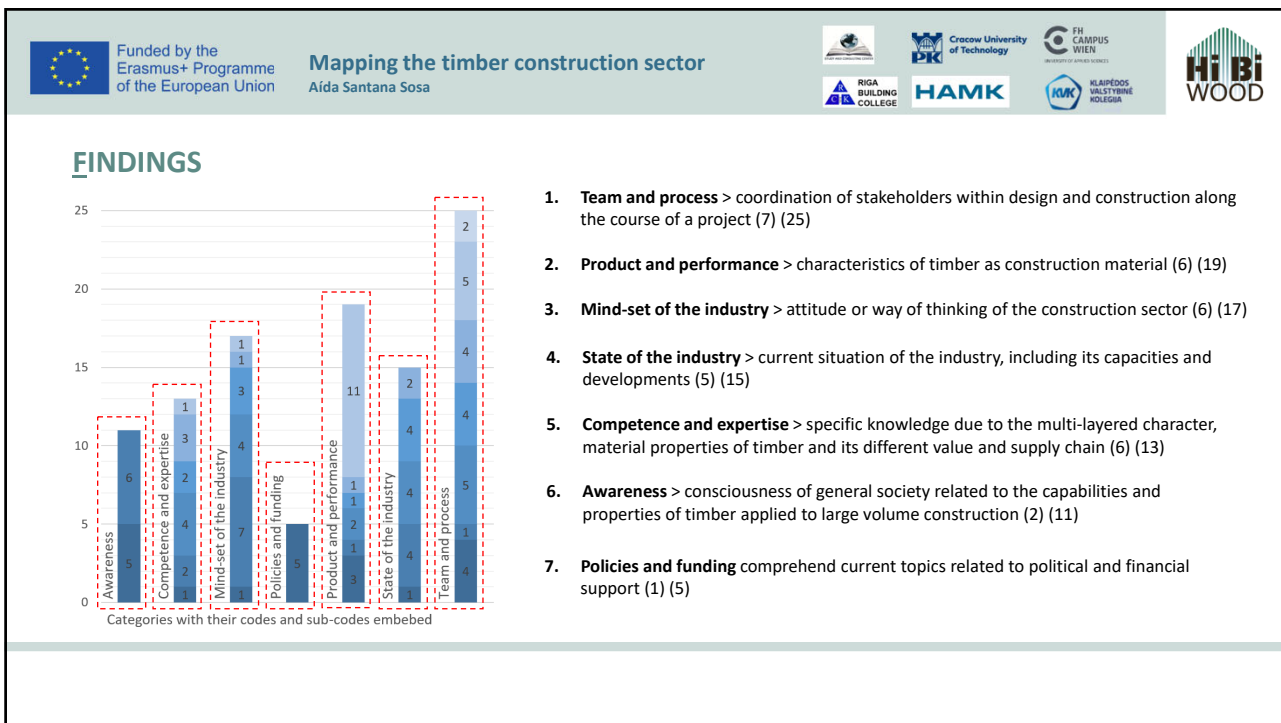
## FINDINGS

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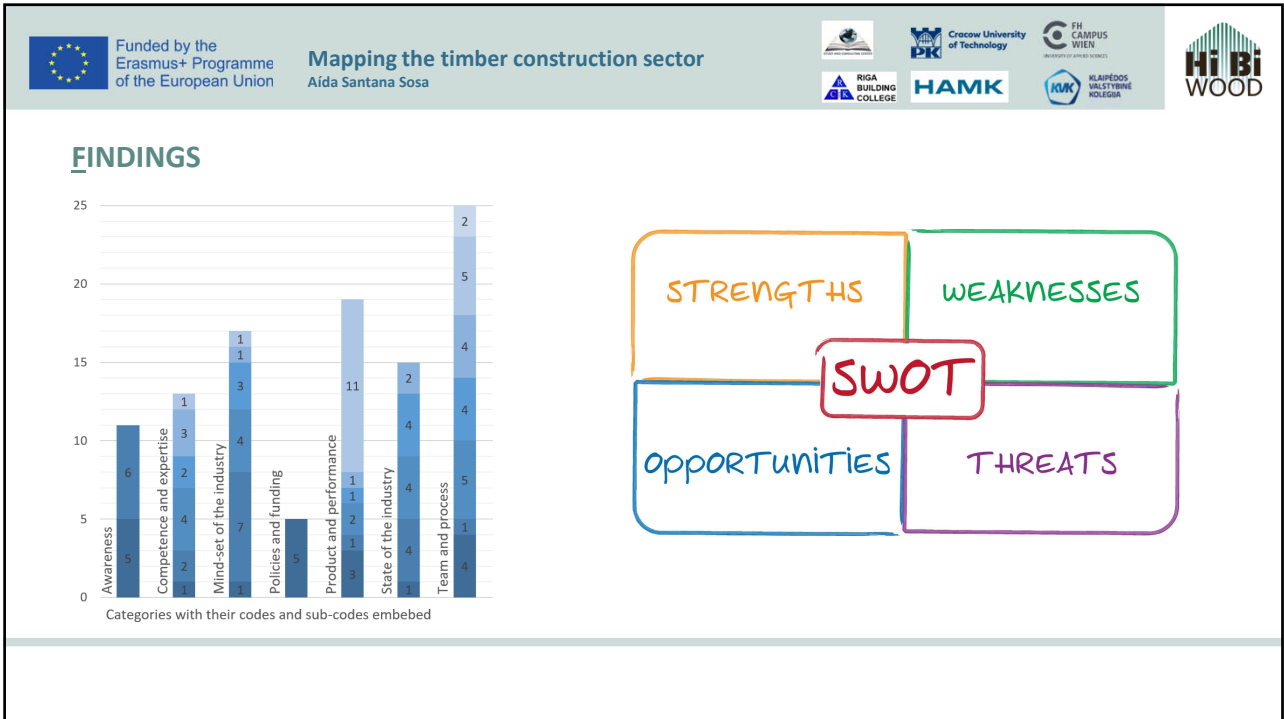


