SCALE UP
community-driven
bioeconomy development

Task 2.3 Regional Biomass and Nutrient Availabilities

Study on the availability of biomass for the bio-based building value chain in the French Atlantic Arc

February 2024

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Regional biomass and nutrient availabilities in the French Atlantic Arc

1. Introduction

1.1 Background

The French Atlantic Arc is composed of 4 regions in the Western of France: Brittany, Normandy, Pays de la Loire and New-Aquitaine regions. It is the field of intervention of the Association of the Chambers of Agriculture of the Atlantic Area (AC3A), an association created in 1993 by 27 local chambers of agriculture. The chambers of agriculture were willing to work on common agricultural issues in this geographical area at the European level. Now 4 regional chambers of agriculture - one per administrative region - are involved in the SCALE-UP project.

Agriculture in the Atlantic Arc covers an area of 89,656 km^2. It has many characteristics in common from one region to another: the influence of the oceanic climate and the proximity of the sea have shaped the typology of farms that are very much linked to cattle breeding, particularly because of the importance of the bocage and marsh areas.

These regions face strong demographic pressure due to their proximity to the Atlantic coast and the English Channel.

Environmental issues are also critical. These regions are fully affected by the impacts of climate change, with a rise in temperature and a reduction in water resources, which until now had spared these regions with high rainfall.

Agriculture in a few key figures (RGA 2020)[1] :

- 144,000 farms and 187,000 farmers.
- Predominance of livestock farming: more than 2/3 of the farms are primarily engaged in livestock production.
- Arable crops represent between 32 and 39% of the agricultural area. But these areas are constantly growing.

[1] Source: agricultural census (RGA) 2020.

Number of farms and share of livestock farming in the French Atlantic Arc		
REGION	**NUMBER OF FARMS**	**SHARE OF LIVESTOCK FARMING**
Brittany	26 347	80%
New-Aquitaine	64 200	31%
Normandy	26 510	56%
Pays de la Loire	26 409	70%

Source : RGA 2020.

The agricultural orientation of these regions is changing and evolving towards a decrease in livestock production: the main reasons for the disengagement of farmers from livestock production are working time constraints and the high drudgery of work, combined with unprofitable meat prices. In addition to this, the reduction in meat consumption recommended by the Intergovernmental Panel on Climate Change (IPCC) to cope with climate change, the context is moving towards an increase in crop production in these four regions.

This context is favourable to the development of fibre plants in these regions, especially as these crops offer important advantages for future climate challenges. This issue will be addressed in the next chapters.

1.2 Scope of the study

We have chosen to focus on the development of four fibre plants linked to the resources available in the rural areas of the Atlantic Arc:

- Straw
- Hemp
- Miscanthus
- Flax

These plants have primary uses such as livestock breeding, human food or animal feed, but their uses are diversifying, particularly for industrial purposes (chemicals, textiles, construction).

Following contact with stakeholders in the fibre plant sector, we have chosen to work on the use of these plants as bio-based construction materials, which is a major issue in the decarbonisation of the building sector.

Bio-based materials are materials derived entirely or partially from renewable organic matter (biomass)[2]. The nature of these bio-based materials is diverse: wood, cellulose wadding, recycled textiles, cereal husks, cork, thatch, meadow grass, etc.

These fibres can be used as raw materials for bio-based building materials in varying proportions. The standard defining bio-based materials does not specify a minimum content of biomass raw materials in the final material.

In 2018 with the ELAN[3] law, the French government is promoting bio-based materials by clearly advocating the use of renewable materials and including environmental performance as one of the main issues for buildings. This has resulted in an environmental regulation for new buildings called

[2] Terminology standard NF-EN 16575 of October 2014: "*Biobased materials are materials derived entirely or partially from living biomass such as wood, hemp, rapeseed, miscanthus, straw, flax shives, among others*".
[3] Loi ELAN: évolution du logement, de l'aménagement et du numérique (ELAN law: evolution of housing, land use planning and digital).

"RE2020", which makes it compulsory to calculate the carbon impact of all new buildings from 1st January 2022. Life-cycle analysis over 50 years is becoming a central element in both new construction and renovation.

The building sector accounts for 30% of France's CO_2 emissions, including the manufacture of materials, construction and housing[4]. Life Cycle Analysis of buildings from the E+/C- experiment[5] shows that 70%[6] of greenhouse gases come from construction materials and equipment. To reduce the sector's carbon footprint, it is therefore essential to limit emissions from these materials.

Biobased materials made from **renewable and local raw materials (wood, flax, hemp, straw, etc.**) capture carbon during construction and throughout the building's lifespan. They are likely to become essential for the construction and renovation sector, which will have to adapt to these new regulations.

It should be noted that the building sector is also working on reuse, which will become compulsory under the EPR (Extended Producer Responsibility) for the building industry, which comes into force in 2023 (law no. 2020-105 of 10/02/20 on the fight against waste and the circular economy). According to the French Building Federation, building waste accounts for 46 million tonnes every year in France.

2. Biomass availability

The latest available data on areas planted with fibre plants (flax, hemp, miscanthus) show varying situations in the French Atlantic Arc. The data from Common Agricultural Policy (CAP) declarations show an overall favourable trend over the last 13 years.

Areas planted with fibre plants (in hectares) in the French Atlantic Arc				
REGION	**2010**	**2020**	**2022**	**Trend**
Brittany	191 ha	882 ha	1,500 ha	↗
New-Aquitaine	535 ha	1,052 ha	1,558 ha	↗
Normandy	34,367 ha	86,499 ha	76,483 ha	→
Pays de la Loire	1,019 ha	5,003 ha	5,159 ha	↗
TOTAL	**36,112 ha**	**93,436 ha**	**84,700 ha**	↗

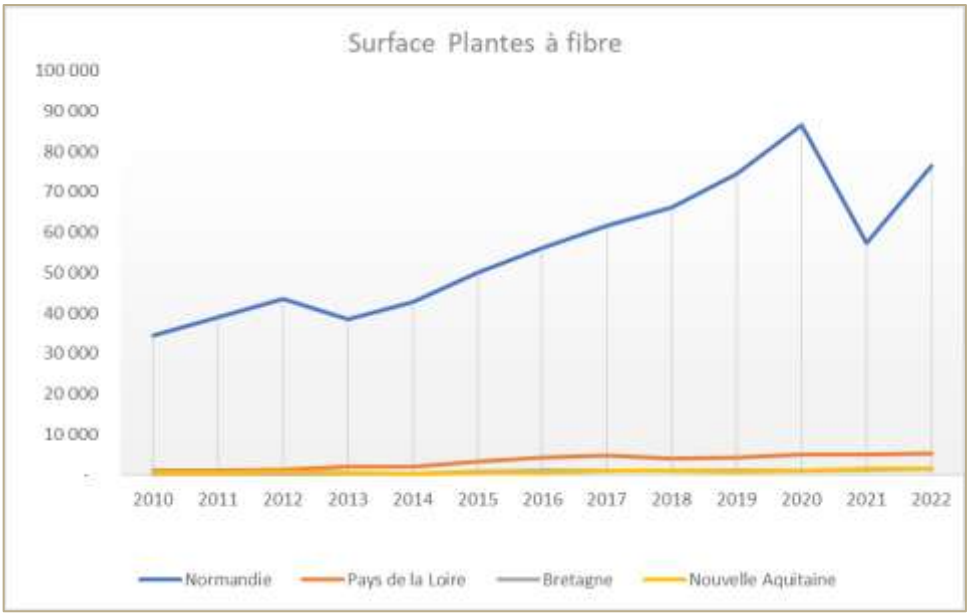
Source : CAP declarations.

The increase in surface area has been exponential: +57% in 13 years, thanks in particular to the Normandy region and the growth in demand for fibre flax.

The latest figures from the graphic parcel register (Registre parcellaire graphique – RPG) of 2022 show that this increase is continuing steadily throughout the Atlantic Arc, under the influence of local stakeholders. The New Aquitaine region, despite being the largest in France, is the region with the less surface area planted with fibre plants.

[4] Source: Hélène Lenormand, "*Growing thermal insulation: an overview of materials available in France*", 2022.
[5] The E+/C- experiment is a tool that has been used to calculate a building's energy balance and assess its greenhouse gas emissions throughout its lifecycle. This experiment, which was launched in 2017, served as a basis for the RE2020. https://www.cerema.fr/fr/actualites/batiment-cerema-experimentation-e-c-energie-carbone. This experiment has become an E+/C- label.
[6] Source Cerema : https://publications.cerema.fr/webdcdc/pti-essentiel/impact-carbone-batiment/

Evolution of the surface area planted with fibre plants in the French Atlantic Arc (from 2010 to 2022)



Source : RPG 2022.

2.1 Availability of straw

Straw is a residue from the harvesting of cereals for animal feed or human consumption (bread, dough, etc.). There are several types of cereal, but wheat is the most widespread crop in Western France, and for the moment it is the only one described in the professional rules for straw construction.

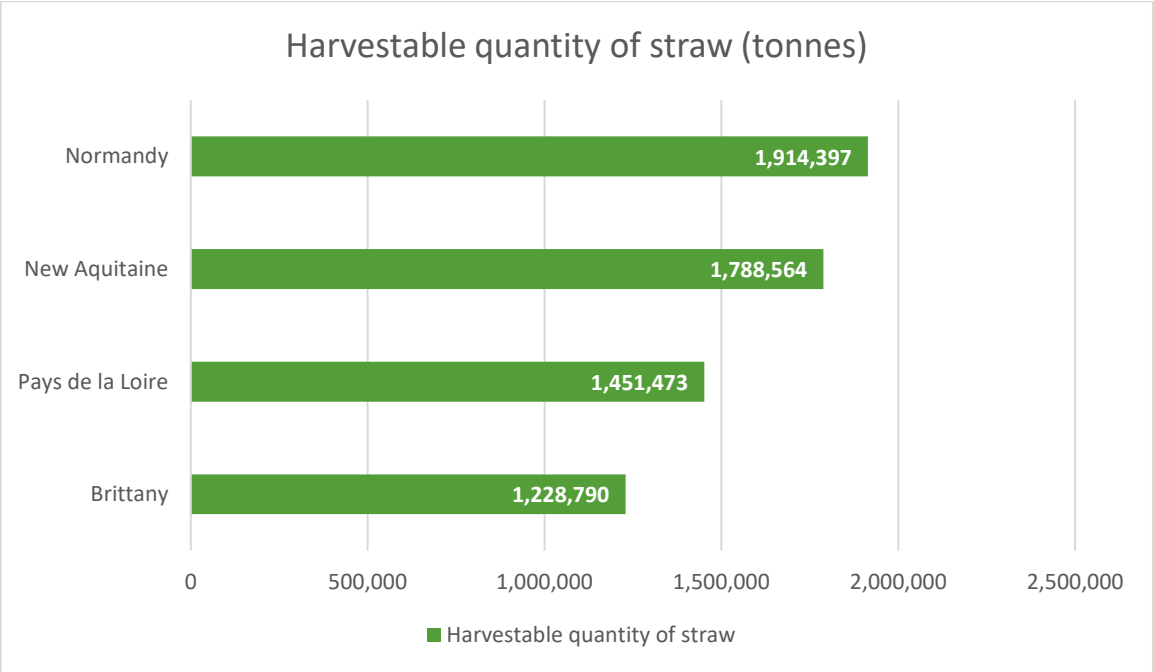
© Chamber of Agriculture of Vendée

Using data from FranceAgriMer (public administrative establishment in charge of collecting and analysing economic data of the agricultural sector), we have established the quantities of straw harvested[7] in the Atlantic regions as an average over 4 years (2018/ 2019/ 2020/ 2021) to avoid variations in harvesting due to weather conditions and in relation to areas sown.

