



**Bio-materials for building envelope - expected performance, life cycle costing & controlled degradation**

Anna Sandak PhD  
CNR-IVALSA

**BI****4ever**



Architect Michael Green of Vancouver says:  
“The Earth grows our food. **The earth can grow our homes.** It’s an ethical change that we have to go through.”

Australian architect Alex de Rijke adds:  
“The 18th century was about brick, the 19th about steel, the 20th about concrete, and **the 21st century is about wood.**”

# IVALSA experiences



# Renzo Piano *Le Albero* (Trento)



# Wood performance



# Bio4ever goals



**Promote innovative bio-materials** with minimal environmental impact

**Establish original construction strategies** by reducing gaps between expectations of designers, developers and consumers



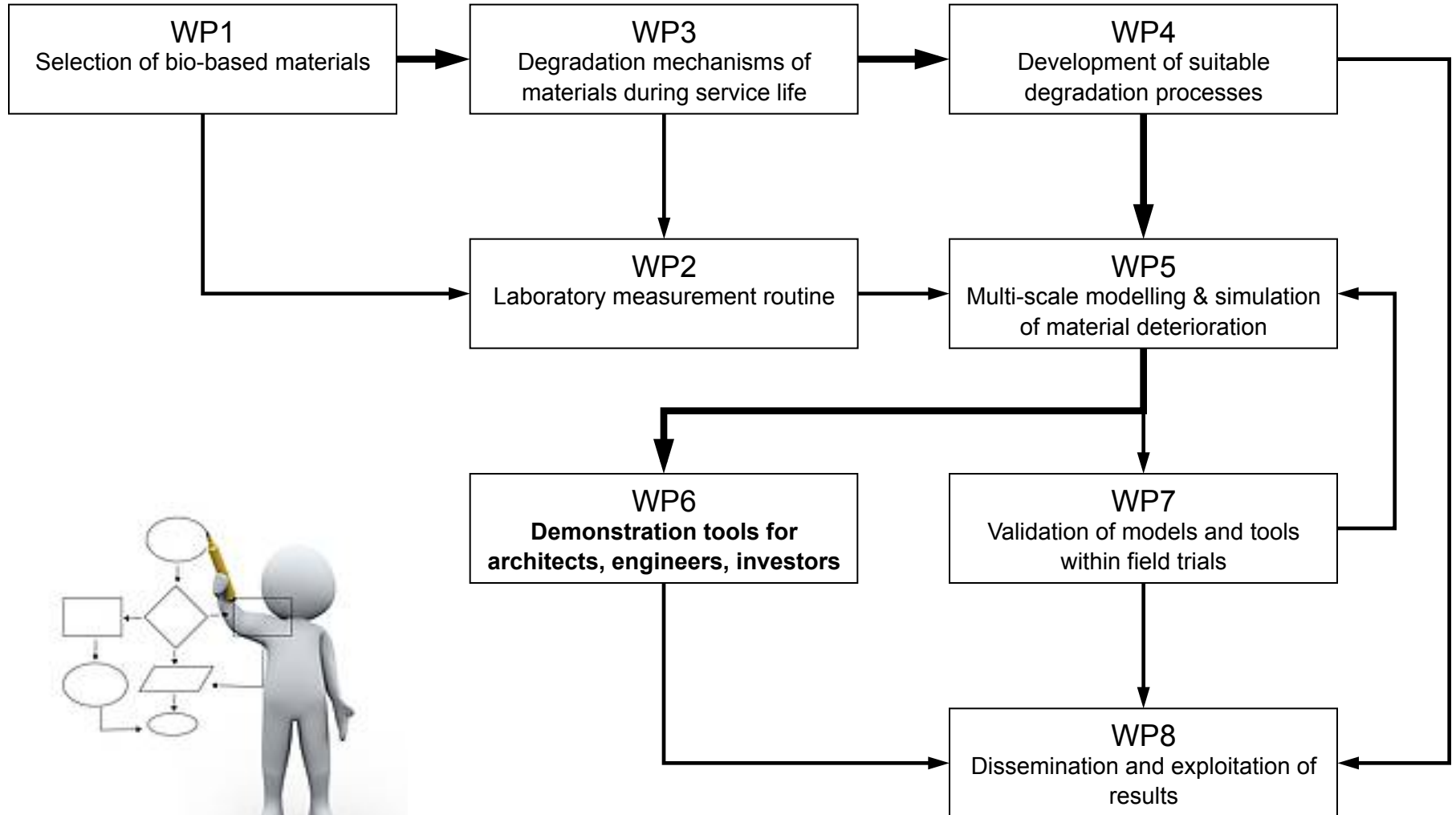
**Integrate science and experiences** for understanding functional and aesthetical performance of bio-materials during service life

**Improve sustainability of bio-materials** by controlling its transformation at the end of use



**Create new business opportunities** for the construction industry by using validated material solutions and design tools