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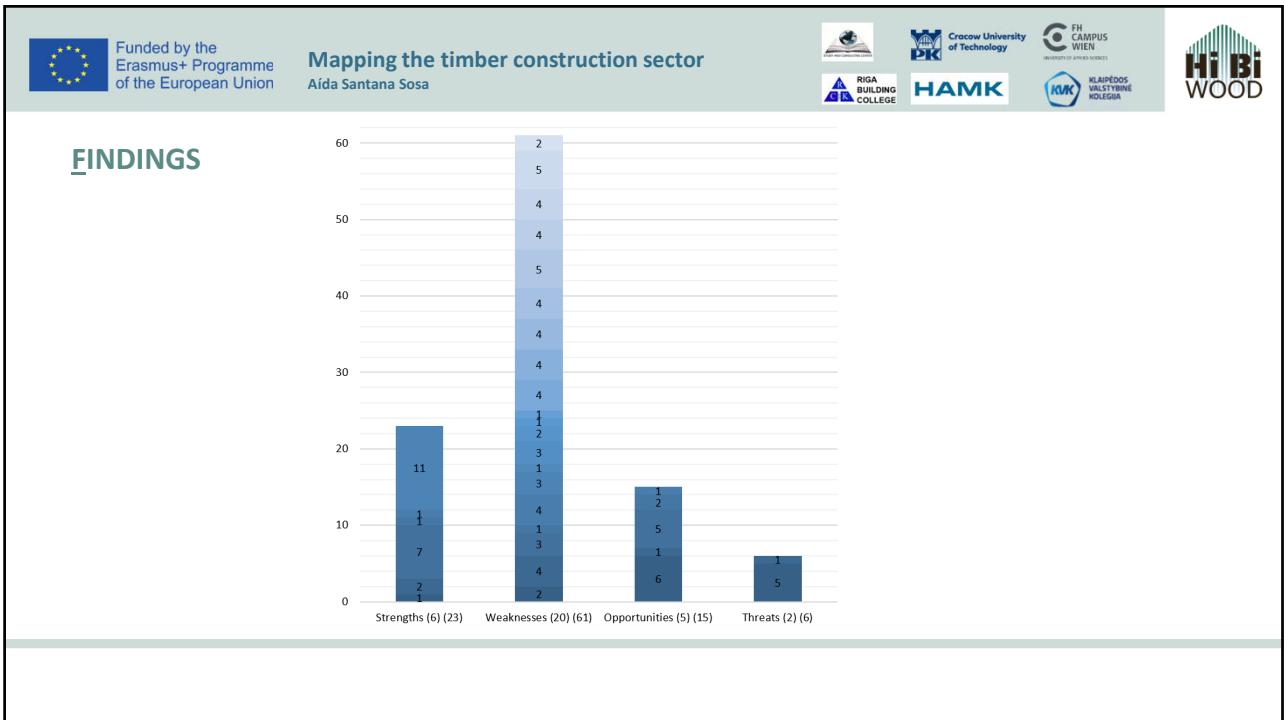


