SB&WRC Project

Economic assessment of prototype 2: Polyester from waste duvets

June 2019
Abstract of the project
The SB&WRC (Sustainable Bio&Waste Resources for Construction) project, an undertaking of more than two years, aims to conceive, produce and test three innovative, low-carbon, thermal insulation materials from agricultural co-products and recycled waste. The project is supported by the development program Interreg France (Channel) England and is co-financed by the ERDF (European Regional Development Fund) for 69% of its total budget which is estimated to be 1.8M€ (including a 1.26M€ contribution from ERDF).

This project, led by Nomadéis, is carried out by a cross-channel partnership which gathers academic research laboratories, private research and consulting companies, manufacturers and professional non-profit organisation of the building sector:
- Nomadéis;
- Veolia Propreté Nord Normandie;
- University of Bath;
- Ecole Supérieure d’Ingénieurs des Travaux de la Construction de Caen (ESITC Caen);
- Construction 21;
- UniLaSalle;
- University of Brighton;
- Alliance for Sustainable Building Products.
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List of acronyms and abbreviations

Acronyms
LCA: Life-cycle assessment
SB&WR: Sustainable bio and waste resources for construction
SME: Small and medium enterprises

Abbreviations
H : hour
K: Kelvin
kg: kilogram(s)
m: metre(s)
W: Watt
t: ton(s)
λ: thermal conductivity
R: thermal performance
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1. **Introduction**

As part of the SB&WRC project, the technical, environmental and economic characteristics of the three low-carbon insulation materials prototypes for construction were assessed in order to gain a comprehensive and multi-dimensional understanding of their strengths and weaknesses. Many innovative products that are developed in research centres never reach the market because they are simply not price-competitive compared to existing products. The economic assessment aims to determine whether the three bio and waste-based insulation materials that were developed would be competitive relative to conventional, mineral-based insulation materials by estimating the selling price of the prototypes. It is also an opportunity to identify the factors that have a large impact on production costs and thus to devise cost-optimisation strategies. These results will be useful in the perspective of mass production and dissemination of insulation products on the market.

The present study focuses on the insulation material for construction that is based on polyester from waste-bedding polyester. The prototype was developed by researchers at the University of Brighton in the UK and at ESITC Caen in France, who have tested the thermal, mechanical and fire-resistance properties of the insulation material and thought about its practical application on construction sites. It can be used as a non-load bearing, soft insulation material in timber framed housing.

2. **Methodology and data**

The economic assessment of the insulation materials for construction is essentially a simulation exercise because these materials are not yet produced on a large scale given that they are still at the prototype stage. For the purposes of this study, a model was developed for a representative and fictitious company that would manufacture the polyester insulation material in France. Such company would collect waste duvets from a waste management operator, clean them, and then ship the insulation material to its clients.

The modelling methodology for the polyester-based insulation material is different from the one used for the two other prototypes, because the price of collected and sorted waste duvets - the main raw material - is unknown. In France and in the UK, the furnishing items waste stream is not properly organised yet. Contracts between local authorities (who collect and store the waste), waste management operators, and companies specialised in recycling and reusing waste products have still not been signed. In other words, the market for the collection, treatment and reuse of waste bedding does not exist yet, and therefore the price of treated waste duvets is not disclosed. This is problematic since all major costs must be measured to compute unit production costs.

In short, given that the price of waste duvets is unknown, that these are the central component of the insulation material, and that no convincing methods exist to reliably estimate their cost, unit production costs could not be measured using the usual “bottom-up” approach, whereby all costs are quantified exhaustively. Therefore, instead of estimating production costs and deriving the selling price of the insulation material, a top-down approach was developed. It consists in: i) assuming that the polyester-based material would be sold at the same “target” price as competing insulation products on the market; ii) estimating unit production costs net of duvet purchase costs, and iii) inferring the purchase cost of waste duvets by subtracting unit production costs from the “target” price.
More precisely, the following steps were undertaken:

1. The production process for the waste bedding insulation material was broken down into its main steps: the sourcing of raw materials including waste duvets; cleaning and preparation of duvets; packaging and shipping of the insulation material. The amount of inputs required at each step was estimated (e.g. machinery, consumables, labour).