# Bio4ever concept





# WP1. State-of-the art of available bio-based construction materials

**Objective:** to select bio-based materials for studies

## Bio-based products



Artuso (Italy)



Oregon State Univ. (USA)



MFE & FPT (Greece)



ITD (Poland)



Oklahoma State Univ. (USA),  
Bangor Univ. (UK)

## Modified wood



Skog Landscap (Norway)



FirmoLin (Netherlands),  
Maspel (Italy),  
Ljubljana Univ. (Slovenia)



Salzburg Univ. (Austria)



Poznan Univ. (Poland),  
Trento Univ. (Italy)



Bern Univ. (Switzerland)  
k-plus (Austria)



1.1 Report on the bio-based materials to be used in sustainable building

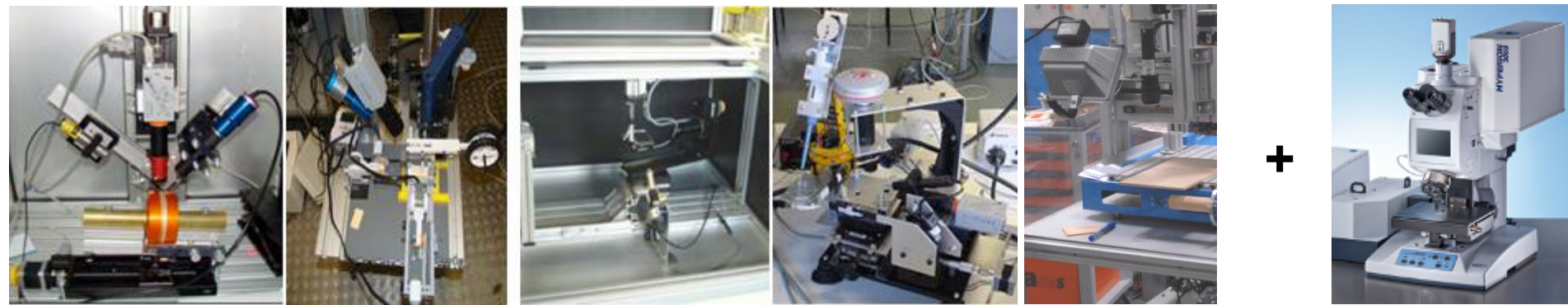


M3

# WP2. Lab measurement routine for multi-scale characterization

**Objective:** to prepare multi-sensor experimental set-up and to characterize bio-based materials along life cycle

An integrated set of prototype and ordinary instruments for determination of bio-materials properties at different scales (from nano to macro) is available at the **Lab. of Surface Characterization**



Other CNR-IVALSA laboratories to be involved: Wood Quality and Non-destructive Testing, Wood Drying and Thermal Treatment, Preservation and Biodegradation, Fire Behavior, Chemistry of Wood and Wood Products,



2.1 Set of instruments for characterization of investigated bio-materials

2.2 A routine measurement protocols



M6

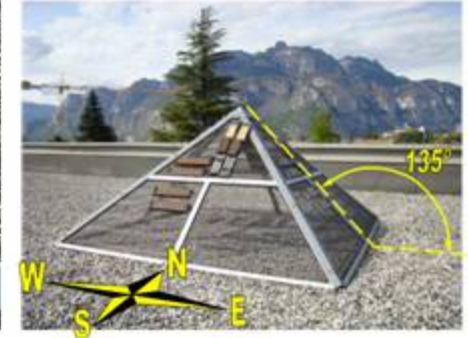


M8

BIO4ever

# WP3. Degradation of bio-materials during service life

**Objective:** to understand mechanisms of biotic and abiotic degradations of natural materials in use



Artificial weathering: QUV, Suntest and custom weathering machine

Natural weathering: stations located at CNR-IVALSA or elsewhere

In field inspections of the real buildings

Living laboratory



3.1 A database of comprehensive characteristics and material properties before and after degradation



M18

3.2 Software tools simulating the progress of deterioration at different scales



M21

# WP4. Optimal end of life transformation

**Objective:** to identify best end of life solution for each bio-material investigated



Validation of the state-of-the-art methods (pelletizing, combustion, gasification, digestion, land filling, animal bedding, fermentation, platform molecules production)  
Intensive experimental trials with root fungi, bacteria and insects  
LCA, LCC, EPD