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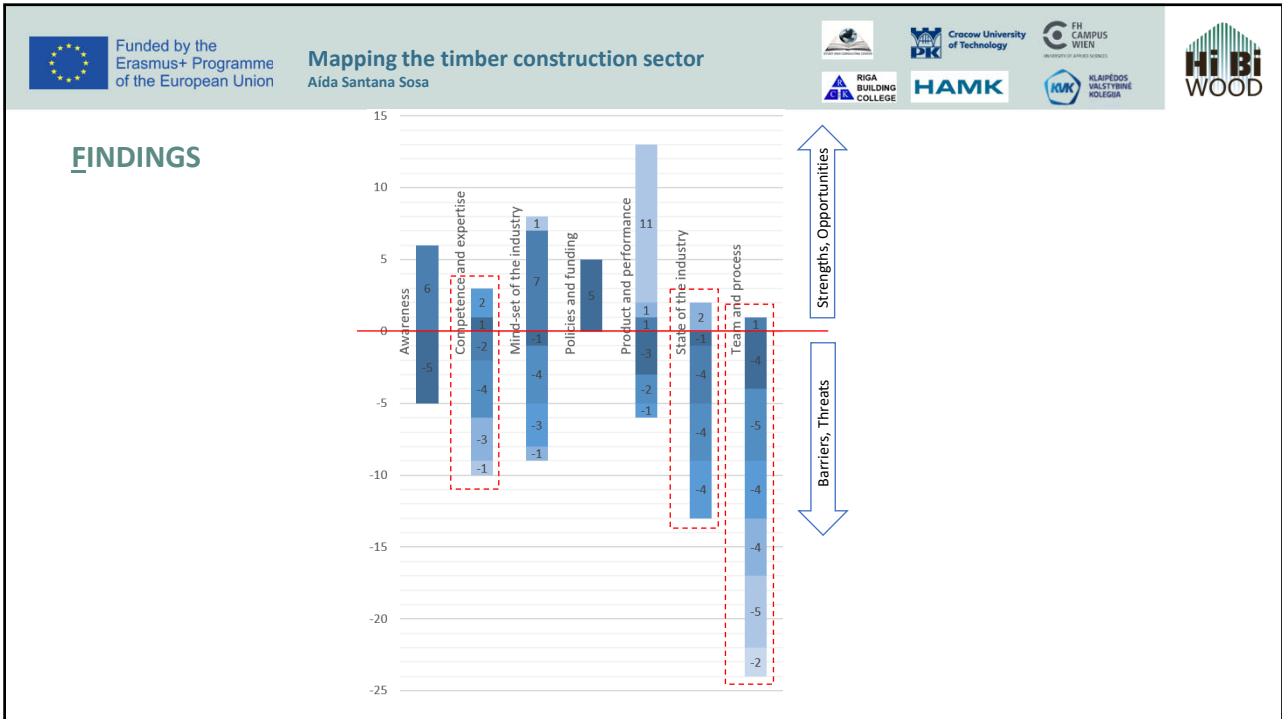




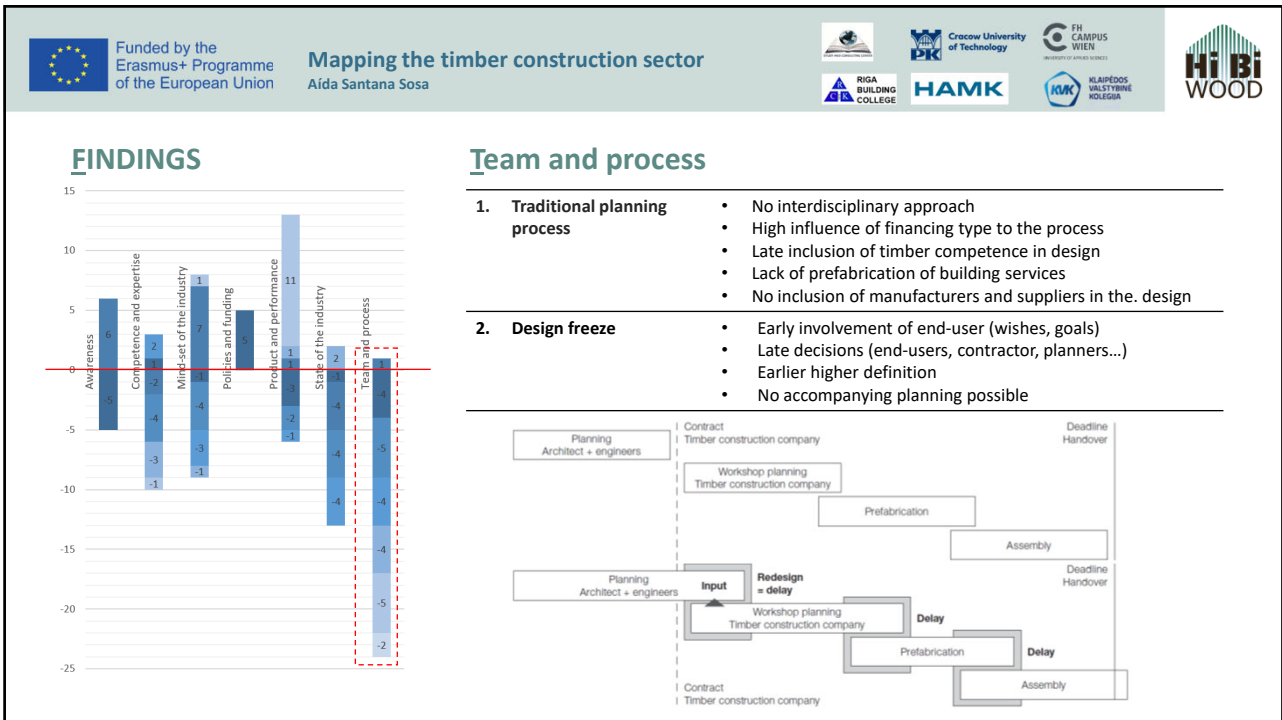
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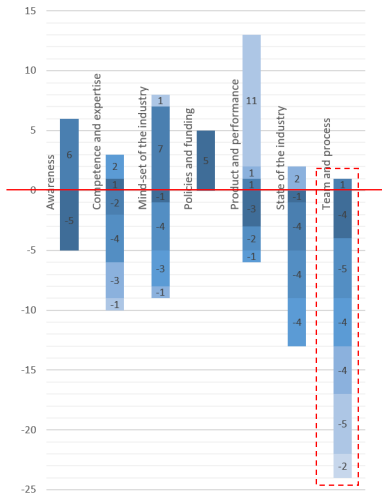