Breakdown per region of cereal crop surfaces in 2022 in the French Atlantic Arc	
Brittany	433,858 ha
New-Aquitaine	742,756 ha
Normandy	592,645 ha
Pays de la Loire	521,532 ha

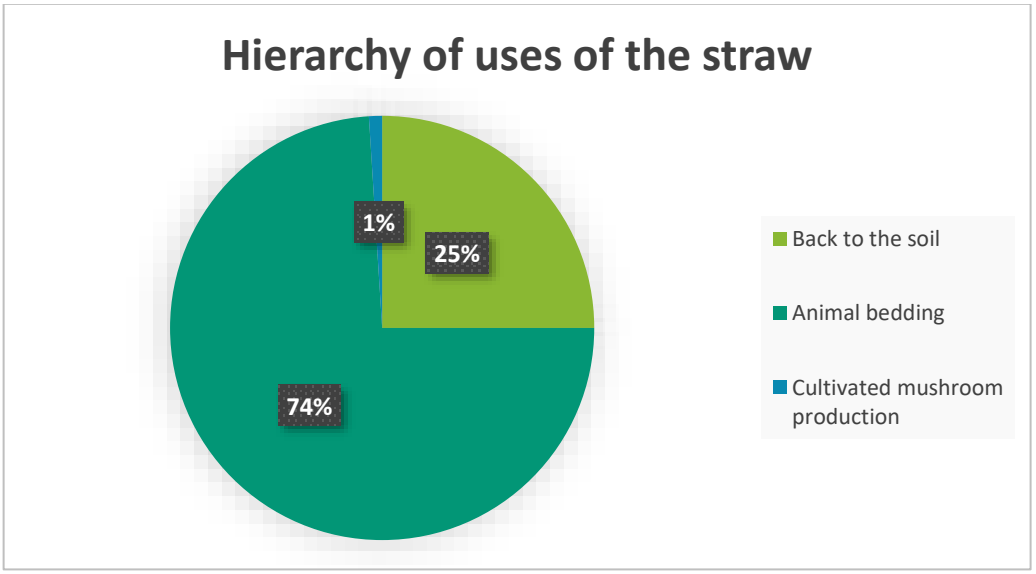
[7] Quantities exported from the field. Excluded from this table are the quantities of unharvested straw left on the ground. This return to the soil is used as fertiliser to improve the agronomic quality of the soil.

Normandy is the region with the highest straw production (average theoretical yield over 4 years).



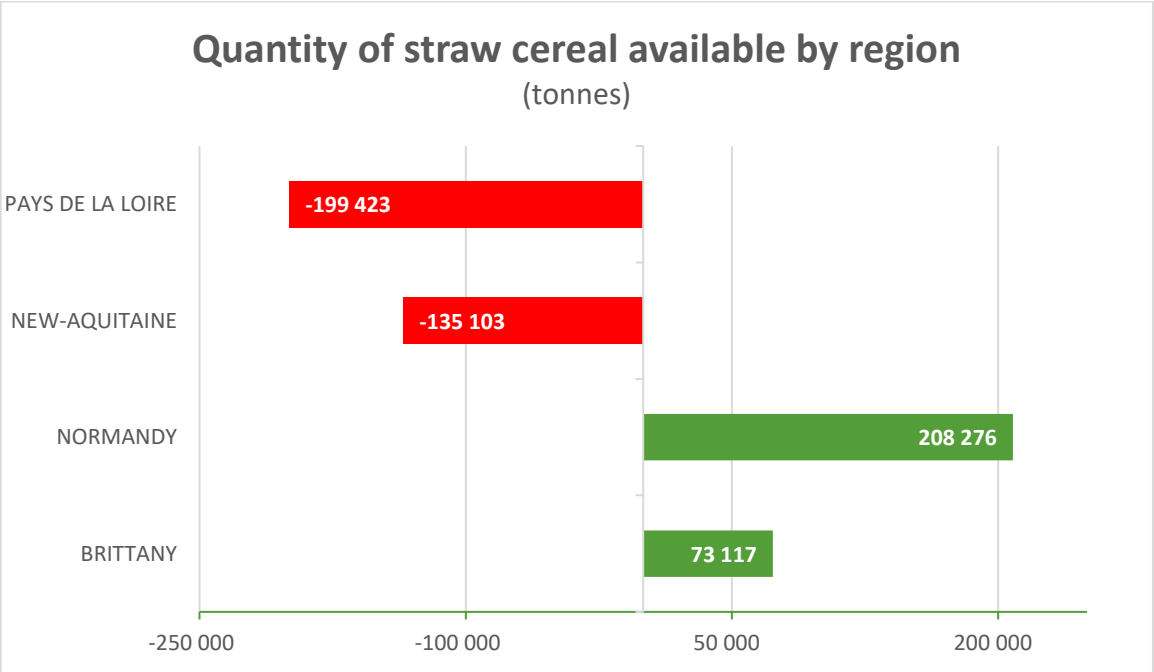
Source: FranceAgriMer - average quantity over 4 years (2018/2021)

Almost 6.383 million tonnes of straw are harvested in the French Atlantic Arc region. The main use for this by-product is as animal bedding. Some farmers leave the straw on site after the wheat harvest. This practice is difficult to quantify, and varies greatly from region to region, from livestock farming to arable farming - some farmers even consider this practice to be "wasteful". FranceAgriMer nevertheless worked on estimations regarding the primary uses of straw (graph below), including the use of straw as an agronomic input to soil. It also includes cultivated mushroom production, as in some regions, straw is used for mushroom production. The Pays de la Loire region is one of the regions with the largest production of cultivated mushrooms.



Source: FranceAgriMer - average over 4 years - Uses in the French Atlantic Arc

Once the conventional uses of the straw are fulfilled, the availability of straw for other purposes varies from one region to another. It depends on production volumes and local uses. In New-Aquitaine and Pays de la Loire, for example, straw cereals, including wheat, are used for livestock farming, which is very common in these regions. Straw shortages are compensated for by straw imports between regions of France, or even from neighbouring countries. For example, some counties in the New-Aquitaine region have a shortage in straw production and need to import straw from Spain. These import/export flows are not known in terms of volume.



Source: FranceAgriMer - average over 4 years

The quantities of straw available are not linked with the number of livestock in the region, as shown in the table below.

Number of livestock by Large Bovine Unit equivalent[8] in the French Atlantic Arc	
Brittany	5,129,166
New-Aquitaine	3,002,934
Normandy	2,350,000
Pays de la Loire	3,544,500

Source: RGA 2020.

Brittany is the region with the highest livestock numbers in LBU equivalent, followed by Pays de la Loire. However, Brittany has a surplus of straw, as does Normandy.

There are several reasons for this. Both Brittany and Normandy have a majority of dairy cattle. However, dairy farms have opted for slurry systems rather than straw-covered areas to comply with standards.

[8] The herd includes all animals in Large Bovine Unit (LBU) equivalent: cattle, pigs, poultry, goats, sheep, etc.

In contrast, beef cattle farms - which are much more common in the Pays de la Loire and New-Aquitaine regions - are on straw pastures. In addition, grazing is practised for longer periods in Normandy and Brittany, due to weather conditions that are more favourable for grass growth, particularly in summer.

Other livestock reared in buildings (poultry, pigs) are either on slatted floors, or use very little straw and therefore do not have a significant impact on straw use. These livestock are very present in the Brittany region, which is the leading region for pigs (56% of French livestock), and for poultry.

2.2 Availability of Hemp

Agricultural hemp is an annual plant in the *Cannabinaceae* family. Only *cannabis sativa* - with a low THC content (< 0.2%) - is grown. Hemp is subject to strict regulations and only certified seed is authorised. The use of self-grown hemp is strictly prohibited, as it may increase THC levels. Before harvesting, checks are carried out on 30% of crops to verify THC levels.

Originally from Central Asia, hemp has been cultivated for 8,000 years, mainly for its textile fibre. Its surface area shrank considerably with the emergence of competing fibres such as cotton and synthetic fibres in the 20th century. However, in recent years, with the development of uses for hemp, production has risen again. In 2022, the areas planted with hemp in France were 21,700 ha, compared with 12,000 ha in 2015. France leads the European hemp production with 50% of the planted surface area.

To assess the availability of hemp biomass, it is important to be familiar with all the possible uses. Knowing how to make the most of the whole plant, even the hemp dust, is key in the profitability of this crop. Hemp has many uses, both for food and non-food purposes:

The many uses of the hemp

Part of the hemp	% of the plant weight	Distribution of uses
Seed	10%	Harvested in September. 84% for feed (bird and fish) 15% for human consumption including protein and oil 1% for cosmetic
Chenevotte	44%	48% for animal bedding 28% for aggregate 22% for horticultural mulching 2% other
Fibre	24%	50% for fine paper 29% for insulation in building 10% plasturgy 10% textile 1% other
Flower[9]		Harvested in August for CBD and other molecules.
Dust	22%	57% for compost 33% for energy 10% other

Source: Interchanvre.

[9] We will not be dealing with hemp flower harvested for CBD - this is a very specific sector.

Hempseed is used as animal feed for birds and as fishing bait. Hempseed oil, produced by crushing hempseed, is of high nutritional quality (rich in omega 3, fibre and protein). The oil is also used in cosmetics.

The hemp stalk is made up of fibres that surround the chenevotte. The fibres, obtained by defibrating the stalk, are used in a wide range of applications (fine paper, insulation, automotive plastics, window profiles, textiles). The chenevotte, which is the wood of the plant, is highly absorbent, making it ideal for bedding and mulching. It is also used in construction and makes good compost at the end of its lifespan.

The dust or fines have a high absorbency and are rich in carbon. It is used as an organic amendment or bedding for cattle. After compression, it is used as fuel in industrial boilers.