 4.1 Report on bio-materials degradation by insects

4.2 Recommendations for best end-of-life transformation

4.3 LCA and LCC including reuse, recycling, energy conversion and waste to proteins transformation

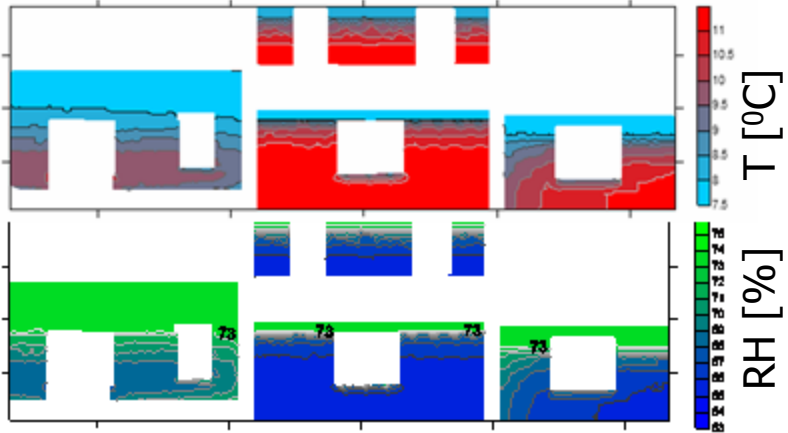
 M17

 M20

 M24

# WP5. Multi-scale modeling and simulation of material deterioration

**Objective:** to develop numerical models of bio-materials performance during service life



- Selection of the most suitable data pre- and post- processing algorithms
- “Data Fusion” for the integration of experimental data
- Multivariate classification of bio-materials quality/functionality - special focus on aesthetical aspect
- Design of dose-response model for material deterioration at different scales
- Integration of models with software tools for architects



- 5.1 Models simulating changes in function of the weathering doses and construction details
- 5.2 Visualization of aesthetical changes to the bio-materials along service life
- 5.3 Tool for computation of service life period and maintenance scheduling



M25



M30

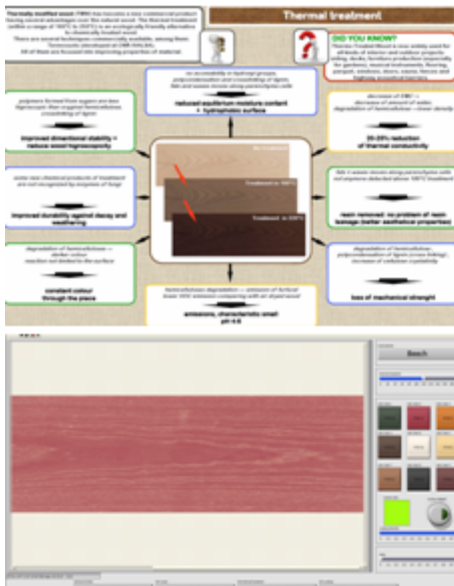


M36

# WP6. Demonstration tools for architects, engineers and investors

**Objective:** to promote correct use of wood and bio-materials in buildings

*“I HEAR AND I FORGET – I SEE AND I REMEMBER – I DO AND I UNDERSTAND”*  
*Confucius, 551–479 BC*



6.1 Book with success stories to inspire investors and engineers

6.2 Outdoor demonstration station (living lab)



M29



M32

# WP7. Validation of models and tools within field trials

**Objective:** to assure highest reliability of numerical models



durability studies in the field

evaluation of mould risk

continuation of Round Robin weathering test COST FP1006

short term waterlogging

## **International network:**

COST Action FP 1006 Bringing new functions to wood through surface modification

COST Action FP 1101 Assessment, Reinforcement and Monitoring of Timber Structures

COST Action FP 1303 Performance of bio-based building materials

COST Action FP 1407 Understanding wood modification through an integrated scientific and environmental impact approach (ModWoodLife)

COST Action TU1403 Adaptive Facades Network

IUFRO

SISNIR Italia



D 7.1 Supplementary data set to be used for further models improvement



M33

BI4ever

# WP8. Dissemination and exploitation of results

**Objective:** to prepare open source knowledge platform on the bio-based building materials



8.1 Website with easy to understand multimedia

8.2 Technical handbook dedicated for designers and contractors

8.3 Software simulating changes of functional and aesthetic performance

+ workshops and exhibitions, web TV & booklets, scientific publications



M1









M24



M36



# BIO4ever impact

-  **compatible with the foreseen research needs** as summarized in Horizon 2020: “advanced materials”, “added-value functionalities”, “extended in-service life of materials” and “widening material models”
-  **corresponds to pan-European low carbon building agenda**
-  **address to the top problems** to be solved in next 50 years: **environment, energy and food**
-  **promote bio-materials in the construction sector**, assuring confidence of designer, contractors and end-users
-  **contribute to practical understanding of the functional and aesthetical performances** during the whole life-time service
-  **contribute to the prevention of forthcoming risk** related to disposal of building **materials wastes**

# Opportunities for you

- To continue previous initiative (RR test 2)
- To test innovative bio-materials
- To participate to STSM / Training Schools
- To use facilities of the Laboratory of Surface Characterization
- To work with us as a research assistant (PhD student or post-doc)





Thank you