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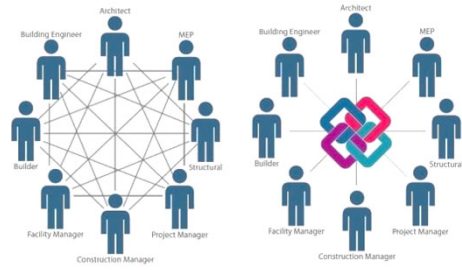
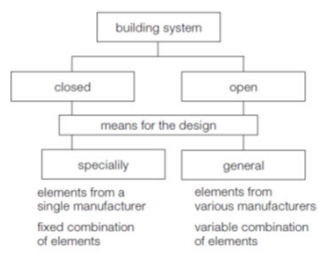
### FINDINGS




| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Mind-set of the industry | 1     |
| Policies and funding     | 4     |
| Product and performance  | 5     |
| State of the industry    | 11    |
| Team and process         | -2    |

### Team and process

- 3. Cooperation models**
  - Alliances (UK, USA and Canada)
- 4. Too many specialized software**
  - Incompatibility between software
  - Open BIM still works like file transfers
- 5. High fragmentation and no cohesion**
  - Close systems and platforms
  - Too many possible solutions
  - Lack of combination of 2D and 3D prefabrication
  - Traditional construction process (sub-constructor)






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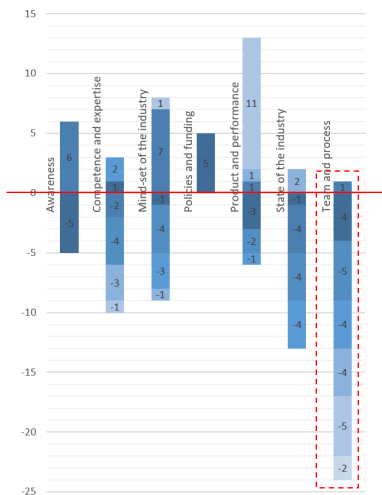


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### Team and process

- 6. Tendering process**
  - Complex and elaborate tendering
  - Redesign after tendering (in-house systems)
  - Over-processing (interface arch. - prod.)
  - Reduced bids, higher resources (redesign)
- 7. Coordination between production and construction**
  - Higher logistics related to transport
  - Store capacity and time (logistics)
  - Different delivery times
  - Coordination timber - concrete constr.
  - Coordination between prod. and constr. Capacity




Structural engineering concept

Final plans detail (Architecture)


Construction detail  
(Timber construction company)

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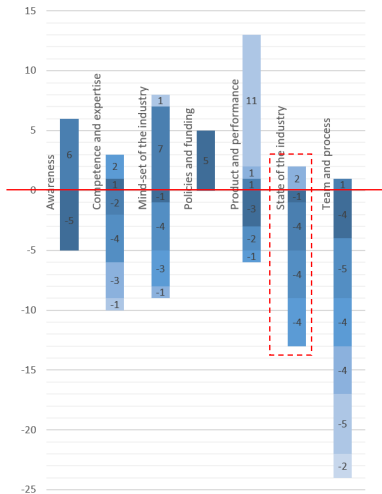


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### FINDINGS




| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Mind-set of the industry | -1    |
| Policies and funding     | -4    |
| Product and performance  | 11    |
| State of the industry    | -2    |
| Team and process         | -4    |

### State of the industry

- Restrictive regulations or processes**
  - Material neutral arch. competitions
  - Technical proof of each solution
  - Restrictive regulations (fire, height...)
  - Lack of common standards (fire, noise...)
- Small lobby**
  - Acquisition of projects through own network
  - Small pool of partners
  - Lack of influence in policies
  - Little predisposition of decision-makers





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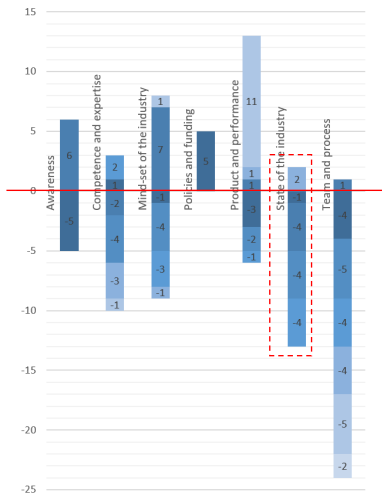


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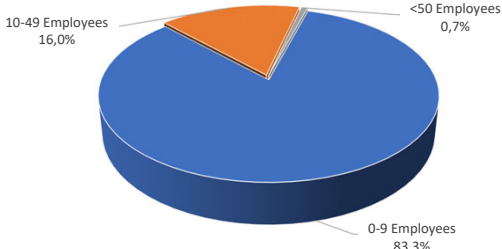
### FINDINGS



| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Mind-set of the industry | -1    |
| Policies and funding     | -4    |
| Product and performance  | 11    |
| State of the industry    | -2    |
| Team and process         | -4    |

### State of the industry


- Complex cost calculations**
  - Complex and not standardized
- Lack of resources of SMEs**
  - Lack of financial capacity
  - Lack of infrastructure
  - Too few companies as general or total constr.
  - Resistance to adaptation (overloaded)
- Tendency of construction sector**
  - Towards product-based construction
  - Towards industry 4.0 (Smart/Virtual Factory)