2. All variable and fixed costs associated with each step of the production process were identified and measured in a detailed and comprehensive way. However, as explained earlier, the cost of duvets was ignored because no data exists on the price of waste duvets. Thus, total annual production costs **net of duvet purchase costs** were quantified.

3. Feasible, total annual output for the fictitious company was estimated.

4. Unit costs of production (net of duvet costs) for a prototype were computed by dividing total annual costs by total annual output. This unit cost for one prototype was then converted into unit costs for 1 m² of mural cover, for a thermal performance of R = 5 m².K/W.

5. Three “target” selling price levels were defined, based on the price of competing insulation materials on the market. Prices are for 1 m² of mural cover, for a thermal performance of R = 5 m².K/W:
   - a. 4€: similarly to straw bale and glass wool;
   - b. 10€: similarly to cellulose wadding and mineral wool;
   - c. 20€: similarly to most bio-based insulation materials such as wood fibre, sheep wool and hemp wool.

6. A typical margin was applied to the duvet-based insulation material.

7. The purchase cost of duvets was computed, for each of the three target prices, and for a given prototype with 1 m² of mural cover and a thermal performance of R = 5 m².K/W, as: duvet purchase cost = target price – margin – tax – unit production cost (net of duvet costs).

It should be noted that this analysis is a simulation exercise that relies on certain hypotheses and on the data available. Thus, results should not be taken at face value. However, they give a good idea of the magnitude and distribution of production costs.

This modelling exercise is particularly data-intensive, since the quantity and unit cost of all inputs (including labour, rent, advertising etc.) must be known, and total output must also be estimated. Data sources mainly include:

- Data from the University of Brighton and ESITC Caen and discussions with the researchers that were involved in the project.
- Additional research. For instance, most price data come from the internet or from discussions with suppliers.
3. Prototype description: polyester from waste bedding as an insulation material for construction

The University of Brighton and ESITC Caen have developed an insulation material prototype for construction that uses waste bedding. The rationale is that duvets are part of a waste stream that is under-exploited in the circular economy, since most duvets and pillows in France and in the UK are currently not re-used or recycled. They are either sent to landfills or used as an energy source as part of waste-to-energy schemes. Unfortunately, these two solutions generate pollution. Therefore, the idea developed as part of the SB&WRC project is to exploit the interesting thermal properties of the duvets by re-using them as an insulation material for the construction industry.

The waste bedding can be used as a non-load bearing insulation material that would fill a typical timber stud module (or OSB frame) in a wall. A Tyvec membrane can also be added to deal with the air permeability of the external wall system.

Table 1 reports the dimensions and thermal properties of the waste bedding-based insulation product. The dimensions are those of a typical, large duvet.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>2 m</td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>2 m</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>0.04 m</td>
<td></td>
</tr>
<tr>
<td>Area</td>
<td>4 m²</td>
<td></td>
</tr>
<tr>
<td>Volume</td>
<td>0.16 m³</td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>19.5 kg/m³</td>
<td></td>
</tr>
<tr>
<td>Mass</td>
<td>3.12 kg</td>
<td></td>
</tr>
<tr>
<td>Thermal conductivity</td>
<td>0.043 W/mK</td>
<td></td>
</tr>
<tr>
<td>Thermal performance (R)</td>
<td>0.93 m².K/W</td>
<td></td>
</tr>
<tr>
<td>Thickness for R = 5 m².K/W</td>
<td>0.22 m</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Characteristics of a standard polyester duvet

4. Regulatory context

In Europe, extended producer responsibility (EPR – *Responsabilité Elargie du Producteur* in French) schemes are extensively used to reduce the environmental impacts associated with a product’s entire lifecycle. Under this policy approach, producers of consumer goods are financially and/or physically responsible for the collection, transport, treatment, re-use, recycling or final disposal of goods that are disposed of by consumers. The objective is, by making producers are accountable for the negative environmental and social impacts associated with the waste flows they generate, to prevent excessive waste production, promote more environmentally compatible product design and foster the collection, re-use and recycling of products at their end-of-life.