The surface area planted with hemp in the Atlantic Arc was **4,668 ha** in 2022 broken down as follows:

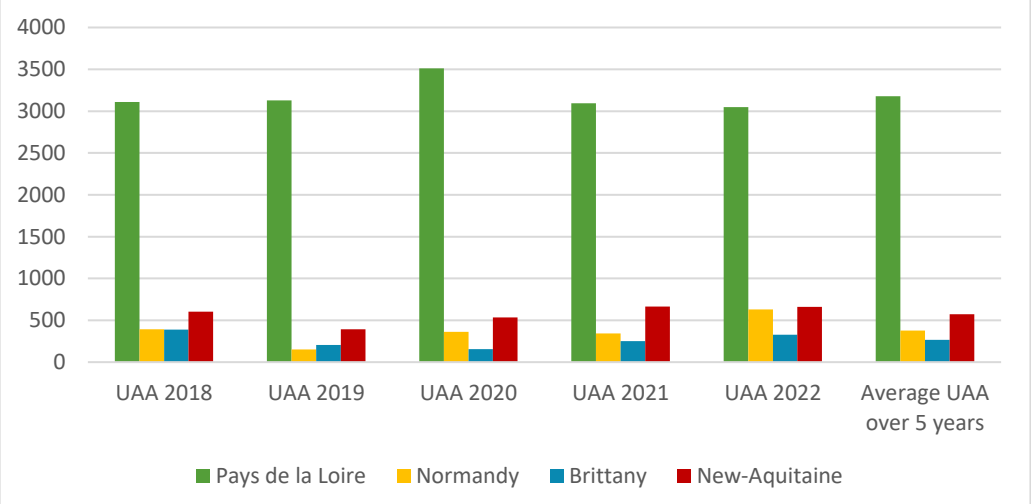
Breakdown of hemp surfaces declared for the 2022 CAP in the Atlantic Arc	
Brittany	329 ha
New-Aquitaine	661 ha
Normandy	631 ha
Pays de la Loire	3,047 ha

Source: Graphic plot register (RPG) 2022, Regional Chamber of Agriculture of New-Aquitaine.

The Pays de la Loire region concentrates the largest number of hectares in the west of France (65% of the area studied). This is largely due to the dynamism of the stakeholders in the Pays de la Loire region, particularly the CAVAC (agricultural cooperative for hemp production), which is located in Vendée and has been involved in hemp production and the manufacture of bio-based insulation materials for over 15 years.

The Hemp-It cooperative produces hemp seed. It is located in Maine-et-Loire, and contributes to this dynamism. However, the figure below does not consider Hemp-It surfaces as they deal with hemp seed and not fibre hemp.

Evolution of hemp surfaces by region over the last 5 years (2018-2022)



Source: CAP declarations.

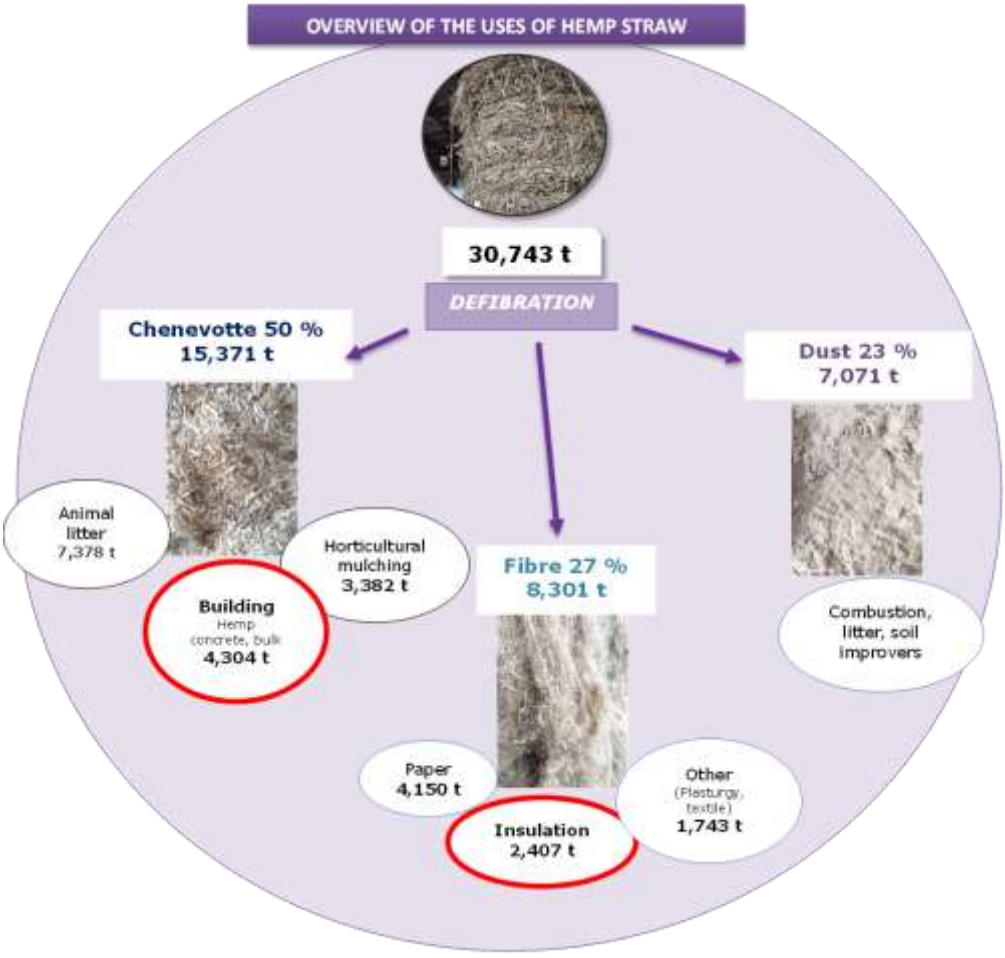
The assessment of hemp production in the graph above has been made based on hectares of fibre hemp declared to the CAP, using average yields: 1 tonne of dry matter for hempseed and 7 tonnes of dry matter for hemp straw. An average over the last 5 years has been calculated to show the trend (and avoid annual variations due to particular circumstances such as the weather), however the graph shows there have not been any major variations in the surface areas over this period.

The table below assessed the yield of seed and the yield of straw from the hemp production in the Atlantic Arc, using the average surface area calculated over the 5 years (2018-2022) and the theoretical production per hectare assessed as follows: yield of 1 tonne of dry matter per hectare for hempseed, and yield of 7 tonnes of dray matter per hectare for hemp straw.

Theoretical hemp production in the Atlantic Arc (for the 4 regions, excluding CBD)	
Average hemp surface	4,392 hectares
Estimated hempseed yield	4,392 tonnes
Estimated straw yield	30,743 tonnes

Source: RPG, average 2018-2022.

Driven by demand for bio-based materials and the dynamism of the local stakeholders involved, hemp production is expected to increase over the next 3 years. Hemp-based building materials come from hemp straw. Based on the data from FranceAgriMer, it has been possible to estimate production volumes in 2022 for the Atlantic Arc and their various markets. It is estimated that **6,711 tonnes of hemp** produced in the Atlantic Arc were processed for the building market and transformed into hemp concrete or insulation. This amount has been calculated based on the average hemp surface of 4,392 hectares.



2.3 Availability of miscanthus

Miscanthus is a perennial rhizomatous grass of the C4 type[10] , which contributes to its high productivity. *Miscanthus x giganteus,* the only species grown in France, is triploid and therefore sterile, and its rhizome is non-tracking. These two characteristics ensure that the plant is non-invasive. Miscanthus is a perennial plant planted for at least 20 years. From the 2nd year of cultivation, no maintenance (weeding, inputs) is required: no weeding, no nitrogen inputs, no plant protection treatments.

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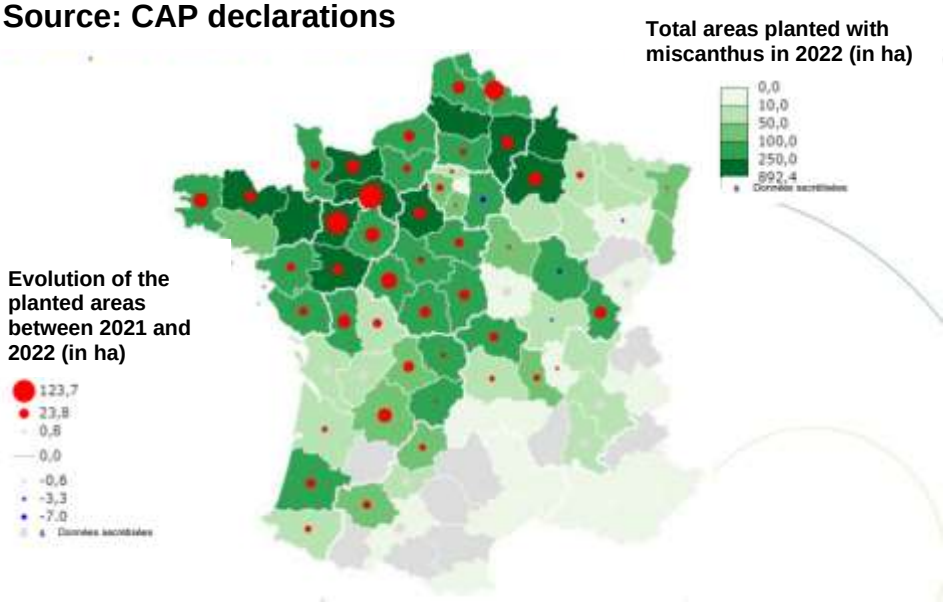
The miscanthus sector is still in its early stages in France, with few local stakeholders handling large volumes. Most of these stakeholders are members of the France Miscanthus association. Novabiom is the leading miscanthus planter, while Lamont Colin énergies is France's largest miscanthus producer. Biomis G3, an association created in 2013, brings together producers, manufacturers (Calcia cement, PSA, Addiplast, etc.) and local authorities. Biomis G3 aims to develop industrial markets for miscanthus. It is particularly interested in sustainable building and bioplastics. Its role is to bring together manufacturers and local authorities around the miscanthus use and to explore the possibility of setting up integrated local supply chains.

In 2023, a total of 11,000 hectares had been planted nationwide, with an annual increase of 18% over the last five years[11]. Several sources of data were used to assess the available biomass: FranceAgriMer, CAP declarations and a study by the France Miscanthus Association[12].

[10] It has a C4-type photosynthetic metabolism. C4 plants use the C4 carbon fixation pathway to increase their photosynthetic efficiency by reducing or eliminating photorespiration.
[11] The miscanthus sector in France - France Miscanthus - February 2023
[12] https://france-miscanthus.org/le-miscanthus-en-chiffres/

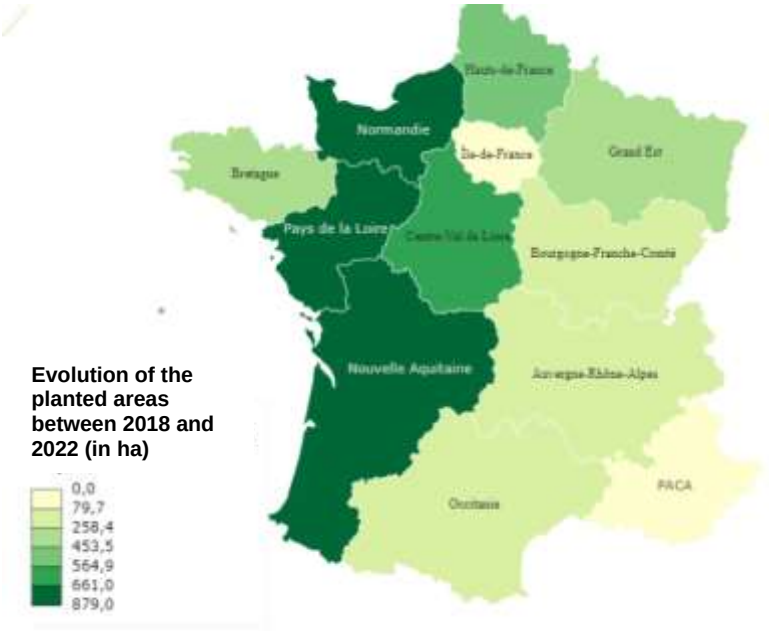
Location of miscanthus planted areas in 2020.

