Theoretical and experimental modeling of the energy and environmental behavior of bio-based building materials

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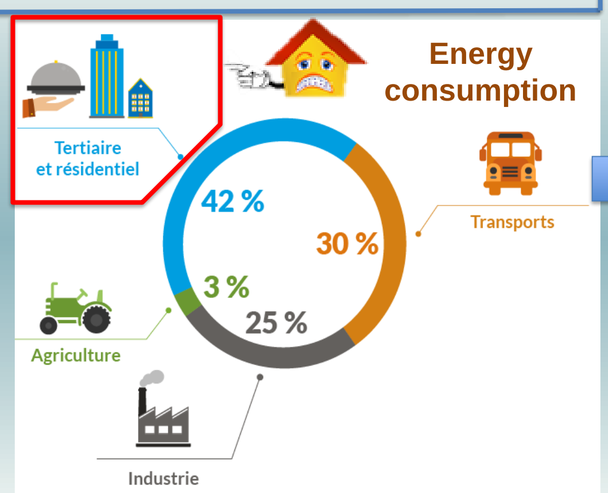
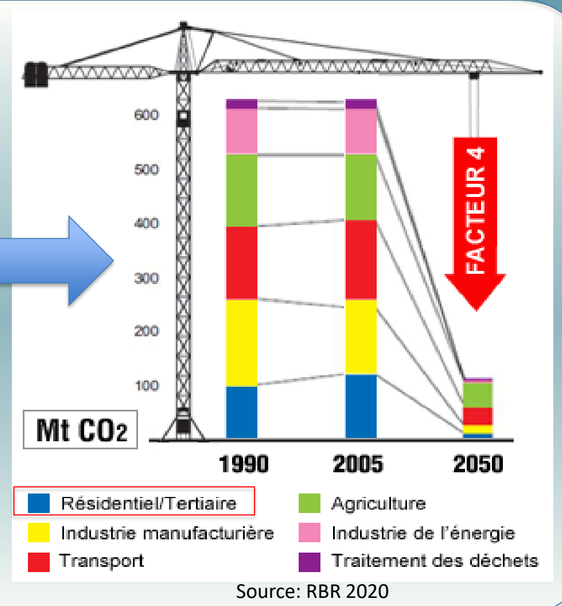
Environmental cirumstances