In order to fulfil their obligations under the EPR principle, the producers can either develop i) individual schemes or ii) collective schemes through the creation of an entity call “eco-organism”. In that latter case, the eco-organism is in charge for the collection of funds from the producers and the management of the proper end-of-life of the products, through financial support to the municipalities and/or direct contracts with waste operators. The Figure below shows the typical organisation of an EPR with an eco-organism.
In France, since 2011, the law has required issuers on the market of furniture components to take charge of the collection, sorting, reuse and disposal of these products (called "waste furniture components" - WEEE) in the form of an ERP channel. Two eco-organizations, Éco-mobilier (focusing on household furniture and bedding) and Valdelia (focusing on professional furniture), were accredited by the State at the end of 2012. Since 1 October 2018, upholstered seating or sleeping products (PRAC), to which duvets belong, have been brought within the scope of the ERO DEA. The first call for tenders for the collection and management of used sleeping bags was recently launched by Éco-mobilier and the companies’ bids are currently being evaluated. The emerging ERP sector for the management of this waste is therefore in the process of being structured.

5. Production scenario value chain

For the polyester-based insulation material, the production scenario is the following. A company collects polyester duvets from a supplier, who would most likely be a waste management operator. The supplier has already collected, transported, hygienized and sorted the duvets so that polyester duvets are separated from duck feather ones (duck feather duvets represent a large part of the products available on the market). Once they reach the company, the material is cleaned, packed and shipped to building materials retailers.
6. Cost breakdown

6.1 Feasible output and labour

It was assumed that the company employs a total of 6 full-time workers, split into two different teams. The first four workers are specialised in cleaning the duvets. The second team of two workers oversees various other tasks, such as packing and shipping them. They are also responsible for administrative and business-related tasks (supply chain, sales etc.), and for repair, maintenance, storage etc. Each worker will work for about 203 days a year, if all weekends, national holidays and reduction in working hours are deduced and a 5% absenteeism rate is considered. This represents a total of 1,421 effective hours (amongst 1,624 spent in the factory) annually per worker.

Each member of the duvet-cleaning team operates 5 washing and drying machines at the same time. A full 100-minute long cycle comprises the following phases: loading the washing machine, washing the duvets (35-minute cycle), unloading and reloading the duvets into the drying machine, and finally drying the duvets (30 minutes). One worker can feasibly manage 5 washing operations in parallel during one full cycle, if the start of each operation is staggered by around 5 minutes. It is assumed that each washing and drying machine can be filled with three, 3.12 kg duvets at the same time. A worker can thus process 15 duvets during each 100-minute cycle (i.e. 9 per hour). 4 full cycles can feasibly take place during a normal working day. Therefore, given that 4 workers are dedicated to cleaning the duvets, that there are 4 cycles every day, and that each cycle cleans 15 duvets, a total of 240 duvets are processed every working day. This translates into 57,456 duvets per year, which is equivalent to 179.26 tonnes a year, or 9,192.96 m³.

6.2 Variable costs

6.2.1 Labour costs

Each worker is assumed to earn a gross salary of 1,600€ per month, which corresponds to 19,200€ annually. This is slightly higher than the minimum wage in France (1,522€). However, it has been established that the factory opens 252 days per year, after deducting the 104 days of weekend and the mean of 10 national holidays during the week per year. Therefore, regarding the total number of man-days worked, we reach a full time equivalent of 7.45 workers. The employer contribution will be of 26,568€. Therefore, the total cost of the workforce for the company amounts to 141,768€ per year.

6.2.2 Duvet cleaning

The costs associated with washing and drying the duvets are modelled as variable costs and based on price data from launderettes and cleaning companies. One cleaning cycle followed by a drying cycle cost at least 10€ in a launderette. If added value (or margin) is deduced from this amount (e.g. 20%), one gets an approximation of duvet cleaning costs: 8€ per full cycle. Given that a total of 80 cycles occur during one working day, and that there are 239.4 days worked per year, total duvet cleaning costs amount to 153,216€ annually.