10-49 Employees  
16,0%

<50 Employees  
0,7%

0-9 Employees  
83,3%




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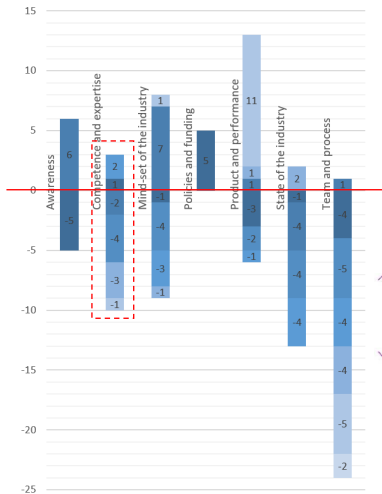


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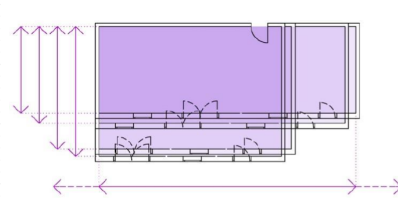

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### FINDINGS




| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Market of the industry   | -4    |
| Policies and funding     | 1     |
| Product and performance  | 5     |
| State of the industry    | 11    |
| Team and process         | 2     |

### Competence and expertise


|  |  |
|--|--|
| <p><b>1. Lack of expertise in the design phase</b></p> <ul style="list-style-type: none"> <li>• Related to common planners</li> <li>• High complexity of specific software</li> <li>• Overestimation of own competence</li> <li>• Underestimation of complexity</li> </ul> | <p><b>2. Insufficient and inadequate training</b></p> <ul style="list-style-type: none"> <li>• Lack of know-how in conventional training</li> <li>• Lack of specialized trainings</li> </ul> |
| <p><b>3. Competence about production and construction</b></p> <ul style="list-style-type: none"> <li>• High competence of manufacturers and constr. companies</li> </ul>   |  |

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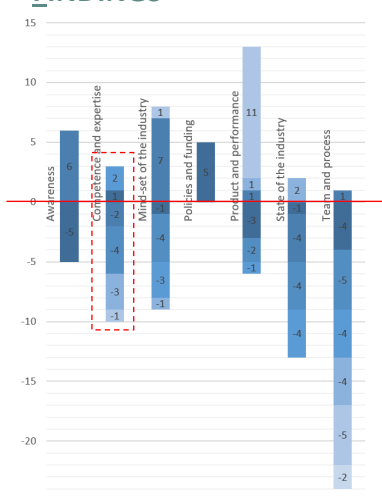


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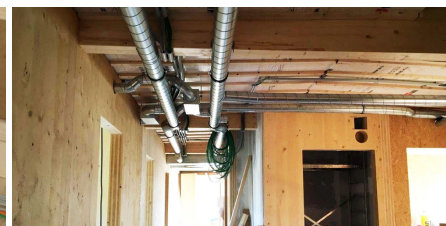
### FINDINGS



| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Market of the industry   | -4    |
| Policies and funding     | 1     |
| Product and performance  | 5     |
| State of the industry    | 11    |
| Team and process         | 2     |