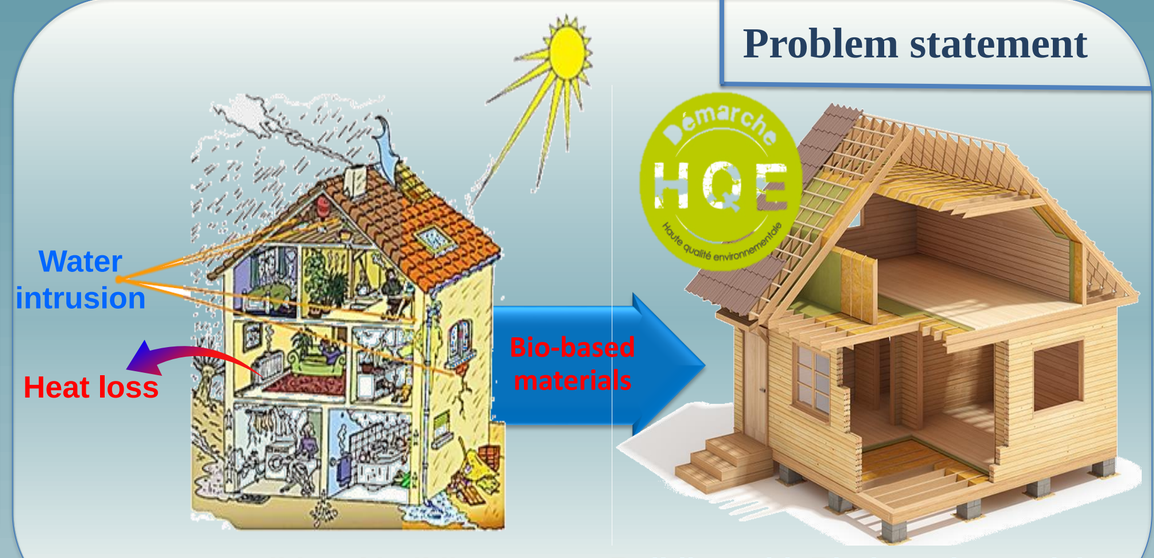


Source: Ministry of the Environment, Energy and the Sea



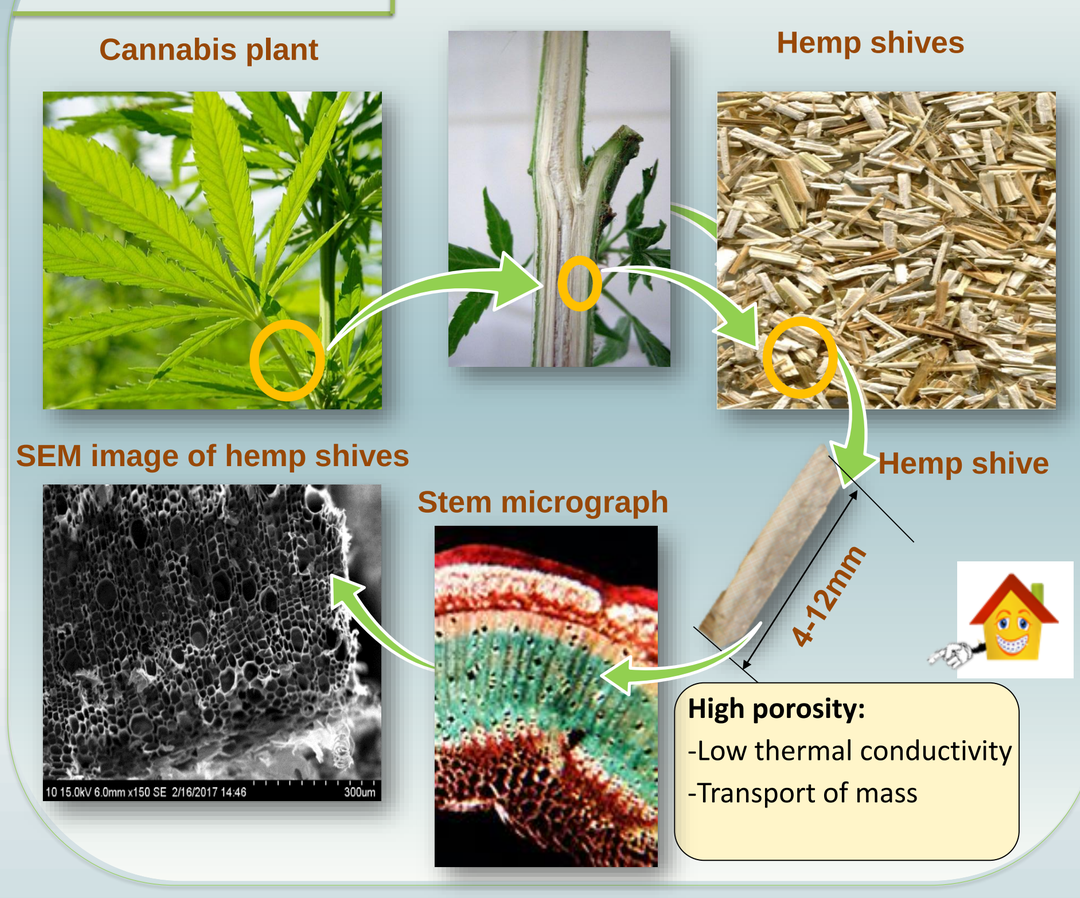
Source: RBR 2020

Problem statement



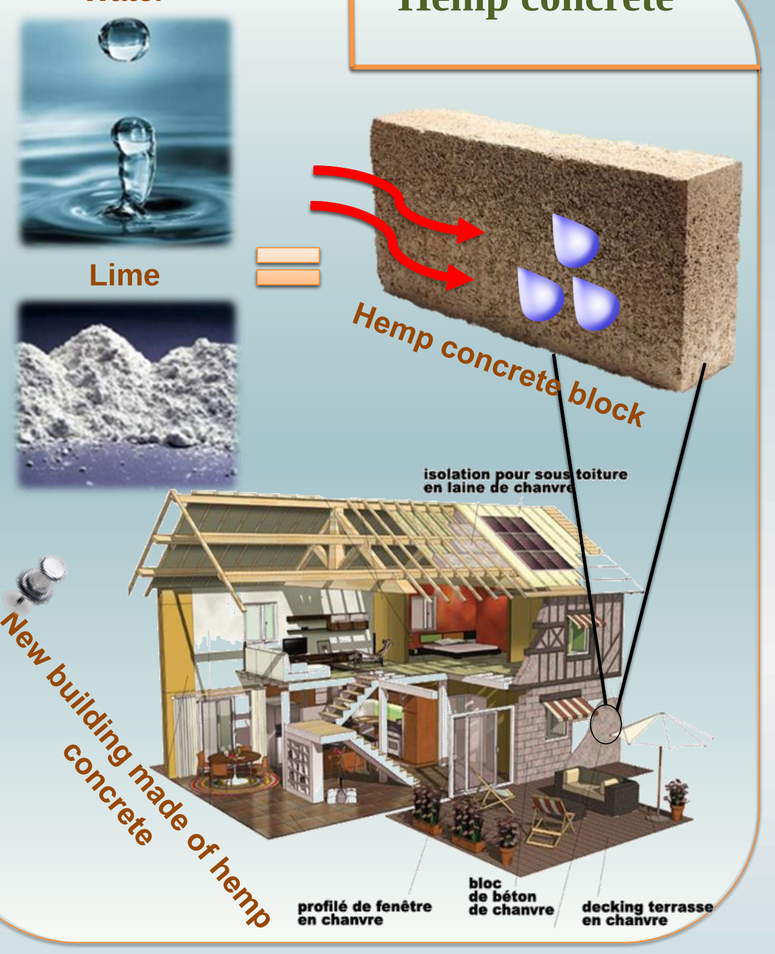
Traditional building — Building with Bio-based materials