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6.2.3 Other consumables

9 duvets can be stacked on a europalette, therefore 5,776 europalettes must be purchased every year, given total output, for a total cost of 159,995.20€. The annual cost of packing plastic is 1,953.73€. The plastic wrapped europalettes are stored and readily available when an order arrives.

6.3 Fixed costs

6.3.1 Manufacturing equipment

While washing and drying machines are the main pieces of manufacturing equipment in the workshop, all the costs associated with their use have been accounted for in part 6.2.2 and measured as variable costs. Thus, any fixed costs related to washing and drying machines are already captured in the 8€ per cycle cost reported above.

6.3.2 General workshop equipment

Several tools must be purchased for repairs, for an annual cost of around 179.77€, when amortised over 5 years.

Packing equipment (1 packing/wrapping machines, 1 wrapping tool and 1 pallet truck) costs 281.57€ annually (amortised).

In terms of furniture, we assume that 8 worktables and 4 closets for tools must be purchased, thus representing 456.70€ annually when amortised over 10 years.

An industrial hoover and one high-pressure cleaning machine are used as a proxy for cleaning expenses. They amount to 71.49€ every year (amortised).

In total, these additional expenses add up to around 989.53€ per year.

6.3.3 Office: rent, ICT, supplies

Total workshop area is estimated to be equal to 427 m². This comprises:

- 112 m² for the actual workshop fitted with the washing and drying machines, worktables and closets for tools.
- 250 m² of storage space: half for raw materials, and the other half to store the output.
- 10 m² of furnished office space. The office is used when the employee works on business, sales, supplies and administration management activities.
- 15 m² for communal spaces, such as toilets, bathroom and a kitchen.
- Another 40 m² can be added to account for corridors and other spaces.

Given that the average rent for commercial spaces in the Seine-Maritime département in Normandy is about 5€/m²/month according to the website Cessionpme.com², total rent over a year amounts to 25,620€ annually.

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² CessionPME (2019) accessed on 28/05/19: https://www.cessionpme.com/annonce.location-entrepot-bureaux-saint-romain-de-colbosc-76430,1716181,A,offre.html. For any real estate advertisement, at the bottom of the webpage, the median rent in the same département is displayed.
The worker will need an office space fitted with a desk, chair, closet, and various office supplies and stationaries to carry out more managerial and administrative tasks. These costs add up to 80.04€ per year (furniture-related expenses are amortised).

Finally, the office will have to include IT equipment (computer, printing machine, telephone, etc.). Annual IT expenses have been fixed at 7,150€ (around 0.5% of the turnover).

### 6.3.4 Utilities

Utilities include:

- Water consumption for 1 full-time worker is estimated to be around 25 m³ per year thanks to Eau de Paris’ online calculator\(^3\). The water needed for the cleaning process is already included in the 8€ production cost per cycle. This comes at a total yearly cost of 586.5€ because there are 6 workers;

- Gas consumption for heating all areas in the workshop except storage is equal to 7,965 kWh/year according to ADEME (2014)\(^4\), which estimates that a typical storage area or workshop consumes between 35 and 55 kWh/m²/year of gas for heating. The annual gas bill is equal to 691.66€;

- Electricity consumption, which is split between the electricity requirements of the 20 washing and drying machines\(^5\) (371,597.94 kWh per year) and general consumption related to lighting, small equipment and appliances used in the workshop (25 kWh/m²/year) adds up to around 486,411.94 kWh per year. Electricity expenses represent 35,266.08€ a year;

- Internet access and telephone bills, which cost 180€ per year.

### 6.3.5 Other fixed expenses

A typical company must have a budget for fixed expenses such as insurance fees and accountancy fees. While these costs can vary significantly depending on the number of hours an accountant is hired or on the various options included in the insurance contract, they come at an estimated total annual cost of 5,440€, for a company with 6 employees. Similarly, it was assumed that 28,000€ is spent on advertising.