Source: CAP declarations



Source: France Miscanthus

The north-west of France accounts for most of the area planted according to 2022 sources.



Source: France Miscanthus

The Atlantic Arc is the area in which surfaces planted with miscanthus increased the most between 2018 and 2022, particularly in Pays de la Loire, Normandy and New-Aquitaine regions.

Growth in miscanthus planted areas between 2018 and 2022		
REGION	**SURFACE (2022)**	**INCREASE**
Brittany	914 ha	+ 334 ha
New-Aquitaine	882 ha	+ 666 ha
Normandy	1,259 ha	+ 676 ha
Pays de la Loire	1,812 ha	+ 883 ha

Source: RPG 2022.

This production has grown strongly in recent years. With an area of 6,400 hectares in 2019 and an average yield of 12.73 tonnes of dry matter per hectare in the growing phase (from the 4th year of age, the yield is lower in previous years), the French production is estimated at 57,440 tonnes in 2019.

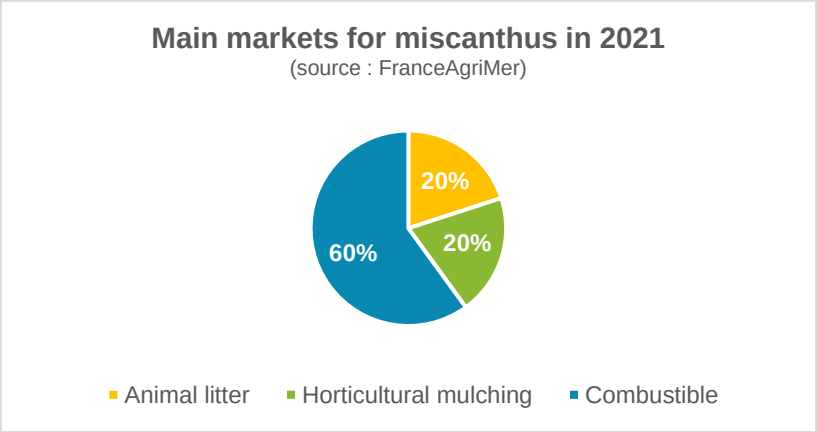
Projections have been made for the years 2020 to 2023, based on historical and newly planted areas, and assuming that the average growing yield remains at 12.7 tonnes/ha. The health situation and the slowdown in activity due to the coronavirus in spring 2020 have slowed development. As a result, production is expected to rise, but at a slightly slower pace than forecast: 79,000 tonnes in 2022, and possibly 88,000 tonnes in 2023.

Miscanthus has many diverse uses. In addition to conventional uses such as mulching, bedding, heating and cattle rumination, there are more innovative markets such as bioplastics and sustainable building, which are still underdeveloped.

Miscanthus markets		
AGRICULTURE	**Animal litter**	Interesting for its absorbing properties, miscanthus is used as animal litter in three markets: poultry, cattle and horse. Miscanthus litter is available in several forms: crushed, granulated, re-emitted granules or flour.
	Horticultural mulching	Primarily used by local authorities, private individuals and farmers (mainly horticulturists and winegrowers) for its absorbing and insulating properties that preserves soil moisture and act as a thermal insulator for plants.
	Rumination	The use of miscanthus to help cattle rumination has been under development for several years, notably by the Lamont-Colin farm, which has largely developed this niche market. Miscanthus has no nutritional value, though it helps cattle rumination.
ENERGY PRODUCTION	**Combustible**	Miscanthus is an alternative to coal or wood. For instance, it is used in the furnaces of alfalfa dehydration plants. It is a renewable energy source, with the advantage of being produced close to the plants. It has the same calorific value as wood. Miscanthus can also be used in boilers.
	Biofuel	The Futurol 2nd generation biofuel project, launched in 2008, incorporates several potential biomass sources, including miscanthus. In early 2020, the Futurol project process was bought by Croatian oil company INA.
BUILDING	**Bio-based concrete**	The cement manufacturer Alkern is currently developing concrete blocks made from miscanthus.

OTHER EXPERIMENTAL USES	**Bioplastics**	Miscanthus has for several years been the subject of studies and projects to explore its use as a polymer compound. The first markets are in the automotive sector, but projects are still in their early stages. Indeed, a tonne of micronized miscanthus is sold for around 600 € to 700 € per tonne.

Source: FranceAgriMer[13].



2.4 Availability of flax

Sown in March, the flax is harvested in July and pressed in August-September. It is stored on farms and processed in scutching plants throughout the year. It is therefore available all year round (except for the holiday period, generally in August). Flax seeds are first sown, generally between March and April, and the plant reaches maturity 100 days later. In June, the plant flowers. Then comes the harvesting stage:

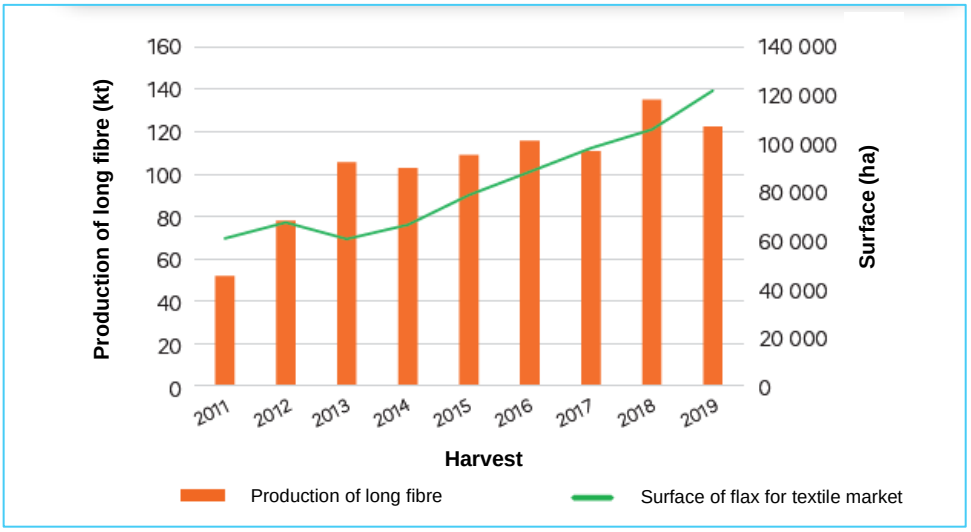
- **Removal**: in July, when all the flowers have disappeared and the stem is hard, it can be harvested and left on the ground to dry.
- **Harvesting**: the seeds on the straw are harvested using a hulling machine.
- **Retting**: this stage consists of separating the textile fibre from the woody part of the flax stalk. The flax growers turn the stalks over to homogenise the whole.
- **Scutching**: this consists of separating the flax fibre from the wood in the stalk. This produces long fibres called flax fibre and short fibres called tow.
- **Combing**: The fibre is then combed to produce fibre ribbons which are sent to the spinning mill.

France is the world's leading producer of flax, accounting for 75% of global production. The production is concentrated in the north-west of France, with most flax grown on the coast between France and the Netherlands, mainly in Normandy (60% of the area cultivated in 2020) and Hauts-de-France (35%) regions. Flax is grown by 8,200 producers.

[13] Study on price formation in the French miscanthus production sector (franceagrimer.fr) 2021

The surface area planted with flax in France has increased by a quarter since 2021. Most of the flax produced in France (over 90%) is exported to Asia, especially China, to be spun and re-exported to Europe[14].

Growth in French fibre flax surface area and long fibre production



Source: FranceAgrimer – Sector sheet, January 2021

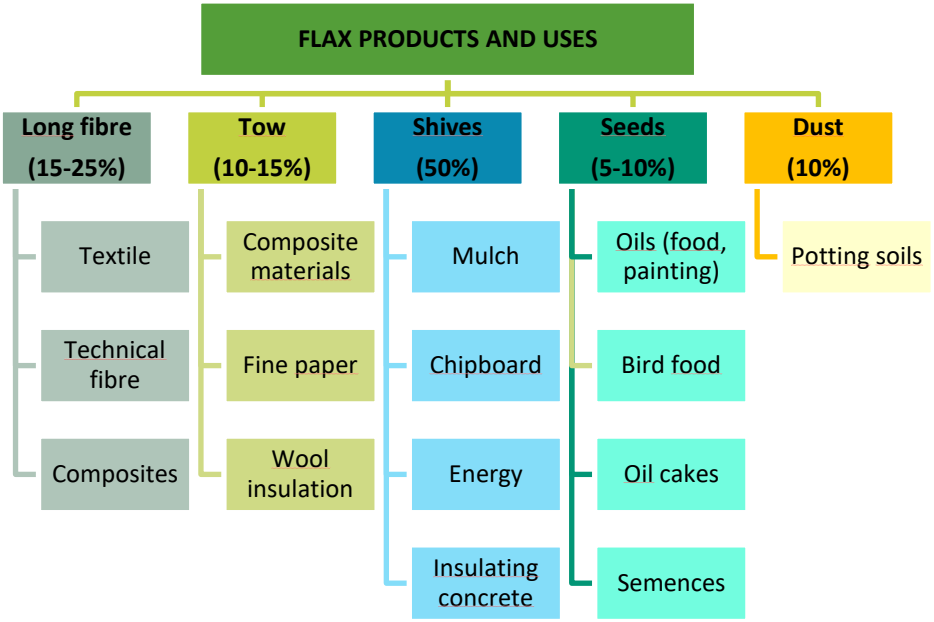
Normandy accounts for almost 2/3 of French fibre flax production. The region has planted 85,256 ha in 2020, representing around 656,000 tonnes of flax straw (527,900 tonnes on 73,315 ha in 2019 - 63% of French production). The surface area planted with flax is growing steadily, doubling between 2000 and 2020 in Normandy. Investments over the last two years confirm this trend for the years to come, driven by new stakeholders in Normandy: new scutching plants from the Depesteele group in the Vexin and the scutching cooperative of North of Caen (new subsidiaries from the Neubourg scutching cooperative and Teillage Lamerant scutching cooperative).

Breakdown per region of flax surfaces in the Atlantic Arc in 2022	
Brittany	257 ha
New-Aquitaine	15 ha
Normandy	74,593 ha
Pays de la Loire	300 ha

Source: FranceAgriMer.

Flax is generally grown for its fibres, but it offers a wide range of products (long fibres, tow, shives, seeds, dust) that can be used for a wide range of purposes. The diagram below shows the various markets for fibre flax. In most cases, the biomass from the crop has to go through two transformation processes before being used. Co-products such as tow and flax shives are very interesting for the manufacture of technical materials, including those used in construction.

[14] Source: Regional Chamber of Agriculture of Normandy, Assessment of resources available for construction in Normandy, May 2022.