Hemp



High porosity:
-Low thermal conductivity
-Transport of mass

Hemp concrete



Experimental characterization of the material

Modelization

Numerical simulation

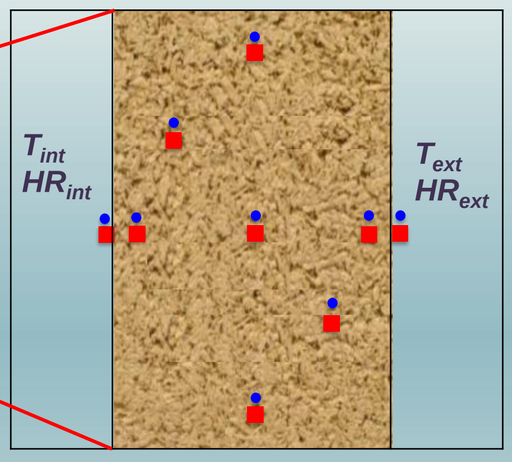
Confirmation

Experimental study at the wall scale

Research methodology

Experimental studies of the hygrothermal behavior of hemp wall

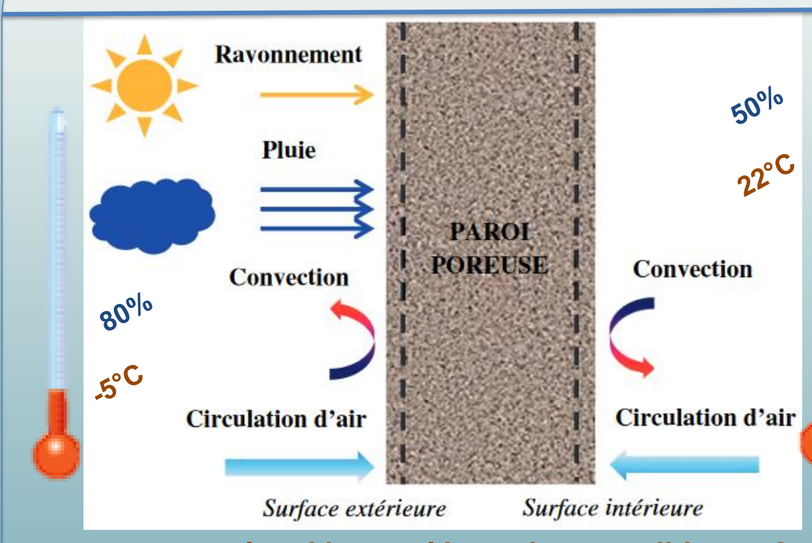
The bi-climatic heat chamber at the IUT of Montluçon



Hemp wall concrete (Implentation of the sensors within the wall)

- Experiments in a bi-climatic chamber will be performed on an instrumented wall of hemp concrete.
- Measurement sequences will be performed with constant temperature and humidity conditions on one side and representative of summer or winter conditions on the other.
- Evaluation of the pressure gradient impact on coupled heat and mass transfers.

Numerical studies of the hygrothermal behavior of hemp wall

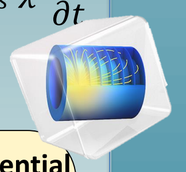


External and internal boundary conditions of a wall [AIT 2013]

$$* c_m \frac{\partial \omega}{\partial t} = div[d_m(\nabla \omega + \varepsilon \nabla T + K \nabla P)]$$

$$* C\rho_s \frac{\partial T}{\partial t} = div(a_t \nabla T + \delta_t \nabla \omega + \zeta \nabla P) + h_{lv}\, \rho_s\, \chi \frac{\partial \omega}{\partial t}$$

$$* h_a \frac{\partial P}{\partial t} = div\left(\lambda_f \nabla P\right) + \rho_s\, \chi \frac{\partial \omega}{\partial t}$$



- A system of three strongly coupled partial differential equations.
- The model will be implemented on the Comsol software (finite element method).
- The measured evolutions of T (° C) and HR (%) within the wall will be compared to the numerical results that obtained by the proposed model.

Expected results

- An improvement of the HAM model (Heat, Air and Moisture) will be implemented on the Comsol multiphysics software by integrating various parameters (pressure, convection, thermo-transfer of the liquid phase and hysteresis).
- Obtain experimental data on the thermal and hydrous behavior of the material.
- Evaluation of the energy impact of hemp concrete on the energy performance of buildings and the comfort of users.