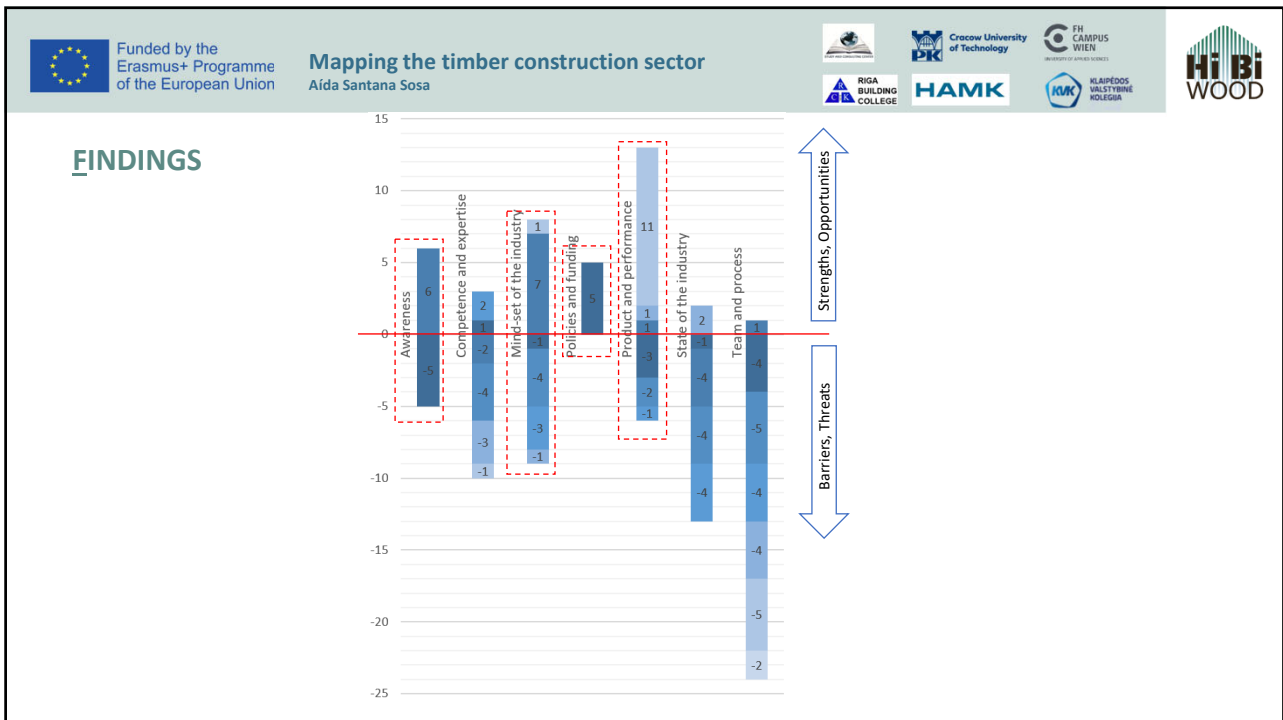
### Competence and expertise

|  |  |
|--|--|
| <p><b>4. Existing lifecycle-approach</b></p> <ul style="list-style-type: none"> <li>• Interdisciplinary multi-layered character</li> <li>• Lifecycle costs approach</li> </ul> | <p><b>5. Expertise of complementary trades</b></p> <ul style="list-style-type: none"> <li>• High mistakes rate related</li> <li>• Higher coordination effort on site</li> <li>• Lack of competence or expertise</li> </ul> |
| <p><b>6. Knowledge from contractor</b></p> <ul style="list-style-type: none"> <li>• Little knowledge and experience</li> </ul>   |  |

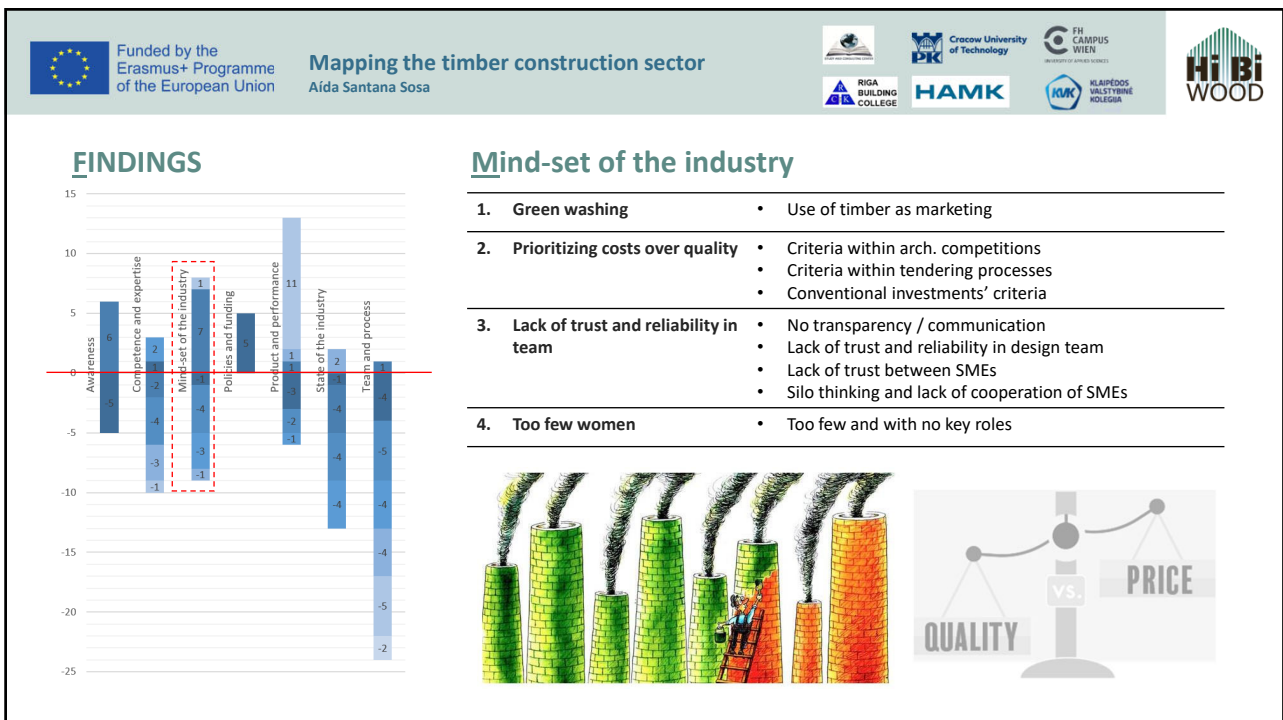



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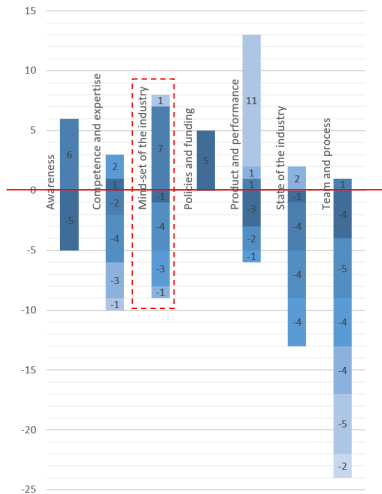
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## FINDINGS




| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Mind-set of the industry | 1     |
| Policies and funding     | 1     |
| Product and performance  | 1     |
| State of the industry    | 1     |
| Team and process         | 1     |