Source: Regional Chamber of Agriculture of Normandy.

Main markets for flax	
Textile	Although flax fibres account for just 0.3% of the textile fibres produced worldwide, the sector remains by far the largest market for them, absorbing 95% of long fibres and 70% of tow.
Non-wovens	It is a market for flax tow for around 15% of its volume.
Composite materials	The emergence of these new applications is largely the result of innovation by SMEs. They also offer great potential for industrial sectors that are particularly demanding when it comes to the properties of materials, such as the marine, aeronautical and rail sectors.
Fine paper	Flax-based papers are light, strong and high quality. They can be used for a variety of purposes (publishing papers, graphic papers).
Animal bedding and horticultural mulching	Thanks to their honeycomb structure, flax shives have a great capacity to absorb water and retain it over the long term.
Energy	Some shives are used for energy purposes. Their calorific value is comparable to that of wood (4 kWh/kg) — for a lower cost of access — and their moisture content is low (10 to 12%). Clearly, 2.5 kg of shives are equivalent to 1 litre of fuel oil.
Oil	Known for its drying and polymerisation properties, linseed oil is used on its own or mixed with other oils, resins and solvents. Flax leaves can also be used to make cosmetic and pharmaceutical products.
Sustainable building	The company De Sutter in Normandy recovers almost all of the shives in the Seine-Maritime and Eure regions to produce particleboard.
Chemicals	Development of the chemicals sector by the Prevcarb company. An integrated biorefinery is under development in Normandy. The idea is to deconstruct shives to produce lignin, cellulose and hemicellulose. Each of these materials will have its own market.

3. Availability of nutrients

To assess the availability of nutrients for the four biomass streams studied, and develop their sustainable use in the building industry, it is important to consider their environmental benefits and the hierarchy of their uses:

- **straw** is a co-product of food production and is used primarily to meet the needs of livestock. Increasing the use of straw in the building sector will not lead to dedicated crops being grown for this purpose, and consequently will not increase the need for nutrients.
- **hemp** requires no fertiliser or plant protection products, and its deep root system improves soil structure, leading to higher yields for the following crop. Hemp cultivation is part of a plot rotation system (a 5-year period must elapse between two crops of hemp), therefore it does not compete with food production.
- **miscanthus** requires no fertiliser or plant protection products and is suitable for cultivation on difficult soils.
- **flax** does not require much fertiliser, and part of the flax biomass that can be used in the building sector is flax shives, which are a co-product of flax production for the textile industry. Therefore, it is possible to develop its use in the building sector without using dedicated crops, and therefore without increasing the need for nutrients.

Nutrient needs and availability as well as environmental benefits are presented in the sections below.

3.1 Nutrient needs and availability for straw

Straw is a co-product of wheat growing. The nutrients used are primarily to boost wheat yields, not straw. This is one of the crops we have the most control over in terms of technical itineraries, as wheat has been grown in almost every region of France for a long time. Interventions vary according to the stage of development of the wheat:

- at tillering stage between December and February, herbicides can be used on wheat crops;
- between February and April for the growing period, fertilisation is applied (3 nitrogen inputs);
- fungicides (powdery mildew, foot rot, septoria, yellow rust, fusarium and brown rust) are used between February and June;
- growth regulators are used between March and April, and insecticides between May and June;
- the grain develops between July and August and is then harvested.

Nutritional needs vary according to the variety of wheat grown and the expected yields.

Nutrient needs for wheat

Biomass	Yield	N kg/ha	P_2O_5 kg/ha	P kg/ha	K_2O kg/ha	K kg/ha	SO_3 kg/ha	S kg/ha	MgO kg/ha	Mg kg/ha
Grain	80 q/ha	144	52	23	40	33	27	11	10	6
Straw	4 t/ha	26	7	3	50	41	5	2	3	2

This crop requires the use of inputs and treatments involving the use of plant protection products. Trials on the use of straw from organically grown cereals for construction were inconclusive in terms of quality. In fact, this straw contains more weeds, which are a constraint for this use. These weeds present a double risk as a potential source of moisture and possible food for pests or moulds.

Straw is sometimes used as a soil improver. It essentially contains potassium, followed by phosphorus, magnesium and calcium in lesser proportions. Straw provides approximately per tonne:

- Nitrogen (N): 7-7.5 units
- Phosphorus (P): 1-2 units
- Potassium (K): 12-14 units
- Magnesium (Mg): 1 unit
- Calcium oxide (CaO): 4-5 units

The nitrogen measured in the straw is not available to crops, as the straw even mobilises the residual nitrogen in the soil for its degradation. The nitrogen availability coefficient is therefore zero. Depending on the nature of the soil, it may be advisable to bury the straw, particularly for its potassium content. Straw is also sought after for the carbon (C/N around 100-120) it can bring back to the soil.

The importance of straw as a soil improver depends on the cropping systems in the area. Pure cereal growers need it to feed their soil, which is why they return straw to the soil. But the other cover crops returned to the soil can also compensate. The overall rotation practised on the farm can also vary this practice from one year to the next.

Withdrawing straw for use as a building material is therefore not an agronomic problem if it is compensated by other inputs. When properly integrated into a farming system with crop rotation, straw resources are available without the need to use mineral nitrogen to compensate.

3.2 Nutrient needs and availability for hemp

Growing hemp is simplified by the absence of disease and pests. Hemp has a high level of genotypic diversity. It doesn't require any plant protection products, thanks to its covering power. It's a "zero-phyto" crop. Hemp has the advantage of having a low nitrogen requirement, as the plant can fetch fertilisers on its own, thanks in particular to its deep roots, which also give it the advantage of requiring little water - which means the plant is highly resistant to drought.

Advantages of the hemp:

- absence of diseases and pests: a "zero-phyto" plant;
- low nitrogen requirement: 0 to 100 u/ha;
- deep roots: low water requirements (except for sowing) and well-tilled soils;
- covering power: no herbicides and clean soils.

Nevertheless, care must be taken at the sowing stage, which takes place from mid-April to early May, to give hemp every chance of developing properly. Hemp is a spring crop with a relatively short growing cycle (between 120 and 150 days). It fits in well with a diversified crop rotation based on autumn crops (hemp, wheat, spring barley/rapeseed, wheat, maize, hemp) and allows the soil to be freed up quickly. It can be planted in between crops cultivation and diversifies soils, leaving them clean and well-tilled for subsequent crops thanks to its taproot. Practical experience has shown that cereal yields after hemp were improved[15] .

Growing hemp absorbs 15 t of CO2, the equivalent of one hectare of forest.

[15] Guide de culture du Chanvre - Terres Inovia - 2020 - www.terresinovia.fr

3.3 Nutrient needs and availability for miscanthus

Miscanthus plantations need weeding in the first year but are maintenance-free from the 2nd year onwards and can be grown for 20 years. It is planted in May. It can be removed at any time. It is harvested in March-April and can be stored in bulk. In the current state of French production, no diseases or pests are detrimental to it, and it requires little or no fertilisation[16].

Miscanthus provides many ecosystem services. Miscanthus cultivation offers catchment capacity in polluted areas and creates attractive wildlife cover, particularly for small game. It can therefore be planted in catchment areas or hunting grounds. The crop does not require any fertiliser and is particularly suitable for use in water catchment areas. Its dense root system improves soil structure and encourages infiltration, helping to combat run-off and erosion. It also acts as a nitrate filter and absorbs heavy metals. The permanent cover provided by miscanthus reduces the formation of gullies.

Finally, the high height of miscanthus provides an effective barrier to wind erosion while limiting the contamination of plant protection products by air. The higher the miscanthus planting density, the more effective the positive barrier effects. Planting strips of miscanthus between agricultural plots therefore helps to reduce the effects of erosion and soil degradation, particularly in arable farming areas. The cultivation of miscanthus is therefore seen as a necessary "no-treatment zone" between plots of land and homes, to act as a buffer zone to prevent plant protection products reaching people by air.

Miscanthus can be used in a variety of ways. Dual-use projects for miscanthus have already been set up in Alsace in certain counties where miscanthus is planted in highly polluted catchment areas and plays a role in regulating this pollution. At the same time, the miscanthus harvested each year is used to fuel a local boiler room that provides energy for the local authority.

3.4 Nutrient needs and availability for flax

Flax is a non-irrigated crop that follows a long crop rotation cycle (6-7 years), which increases crop biodiversity on farms and prevents the spread of disease. It acts as a carbon sink, retaining 3.7 tonnes of CO_2 per hectare[17]. Flax is fast-growing and can be grown in poor soils. It is also environmentally friendly, requiring little nitrogen input. The latest research by the Arvalis institute indicates a requirement of 12 kg of nitrogen/ha for the production of one tonne of unthreshed retted flax. Nitrogen is applied at sowing time.

Weeds should be controlled from the start of the flax cycle. Crop rotation and tillage mean that weeds can be controlled as little as possible. In this sense, flax is an agronomically interesting crop.

Finally, pest control is increasingly being achieved through products that use natural mechanisms to combat crop pests. Several biocontrol products are currently being tested and approved for use on flax by the Arvalis institute.

[16] Miscanthus cultivation technical sheet – Chamber of Agriculture of the Landes
[17] Source : Terre de Lin.

4. The relevance of fibre plants to enhance sustainability in the building sector

4.1. The assets of straw

A local production

Given that cereals are grown throughout the Atlantic Arc, straw is supplied regionally and even at local scale, therefore it does not require important transport - and therefore carbon emissions. According to Luc Floissac[18], 50% of straw supplies come from a source less than 10 km away, 40% between 10 and 50 km and 10% more than 50 km away. However, this figure needs to be put into perspective. Self-builders are still very active in straw construction, but with the development of straw construction by companies and craftsmen, supply distances are likely to be greater. Nevertheless, supplies are expected to remain mainly regional, as transport costs are an important factor in the profitability of straw-based construction.

Recognised professional standards

Straw as a bio-based material for the building market has been organised for several years to ensure its development. For over 10 years, professionals have been publishing professional rules for building with straw. This regulatory framework has enabled straw to gain recognition from the building industry and insurers alike. The ten-year construction guarantee is therefore guaranteed for all straw construction.

A ”carbon sink” material

When straw is used as a soil improver, 85% of the carbon is released into the atmosphere in the form of CO_2. If it is used as a bio-based material in building, the CO_2 captured during the farming process will be stored in the building throughout its lifespan. Straw has a reference lifespan of 50 years, even if older straw buildings exist and show no signs of deterioration. This temporary storage of CO_2 can be quantified in the Life Cycle Assessment (LCA) of straw as being beneficial for the climate[19] since this CO_2 does not end up in the atmosphere. The use of straw is therefore one of the possible ways of reducing CO_2 and does not contribute to the greenhouse effect. The calculation proposed to assess the reduction in CO_2 emissions is based on the quantity of carbon biomass contained in the product and its lifespan. For an average lifespan of 50 years, the reduction[20] is of -14 kg CO_2 equivalent/m² (Fiche de Déclaration Environnementale et Sanitaire (FDES) – Environmental and Health Declaration Sheet)[21]. An FDES is a standardised document that presents the results of a product's LCA as well as health information with a view to calculating the building's environmental and health performance for its sustainable design. It is valid for 5 years.

This lower carbon impact should be seen in the context of the replacement of 'conventional' insulation materials, such as glass or rock wool, which have a high carbon impact. Furthermore, its high-performance insulating properties mean that it saves energy in terms of the buidling’s consumption and therefore reduces CO_2 emissions.

[18] Luc Floissac, La construction en paille, collection *Techniques de PRO*, terre vivante, 2012.
[19] G. DEROUBAIX et al, *Cycles de vie des produits à base de bois et séquestration du carbone*, FCBA, 2012.
[20] Source RFCP (Réseau Français de la Construction Paille) - 2019: https://rfcp.fr/wp-content/uploads/2019/10/Livret-vert.pdf
[21] Source RFCP - FDES collective - July 2022 - verified by INIES. INIES is the national reference database for environmental and health data on construction products and equipment**.** INIES provides Environmental and Health Declaration Sheets: https://www.inies.fr/

Little or no processing

The straw used for construction requires little processing before use. The only constraint on construction is the size of the straw bale. Otherwise, it can be used as is. Straw is the insulation material that requires the least grey energy[22].

Other qualities of straw

These environmental properties are in addition to its thermal insulation and soundproofing qualities, which promote healthy indoor air quality.

The end-of-life of straw insulation material

During deconstruction, the straw can be easily dismantled and separated from the other elements. There are two possible end-of-life options:

- **Composting**: straw is a natural material that can easily be composted in a suitable centre.
- **Recycling**: straw can also be recycled as a soil improver by farmers.

4.2. The assets of hemp

Hemp can be used in many different ways in the building sector:

- Hemp concrete or hemp mortar[23] is made from hemp chips and combined with a mineral binder (lime) and water.
- Hemp wool is used to insulate attics, partitions and floors.
- Hemp felt is made from hemp fibres impregnated with sodium carbonate. It is used to insulate floors, partitions and wooden structures.
- Hemp can also be used to complement other materials such as wood. Hemp concrete can be used to protect a timber frame thanks to its fire-retardant properties.

Hemp-based materials offer a number of advantages:

- As a building material, hemp offers excellent thermal insulation both in winter and in summer.
- In terms of sound insulation, it acts as a sound absorber, reducing ambient noise.
- Combined with the breathable properties of the walls, the natural ventilation provided by hemp regulates humidity by maintaining an optimum hygrometry level in the house. It absorbs excess humidity in the air and releases it when the air is too dry.
- It also offers good fire resistance. Tests have shown that after 3 hours and 30 minutes at temperatures in excess of 1100°C, the unexposed side does not exceed 90°C.
- Hemp cultivation requires less water and pesticides than other traditional building materials, making it an attractive option from an environmental point of view. And because the plant is grown without pesticides, it emits no VOCs (volatile organic compounds).
- Economically, hemp-based materials are currently more expensive on the market. But in practice, a study by Cérema has shown that the thermal performance of hemp concrete can save up to 70% on heating costs.

[22] Grey energy, or embodied energy, is the quantity of energy consumed during the life cycle of a material or product: production, extraction, transformation, manufacture, transport, use, maintenance and finally recycling, with the notable exception of use.

[23] The difference lies mainly in the use: hemp concretes are used for all applications (roofs, walls and floors), while mortars are used for rendering.

4.3. The assets of miscanthus

A recent study carried out by Nobatek in the New-Aquitaine region explored the potential of miscanthus as a lightweight earth construction material, and compared it with the conventional materials: chenevotte and wheat straw. The raw materials tested were as follows:

- For hemp: hemp shives prepared for hemp concrete.
- For miscanthus: ground miscanthus for agricultural mulching, undusted.
- For straw: shredded material for rodent bedding, long fibres (5, 10 cm).
- The mixtures made in constant mass proportion are as follows: fibre 21%, soil 35%, water 44%.

BIOMASS	HEMP SHIVES	MISCANTHUS	STRAW
Pictures			
Handling	Excellent Good wrap Non-elastic material Fibre length < 1cm Easy moulding	Medium Medium wrap Non-elastic material Fibre length 1-3 cm Medium moulding	Low Difficult to wrap (silica) Highly elastic material Fibre length 3-10 cm Difficult moulding (size of fibres, elasticity)
Fibre density	150 kg/m^3	190 kg/m^3	135 kg/m^3
Dry consistency	Excellent Very clean material	Medium Dust seems to affect cohesion	Good Adhesion that seems to fail when wet is resolved when dry
Compression	Compressible materials. There is no breaking strength; the material becomes denser as a function of the force applied. Straw is also highly elastic.		
Thermal conductivity λ = the capacity of a material to conduct heat: for the same thickness of insulation, the lower the λ, the greater its thermal resistance and the better its performance.	= 0.090 W/m².K λ	= 0.067 W/m².K λ	= 0.061 W/m².K
Ways to improve	Already optimised	Dust removal Finer grinding Sorting Defibration	Shorter calibrated cut Press drying

Source: NOBATEK, Exploratory study on plant fibres for lightweight earth, M.LOUVARD, May 2023.

These comparative tests show that there are good opportunities for using miscanthus in bio-based construction materials, but there is still progress to be made in processing the raw material, particularly in dust removal, grinding and defibration. the lack of professional rules for miscanthus building materials is also an obstacle.

4.4 The assets of flax

Particleboard[24]

Flax shives are used in the manufacture of agglomerated particleboard because of their low density (120 kg/m3 unpacked) due to their honeycomb structure. In this application, shives provide materials with:

- high fire-retardant properties: this unique characteristic means that flax panel is used as a major component in fire doors. Even though it is lighter than particleboard, it has better fire-retardant qualities.
- good sound insulation: this property is particularly interesting for the manufacture of doors and partitions.
- flexibility and high resistance to torsion: because flax shives are lighter and longer (between 10 and 20 mm long, with a cross-section of around 2 mm) than wood fibres, flax panels are more flexible and more resistant to torsion than traditional particleboard.

In Normandy, stakeholders are looking to make the most of by-products such as flax shives, and work is underway on the insurability of flax-based materials.

[24] Source: sanopan.com – society De sutter.

5. Development forecasts for bio-based materials in building

The "*technical plant fibres in materials*" market overview assessed the volumes produced by origin of plant fibres in France in 2017:

Bio-based product	Origin	Volume produced
Flexible insulation	Hemp, flax and rice straw	7,200 t/year
Filler insulation	Cereal straw	4,600 t/year
Plant-based concrete	Hemp straw (mainly), flax straw or rape straw	40,000 t/year

These volumes have increased - the market study estimated in 2017 that biobased insulation would see annual market growth of 10% by 2025/2035, thanks in particular to the incentive regulations introduced by the French government.

In this report makes an attempt to evaluate the volumes potentially produced in 2022 and the development forecasts for the 4 regions of the Atlantic Arc, sector by sector, since the dynamics are not the same from one sector to another.

5.1 The current market for straw-bale construction

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Straw construction can be used for all types of building, from detached houses to multi-storey buildings and industrial or commercial buildings.

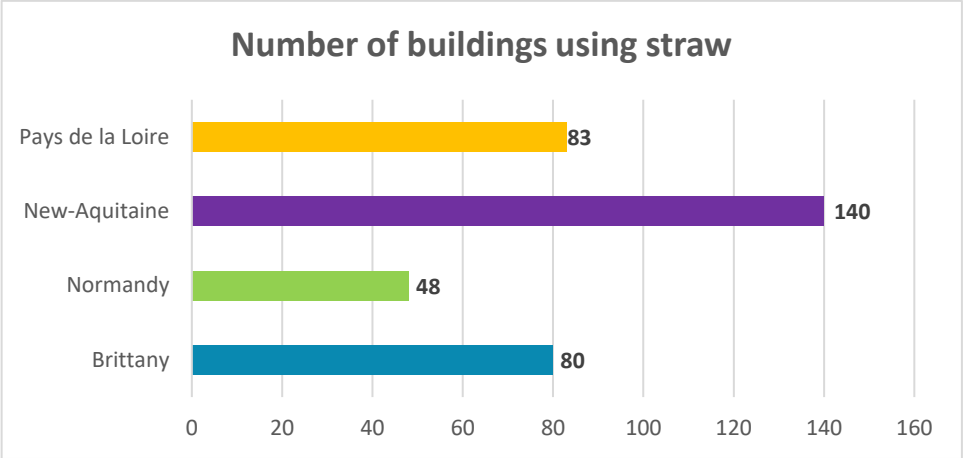
Around 6,000 buildings are constructed in France using straw, and 500 new constructions are recorded every year[25], representing a steady increase of 8% in the number of buildings. The French sector is the most dynamic in Europe.

The development of straw-bale construction depends to a large extent on the presence of agricultural businesses that can supply straw and craftsmen who have mastered construction techniques.

The professional rules for straw construction introduced by the RFCP[26] in 2012 have led to recognition of the straw sector in the construction industry. They serve as a basis for passing on the technical know-how of straw construction to professionals through pro-straw training courses that guarantee access to standard insurance scales.

In the Atlantic Arc region, 351 buildings have been constructed using straw[27] according to the straw construction panorama.

[25] RFCP Green Paper - 2019
[26] https://www.rfcp.fr/les-regles-professionnelles/
[27] Source : http://www.constructionpaille.fr/panorama/



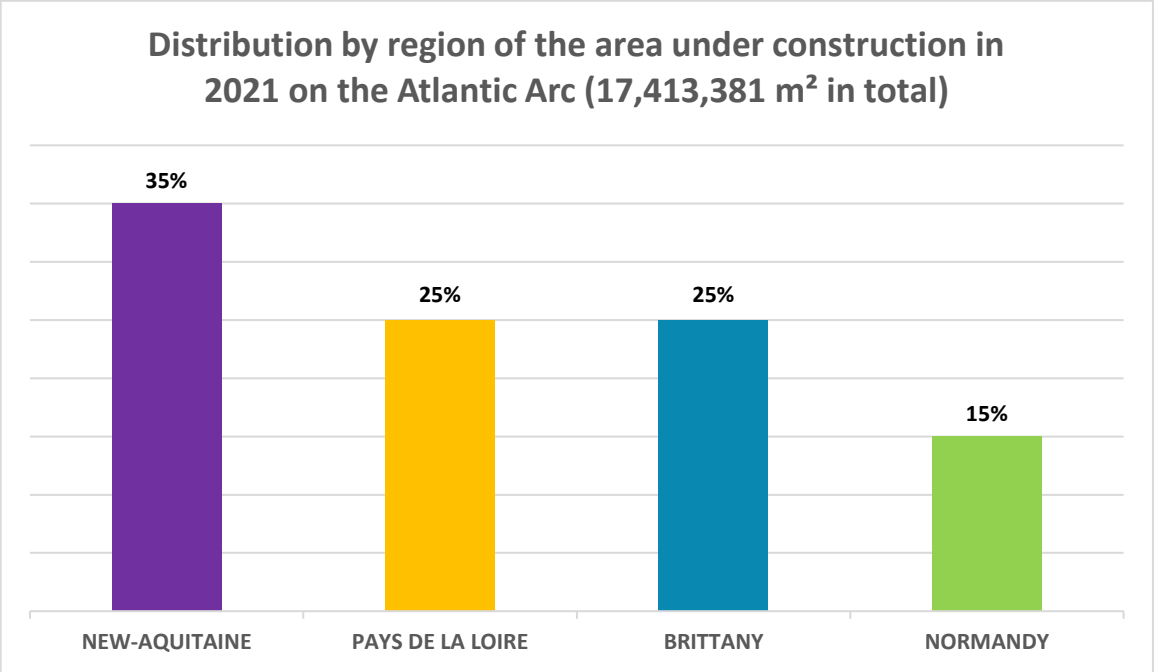
Building with straw is originally a militant and individual initiative, but the interest of local public authorities is growing as they look for sustainable options in public procurement for new buildings. are beginning to be sensitive to the issue of sustainable development in the construction of their buildings and are opting for sustainable building. For the moment, mainly schools are being built using straw. Public procurement is a real accelerator in the development of construction using bio-based materials.