## Mind-set of the industry

- Innovative and disruptive industry**
  - Towards open mind-set, ready for new
  - Open-source databases (projects / network)
  - Rising number of small start-ups
  - Rising number of young experts
  - Little speculation
  - Transfer of Lean concepts
  - Rising number of independent planning eng.
- Willingness from contractors**
  - Rising willingness


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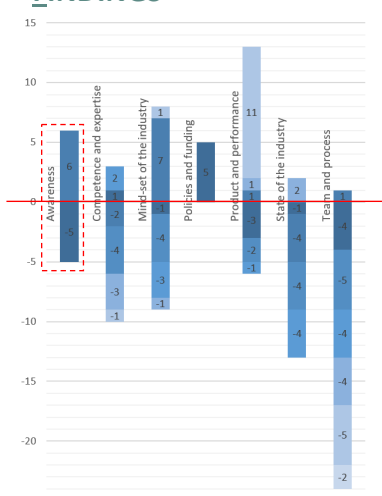
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| Team and process         | 1     |

## Awareness

- General prejudices**
  - Too expensive
  - Fast combustion
  - Insufficient noise insulation
  - Lack of durability
  - Little structural resistance
- Rising general awareness**
  - End of fossil energy and materials
  - Ecological properties of timber
  - Aesthetics and comfort
  - New generation, new requirements
  - Resources scarcity
  - Shared economy incl. platforms





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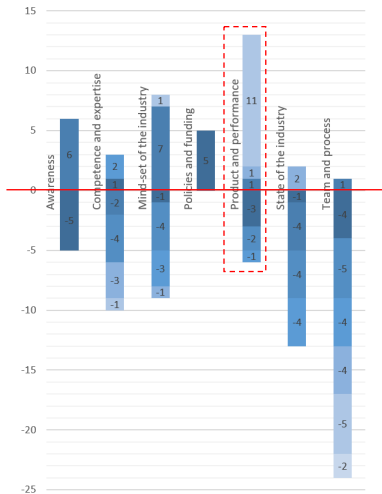


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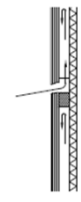


### FINDINGS




| Category                 | Value |
|--------------------------|-------|
| Awareness                | 6     |
| Competence and expertise | 2     |
| Mind-set of the industry | -4    |
| Policies and funding     | -4    |
| Product and performance  | 11    |
| State of the industry    | -4    |
| Team and process         | -4    |

### Product and performance

|                                  |   |
|----------------------------------|---|
| 1. Protection against humidity   | <ul style="list-style-type: none"> <li>Complex planning of building services</li> <li>Protection of the façade</li> <li>Protection of building elements and site</li> </ul> |
| 2. Restrictive design parameters | <ul style="list-style-type: none"> <li>Raster (uneconomical free forms)</li> <li>Transport requirements</li> </ul>  |
| 3. Technical tolerances          | <ul style="list-style-type: none"> <li>Between concrete and timber</li> </ul>   |
| 4. Recyclable, reusable          | <ul style="list-style-type: none"> <li>Recyclable, reusable</li> </ul>  |
| 5. Strength-to-weight ratio      | <ul style="list-style-type: none"> <li>Beneficial strength-weight ratio</li> </ul>  |






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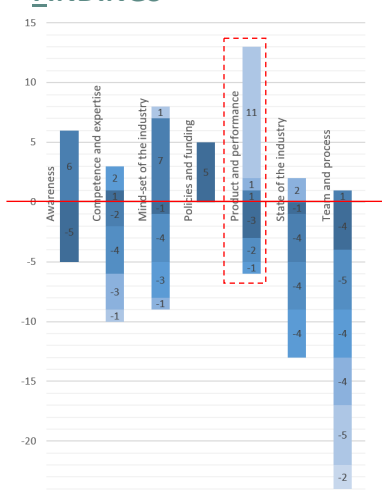


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| State of the industry    | -4    |
| Team and process         | -4    |

### Product and performance


|                                  |   |   |
|----------------------------------|---|---|
| 6. High levels of prefabrication | <ul style="list-style-type: none"> <li>Certainty in project schedule</li> <li>Parallel work on-site and in the factory (shorter overall construction time)</li> <li>Assembly site (shorter construction time on site)</li> <li>High industrialized production</li> <li>Material efficiency (excl. CLT)</li> </ul> | <ul style="list-style-type: none"> <li>Reliable stock planning</li> <li>Certainty of budget and reduction of deviations</li> <li>Less trades on site (less coordination)</li> <li>Higher production quality</li> <li>Mock-up (simulation and technical proof)</li> <li>Tracking (RFID / QR-Code)</li> </ul> |
|----------------------------------|---|---|




**1.**  
Certainty in project schedule projection, and reduction in overall construction duration




**2.**  
reducing the overall cost.



**3.**  
Certainty of budget at an early stage, and reduction of variations during construction.




**4.**  
Reduction in on-site resources and construction waste.



**5.**  
Improvement in quality with fewer defects due to standardised designs.


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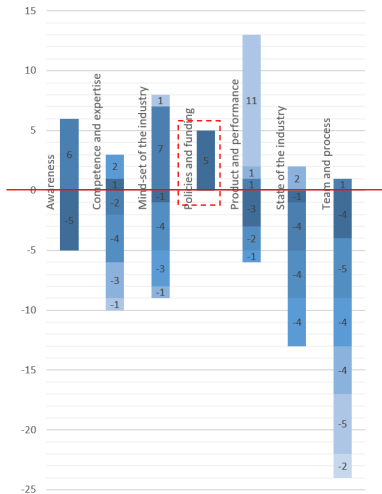
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### FINDINGS