High school of Aizenay in Vendée (Pays de la Loire, France) built with wood and straw insulation - © Regional Council of the Pays de la Loire

Other sectors are clearly keen to develop construction using bio-based materials. In Normandy, the Union sociale pour l'Habitat (Social Union for Housing) has set its target to build all its new projects using bio-based materials by 2025/2026. Straw is one of the materials chosen to meet this target.

The availability of straw in the Atlantic Arc should be compared with potential construction needs. According to Sitadel[28] in 2021, 110,000 homes are under construction in the French Atlantic Arc. If we add other buildings, we arrive at 17,413,381 m² under construction.

[28] https://www.statistiques.developpement-durable.gouv.fr/



The average straw requirement for insulation varies depending on the building: a 100 m² house requires around 6 to 9 tonnes of straw, while non-residential buildings require around 20 kg per m² [29]. Housing accounts for 55% of the surface area under construction and other buildings for 45% in the Atlantic Arc. Based on 2021 data, it is possible to compare the surface areas under construction with the quantities of straw needed for straw insulation.

The table below shows the data for each type of building, and therefore the theoretical straw needs for building in 2021.

Type of building under construction	Homes	Non-residential buildings
Quantity of straw required in T/m².	0,09	0,02
Surface area under construction in m² in 2021	9,812,600	7,600,781
Tonnage of straw required for 100% of buildings constructed with straw (TMS)[30]	883,134 t	152,016
Tonnage of straw required for 10% straw buildings (TMS)	88,313	15,202
Tonnage of straw required for 1% straw buildings (TMS)	8,831	1,520

For 1% of homes built with straw, 8,831 tonnes of straw are needed. This corresponds to the 2,944 ha of wheat needed to supply this tonnage. This figure should be compared with the 2 million 300 ha sown in 2021, therefore 0.1% of the land area.

[29] Source: Céréma and Collectif Paille Armoricain
[30] TMS: tonne of dry matter

Currently, according to RFCP data, the annual increase in the number of straw buildings is 8%, which for the Atlantic Arc represents **29 more buildings per year**, including 23 homes. Assuming a house surface area of 100 m², around **270 tonnes of straw** would have been used for housing construction in 2021. This represents only 90 ha for the whole of the Atlantic Arc.

These figures are expected to rise as a consequence of new regulations, interest from social housing stakeholders and straw-based construction innovations led by local stakeholders.

Even though, overall, the four regions of the Atlantic Arc have a straw deficit (estimating a return to the soil at 25% of the volumes of straw produced), the tonnages of straw required appear low in relation to the tonnage of straw harvested in the regions.

© Chamber of agriculture of Hautes-Alpes

Furthermore, the uses of straw in the building sector are likely to rise and diversify as a consequence of agricultural developments, and in particular the sharp fall in cattle numbers. National beef production fell by 7.3% between 2021 and 2022, and forecasts are even lower for 2023. In some regions of the Atlantic Arc, the decline in livestock numbers is very sharp, and has been a trend for more than 10 years: in New Aquitaine, between 2010 and 2020, livestock numbers - all categories combined - fell by 12%.

REGION	NEW-AQUITAINE	PAYS DE LA LOIRE	BRITTANY	NORMANDY
Number of LUs - 2010/2020	- 12,2 %	- 4,7 %	- 5,5 %	- 6 %

This decline has two consequences: a reduced need for straw for bedding, and an increase in the area under crops that can be sown to cereals and therefore provide straw. However, this increase remains limited to 2% more cereal surface area over the same period (2010/2020)[31].

[31] Source: RGA 2010 & 2020

5.2 Development forecasts for miscanthus in the building market

The development forecasts for plant-based solutions in the building sector offer further opportunities for miscanthus. At present, although miscanthus is used in a variety of ways in the building industry, it is only used as a filling material and not as a load-bearing element. For miscanthus as for the other fibre plants, there are currently two opposing market strategies: "low tech" processes and semi-industrial processes. Some stakeholders opt for the low-tech process, which takes longer to install but is more attractively priced because the agricultural material undergoes little processing, while others prefer blocks or panels, which are more processed products that are expensive but easier to transport and install. The development forecasts for miscanthus are still at the experimental stage and are therefore difficult to quantify. The construction market is assumed to account for 10% of miscanthus markets.

5.3 Development forecasts for hemp in the building market

Hemp has great potential for development in the building market, thanks to its ecological properties and its advantages in terms of sustainability. But demand for hemp is also evolving positively, driven by regulatory changes in the construction sector. Above all, the dynamism of the industry's stakeholders is significantly boosting its development forecasts.

In the Atlantic Arc, the CAVAC cooperative group in Vendée is the biggest actor, both collecting and processing hemp. The cooperative collects 14,000 tonnes of hemp straw from its members, which is then defibred and processed into insulating panels at its CAVAC biomatériaux subsidiary. CAVAC biomatériaux is building a new plant in 2023, with the aim of tripling the area planted with hemp by 2025, from 2,000 ha to 6,000 ha, to meet the demand. In Pays de la Loire, there are two other producers' associations: Chanvre Paysans, which tends to work in short circuits, and the association of hemp producers in Sarthe, whose producers now supply CAVAC. There are no hemp mills in Brittany. However, there are producer associations such as "Lin et Chanvre en Bretagne" and “Bretagne Chanvre Développement”. There are no hemp growers in New-Aquitaine either. Associations of hemp producers, “Lo Sanabao” and “Chanvre Mellois”, tend to work in short circuits. Their markets are essentially self-builders and/or a network of trained local craftsmen. « Les Chanvres de l'Atlantique », located in Geours de Maremme (Landes), mainly processes hemp seed.

In Normandy, from 2008 to 2019, an average of 40 Normandy producers have been growing hemp every year on 350 ha, mainly for Agrochanvre in Barenton. Agrochanvre also collects hemp from neighbouring regions, for a total of 600 ha and 2,500 tonnes of straw per year[32]. In the same time, the textile industry is developing in Normandy, which will put several thousand tonnes of chenevotte on the market. This could destabilise existing industries: as this chenevotte is a waste product for the textile flax industry, it is likely to be sold at a lower price than hemp fibre.

Nevertheless, the development forecasts for hemp in the construction industry are promising. Taking into account the ambitions of existing stakeholders, the area under hemp should increase from **4,668 ha to 8,800 ha** by 2025, giving a theoretical production available for construction of 13,500 T, broken down into 8,700 T for hemp concrete and 4,800 T for insulation.

5.4 Development forecasts for flax use in the building market

Currently, the use of flax in buildings in mainly from short fibre, up to an amount of 11,000 tonnes in 2020, only produced in Normandy. The production of bricks made from flax shives is a market being explored by a number of French manufacturers, including the cooperative Depestele in Normandy. Research is ongoing on concrete block from flax shives. The first is a load-bearing block made from

[32] Source : Regional Chamber of Agriculture of Normandy.

cement, sand, lime, shives and water. It has the same function as a conventional breeze block, but also provides initial insulation. The second insulating block is made from shives, lime, water and additives to reduce the drying time.

No matter what the harvesting conditions, the woody residues of the plant have a certain stability, unlike fibre. Flax is used in the same way as traditional insulation materials. However, it has a much greater heat storage capacity. It takes four times longer for heat to penetrate flax insulation. Flax shives are also excellent sound insulators. The qualities of flax shives are recognised by construction professionals, but the value of this material remains low and is currently a niche market because of the absence of professional rules (and therefore of insurance).

In this report, to assess development forecasts of flax for bio-based building, we chose to keep only the tonnage of short flax fibre used in Normandy (11,000 tonnes). It is the only region producing these fibres in the Atlantic Arc.

5.5 Summary

In the Atlantic Arc, the theoretical volumes of biobased materials produced in 2022 were initially calculated on the basis of the agricultural areas planted and declared to the CAP and the theoretical average yields per crop.

Then, based on the tonnages of fibre plants available, we estimated the proportion potentially used in construction using theoretical percentages.

Theoretical use of biomass produced in 2022	Straw	Hemp	Miscanthus	Flax fibre
UAA planted	2,290,791 ha	4,668 ha	4,867 ha	75,165 ha
Tonne of dry matter theoretically harvested	6,383,000 t	32,676 t	61,957 t	578,770 t
Use in building	270 t	6,711 t	6,200 t	11,000 t

These tonnages are relatively low compared with the conventional materials used in construction. We are still in a niche market. Biobased materials account for 10% of the construction market, and are mainly wood-based.

5.6 Growth assumptions for the bio-based building market

Driven by the RE2020 regulations, the bio-based materials market is enjoying sustained growth of around 10% a year. Industry professionals estimate that demand will double between now and 2025, driven by the new rules, but also by the massification of supply, which makes these materials more accessible. We have chosen three working assumptions:

- Assumption 1: Current growth: 10%.
- Assumption 2: medium progression: 25%.
- Assumption 3: strong growth: 50%.

Estimated volume produced in France based on the 3 assumptions:

Type of bio-based materials	Volume produced in 2017	Estimated volume in 2023	Volume in 2025 Assumption 1 + 10 %	Volume in 2025 Assumption 2 + 25 %
Flexible insulation (hemp straw, flax and rice)	7,200 t/year	7,493 t/year	8,242 t/year	9,366 t/year
Filling insulation (cereal straw)	4,600 t/year	4,787 t/year	5,266 t/year	5,984 t/year
Plant-based concrete (hemp, flax or rapeseed)	40,000 t/year	41,626 t/year	45,789 t/year	52,033 t/year

By applying these assumptions to the Atlantic Arc data, we obtain the data listed in the table below, according to biomass. This projection is applied in a linear pattern whatever the feedstock, even if the dynamics are not the same for miscanthus and flax.