### Policies and funding

- Supporting policies and funding
  - Carbon (CO2) fees
  - Financing of bio-based construction
  - Reinforcement of re-ensidification
  - Fix % of timber in public financed projects
  - Rising awareness towards circular economy




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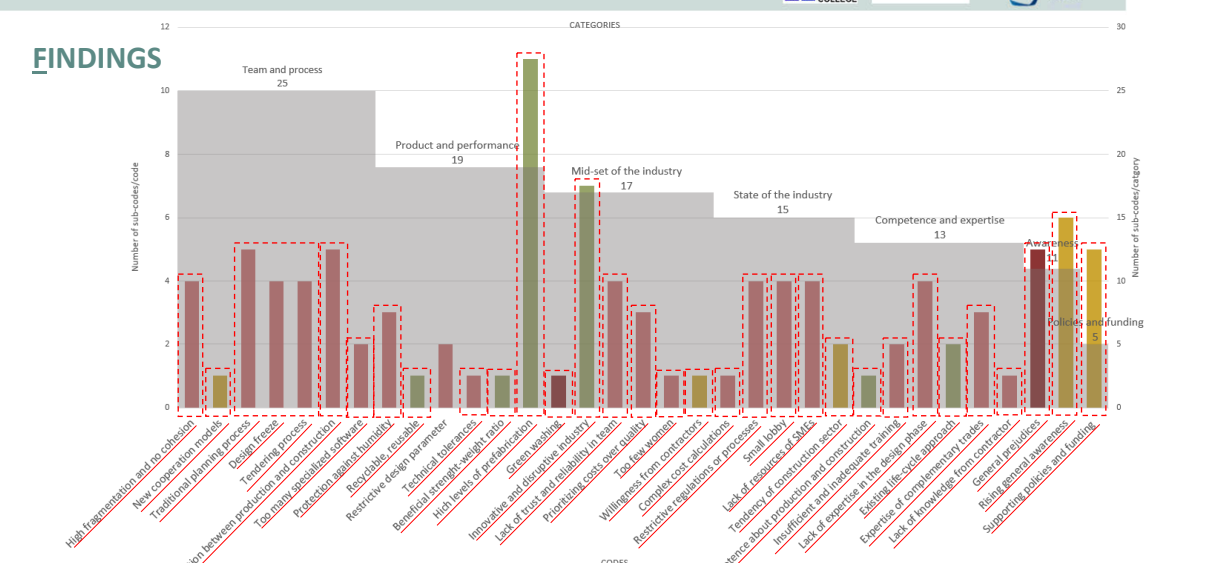
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### FINDINGS



### CATEGORIES

- High fragmentation and no cohesion
- New cooperation models
- Traditional planning models
- Designing process
- Teaming process
- Too many specialised software
- Production on digital software
- Restrictive design parameters
- Recordable, reusable
- Beneficial design parameters
- Technical tolerances
- High levels of prefabrication
- Innovative and derivative
- Lack of trust and reliability in team
- Green washing
- Prioritising costs over quality
- Willingness from contractors
- Complex costs calculations
- Restrictive regulations or processes
- Small lobby
- Lack of resources of CMAs
- Tendency about production and construction
- Insufficient and inadequate training
- Lack of expertise in the design phase
- Existing life-cycle approach
- Expertise of complementary trades
- Lack of knowledge from contractor
- General practitioners
- Rising general awareness
- Supporting policies and funding

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## RECOMMENDATIONS

### A better communication strategy

- A criteria catalogue with dependencies based on built examples and their documentation: Transparent communication between design team and client/contractor/developer
- Establishment of a brand image

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## RECOMMENDATIONS

### A reliable specialist network

- Association or coordination office for timber construction: One national overarching association, network or interest group for timber construction to unite professionals and gain strength and representation in the sector, politics, business and society.
- Network of partners or bidding community with aligned contractual incentives

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## RECOMMENDATIONS

### An increase in standardization

- Increase products standardization through specialization in multi-storey buildings

- Increase prefabrication level

**Roof**  
 LVL-8 purlins with LVL-X boards installed on site  
**Floors**  
 CLT rib-floors for spans between 8 and 7.5 m  
**Compartment walls**  
 CLT walls with acoustic insulation and gypsum board linings  
**Corridor walls**  
 CLT walls with acoustic insulation and gypsum board linings  
**Envelope**  
 Prefabricated timber frame wall with KVM, LVL, or sawn timber  
**Balcony**  
 CLT floors and steel structure

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## RECOMMENDATIONS

### An integration of timber expertise in early design stages

- Cooperation models, independent consultants, consulting network, anticipated inclusion of companies...

- Implementation of timber and timber construction related knowledge in academic curriculum

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## RECOMMENDATIONS

### An integration of timber expertise in early design stages

- Implementation of timber and timber construction related knowledge in academic curriculum

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## THANK YOU!