Availability of biomass for construction	Straw	Hemp	Miscanthus	Flax
Assumed tonnage for 2022	270 t	6,711 t	6,200 t	11,000 t
Surface area	90 ha	4 392 ha	477 ha	1,570 ha
For construction: **+10**	297 t	7,382 t	6,820 t	12,100 t
Equivalent UAA required	99 ha	4,831 ha	525 ha	1,727 ha
For construction: **+25**	338 t	8,389 t	7,750 t	13,750 t
Equivalent UAA required	113 ha	5,490 ha	596 ha	1,963 ha
For construction: **+50**	405 t	10,067 t	9,300 t	16,500 t
Equivalent UAA required	135 ha	6,588 ha	716 ha	2,355 ha

This projection is applied in a similar way for all the biomass streams, but it will not apply in the same way depending on the organisation of the sector, the region - some stakeholders being more ambitious - and whether it is a co-product or a dedicated plant.

6. Conclusions and recommendations

6.1 Conclusions

The aim of this study is to gain a better understanding of the biomass available on the market for bio-based building materials. The aim is also to verify whether this market represents an opportunity for agriculture or whether, on the contrary, it competes with other markets for agricultural production, particularly for human consumption.

The use of bio-based materials in the building industry is clearly on the increase, if not exponential. There are a number of reasons for this, not least the regulatory context, with the effective application of the RE 2020 directive in the building sector and the regulation on zero carbon emissions by 2050. Bio-based materials from fibre plants have very interesting physical properties, particularly with regard to thermal heat, guaranteeing recognised comfort and resistance. Certain regions are also developing “wood-bio-based materials pacts” (Pactes bois-biosourcés) to facilitate the development of the use of these materials. The presence in the regions of stakeholders involved in a dynamic industry - from production to the marketing of finished products - both locally and on the regional or even national market, is also an asset for the development of this market.

However, the advantages of these materials are hampered by a highly restrictive regulatory framework in terms of insurance, with the principle of "one material, one use, one standard". Even though certain sectors, and straw in particular, have developed professional rules that are now recognised, this is one of the main obstacles to the development of bio-based materials.

Other blocking factors include a lack of knowledge about these materials on the part of professionals and the general public. Economic factors (high prices) and regulatory factors (building insurance criteria, standardisation of materials) are slowing down the development of bio-based products and providing little incentive for innovation.

Uneven capacities across the Atlantic Arc

The first lesson to be learned from this biomass study is the wide disparity in availability between the regions of the Atlantic Arc. This territorial disparity is linked to the presence of stakeholders with processing and distribution facilities in the regions concerned. Straw is the more evenly distributed fibre plant across the Atlantic Arc.

Normandy is a leader in fibre flax production, particularly for textiles, while also having a strong presence in hemp. The production is boosted by the strong presence of flax-scutching companies and flax mills. Textiles dominate the market, but the recycling of flax co-products is making strong progress, with a direct impact on bio-based materials for the building sector. The company Agrochanvre promotes hemp production in the region and neighbouring departments through sourcing with local producers. There are currently no downstream stakeholders in the region offering straw, but this is one of SCALE-UP project’s objectives with the support of the solution “Atelier du biosourcé” in Normandy, which aims at setting up a place to gather bio-based building solutions and promote their use for building, including straw-based solutions.

Pays de la Loire is the leading region for hemp production in the Atlantic Arc. In contrast, Brittany, historically a land of flax and hemp, will have few areas planted with flax, hemp and miscanthus by 2022. The same is true of New Aquitaine, despite its size. The CAVAC cooperative invested in hemp processing and the production of bio-based building materials 15 years ago. This explains the growing presence of hemp surfaces in the region. There are also two associations of hemp producers who are more focused on selling through short distribution channels. Straw stakeholders are also well represented in Pays de la Loire: Profibre (linked to CAVAC since 2022), Isol'En Paille, and soon COPANO (the second selected innovator in our region), which is working on an innovative straw panel solution.

In New-Aquitaine, there are no industrial stakeholders in the manufacture of bio-based materials. Instead, there are organisations of farmers working in short circuits, such as Chanvre Mellois. The New-Aquitaine region is supporting the development of very localised industries in rural areas, with a focus on experimentation and links upstream and downstream in the industry. In this way, the preliminary study of markets and the upstream testing of products enable hemp to be grown by groups of farmers.

“SCIC IELO paille” is a cooperative that promotes short circuits and the local economy. Based in the Vienne region of France, its aim is to develop this straw production throughout France, while maintaining strong ethical values by working with the local economy. It promotes a spreading model that aims to bringing production closer to where projects are built. The stated aim is that "chopped straw should not be transported more than 250 km from the wheat production field to the carpenter's workshop or the building site where it will be used".

Uneven availability of resources

Straw is widely distributed throughout the Atlantic Arc and can therefore be used directly without the need for extensive logistics. This resource has a number of technical qualities and assets that make it available to meet the sustainable building objectives of the RE 2020. It can be used immediately: being a by-product of cereal production, it does not require any changes to the crop rotation or the acquisition of technical production know-how. Farmers already grow cereals and have a good command of the crop. There remains, however, a real fear on the production side that the straw construction sector will compete with the need for straw for the animal sector or for returning to the soil. The quantities of straw needed for construction are small in relation to production and do not seem capable of destabilising the livestock market. Furthermore, the structural trend towards a decline in livestock farming, combined with an increase in the area under cereal crops, means that there is likely to be greater availability of the resource without destabilising other agricultural production. A certain vigilance is however needed due to climate change, as weather conditions can make straw rare in certain seasons - as is the case for the 2024 harvest, where heavy autumn rain delayed or even prevented winter cereal sowing. This vigilance is not the only obstacle to the development of straw. Just as there must be a market potential and a commitment on the part of professional craftsmen, the prescription of public contracts and the training of professionals are all levers that will enable the straw market to develop.

Regarding **miscanthus**, Marie Rondin's recent study "*On the trail of a new sector in the building industry: miscanthus*" shows the real opportunities for miscanthus in the construction industry. Miscanthus is a perennial crop whose biomass, once processed, offers excellent insulation and strength properties. With a 20-year production life, low water consumption and no need for phytosanitary treatment during the growing phase, this crop is becoming established in France, particularly in the Atlantic Arc regions, where it is growing rapidly. The miscanthus is a plant that can easily be established in areas where environmental issues are at stake (for instance polluted soils), and can be used to diversify conventional production. Construction and the supply of bio-based materials from miscanthus is a very interesting area for development because miscanthus can be planted in all types of lands, enabling local supplies with a low carbon footprint.

Hemp is developing rapidly in the Atlantic Arc, with an assured increase in the area under cultivation this year. However, this easy-to-produce plant has experienced difficulties, mainly due to unstable markets and a complex harvest. This is making some growers more cautious, as they need to be sure of a market to sell their production. This type of production also requires all the by-products - including dust - to be used if it is to be profitable.

Flax: Flax is mainly grown for the textile industry, which is very demanding and profitable for the sector. This situation does not encourage the development of flax shives, which are used for construction. There are operators in the Normandy and Hauts de France regions. Production is highly concentrated, which could encourage the massification of resources around co-products (shives and tow).

6.2 Recommendations

Increasing the number of these fibre plants is of both environmental and agronomic interest, with development forecasts for crop diversity and markets for farms in the Atlantic Arc. This development will depend on several factors that are worth working on:

- **Developing demand, in particular by mobilising stakeholders**

It is important to provide a political framework and to motivate regional elected representatives and agricultural leaders. Synergies could make it possible to mobilise existing economic stakeholders, in particular the cooperatives with a strong presence in Brittany and New Aquitaine. The cooperative model is an asset that can reassure producers. The development of demand will also require the removal of a barrier to the use of bio-based materials, among which the price, which is still too high. It

is by mass-processing, linked to the industrialisation of the supply, that economies of scale will be achieved to bring competitive prices to the market.

To ensure that the use of biobased materials by building professionals really takes off, awareness-raising campaigns can be used to reach craftsmen and companies who are not part of the biobased materials network. The regional bio-based materials associations (FB², ARPE, Collectif biosourcés Pays de la Loire and ODEYS) are make significant efforts to demystify and educate the public about the use of all bio-based materials, with numerous conferences and tools: directories of professionals, a call for expressions of interest to help local authorities move towards biobased construction, and so on. Similarly, the national industry associations are heavily involved, offering a wide range of tools to promote the use of biobased materials (training courses for professionals, purchasing guide for public procurement).

As a complement to these actions, the SCALE-UP project can extend this influence on a small scale by supporting the two winning companies in the SCALE UP project in cooperation with craft unions and local structures.

The actions of the public authorities, and in particular of the 4 regions which have all adopted a regional plan in favour of the bioeconomy, are important. It is regrettable, however, that under national subsidies such as Ma Prim'Rénov, additional subsidies are not granted for the use of bio-sourced materials.

- **Adapting the offer**

The straw industry is innovating in terms of the type of straw packaging available. At present, straw is used in the form of 36 or 22 cm bales, but other products are emerging, such as blown straw developed by IELO Paille and straw panels designed by COPANO. It is these innovative techniques that the SCALE-UP project can support in developing the use of straw in construction in Pays de la Loire, with the support of COPANO, and in Normandy, with the setting up of the “Atelier du biosourcé” (bio-based workshop). These new forms of packaging mean that straw can be used in a wider range of ways, particularly for renovation.

The miscanthus sector needs to be structured more around sustainable materials, and links with the straw and hemp sectors seem necessary for exchanges on the technical nature of materials, their uses and markets. Hemp and flax have already entered an industrial transformation process, but there is still room for innovation in terms of processes, end-products, etc.

- **Securing farm supply**

The development of local supply chains will inevitably come from downstream and from a precise demand in terms of volume, price and with a production contract to which farms are committed. Farms need to be reassured.

These fibre plants have a number of advantages: they diversify crop rotation, are inexpensive to produce, can adapt to climate change, have low water requirements, and for certain crops and certain areas can be the basis for PES (Payment for Environmental Services) contracts.

However, it is important to study precisely how much land should be planted on each farm to avoid over-specialisation, a return to monoculture or too much substitution for food crops. It is up to each region to strike the right balance between the potential for food production and soil diversification. The bioeconomy approach makes it possible to develop innovative sectors that make sense for the local economy while preserving the environment.

The study shows that the market economy governs the development of these sectors: it is demand that will develop the supply of production and not the other way round. Farmers are interested in these products as soon as they are assured of an outlet.

- **Massification of the supply of bio-based products to be competitive**

The sector has a challenge to seize: a commitment to production purchase prices that is compatible with a guaranteed income for farms, while guaranteeing an attractive price on the materials market: this challenge involves massifying the supply and therefore reducing processing costs.

It is also possible to work on models for pooling processing and logistics tools to amortise collection costs and invest in relevant collective tools that will enable development to be stepped up on a local scale while achieving economies of scale.

Not all sectors will be affected. Straw does not undergo a major industrialisation process. It is part of a local development rationale for local markets, even if the raw product is easily transportable.

- **Creating links between producers, building professionals, local players, users and specifiers**

Public funding is also an important factor, and the networking of relevant stakeholders in the value chain ensures that the initiatives undertaken are sustainable.

The development of these sectors, which have the common characteristic of being firmly rooted in local areas, is an asset for agriculture and the development of rural areas. These plants also have environmental assets that make them attractive for the sustainable building industry.

References

All references used in this report are available in the SCALE-UP deliverable T2.4 “Information package” available online: https://www.scaleup-bioeconomy.eu/.