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\(^5\) Assuming that electricity consumption per cycle is 1.7 kWh for a washing machine, and 3.75 kWh for a drying machine, accounting for the fact that the machines are large (20 kg capacity). Source: Energie douce (2019) Tableau de consommation des appareils électroménagers. Accessed on 12/08/2019 at [https://www.energiedouce.com/content/12-conseils-faq-consommation-electrique-des-appareils-electromenagers](https://www.energiedouce.com/content/12-conseils-faq-consommation-electrique-des-appareils-electromenagers)
Table 2: Summary of variables and fixed costs associated with the duvet-based insulation production process

<table>
<thead>
<tr>
<th>Variable costs</th>
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<tbody>
<tr>
<td><strong>Input category</strong></td>
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<tr>
<td>-------------------</td>
</tr>
<tr>
<td>Consumables</td>
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<tr>
<td>Manufacturing</td>
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<td></td>
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<tr>
<td>Packing</td>
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<td></td>
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<tr>
<td>Labour</td>
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<table>
<thead>
<tr>
<th>Fixed costs</th>
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</thead>
<tbody>
<tr>
<td><strong>Input category</strong></td>
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<td>-------------------</td>
</tr>
<tr>
<td>Workshop equipment</td>
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<td></td>
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<td>Office</td>
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<td>Utilities</td>
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<tr>
<td>Other expenses</td>
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</table>

6.4 **Unit production costs (net of duvets)**

In sections 6.2 and 6.3, all the costs that must be incurred by the company to produce polyester-based insulation material over one year were described and quantified. The sum of all these costs adds up to 539,621.69€ annually. However, as explained in section 2, this figure excludes the costs or benefits associated with sourcing the duvets themselves, since no data was available on this raw material.

Total yearly feasible output was also estimated in section 6.1, where it was determined that 57,456 duvet-based insulation products could be processed in one year given our assumptions.

Unit cost is simply computed as total costs divided by total output for a given year:

\[
\text{unit cost in €} = \frac{\text{total costs}}{\text{total output}} = \frac{\text{variable costs} + \text{fixed costs}}{\text{total output}}
\]

Thus, each duvet-based insulation prototype costs 9.39€ to produce according to the simulation performed on the basis of the available data and the assumptions made.

To facilitate comparisons with conventional insulation materials sold on the market, this figure can be converted into unit production costs per mural m² by dividing it by the area of the standard duvet (4 m²). This gives us a unit production cost per mural m² of 2.35€, for a thermal resistance of 0.93 m².K/W associated with a thickness of 0.04 m.

To reach a standard thermal resistance R = 5 m².K/W, given a thermal conductivity of 0.043 W/m.K, the optimised bale’s thickness must be 0.215 m. Thus, unit production costs for a duvet assemblage with \( R = 5 \) m².K/W are equal to 12.62€ per m².
Table 3: Unit production costs obtained from the economic reasoning

6.5 Margin, markup and sale price

Various types of insulation materials co-exist on the market. The most common products are glass and mineral wool, sold at around 4€ per mural m² for a thermal performance of R = 5 m².K/W. Cellulose wadding, a waste-based insulation material similar to duvets – costs around 10€. Most bio-based insulation materials such as wood fibre, sheep wool and hemp wool are priced around 20€. These three prices were chosen as "target" price levels for the waste bedding insulation material.

In order to derive the insulation material's unit production cost based on the target selling price, one must deduce the margin from the selling price. Assuming a standard 27% distributor margin rate and a 20% producer margin rate implies that unit production costs should be equal to 2.016€, 5.04€ and 10.08€ if the polyester-based insulant is sold at 4€, 10€ and 20€ respectively, for 1 m² with R = 5 m².K/W. In terms of markup, a 20% margin rate is equivalent to a 25% markup, and a 27% margin rate to 37% markup.

6.6 Pricing duvets

As explained in section 2. Methodology and data, the price of waste duvets is unknown because markets for the reuse and recycling of such a waste bedding material do not yet exist in France or in the UK. Nevertheless, the price of waste duvets can be derived by subtracting measurable production costs and the margin from the target selling price.

Table 5 reports that unit production costs for the polyester-based insulation material stand at 12.62 € per m² for a thermal performance R = 5 m².K/W. It must be stressed that this figure captures all production costs, except those associated with the waste duvet "raw material". One can clearly see that each of the three target price levels is below unit production costs. This implies that the price of duvets would have to be negative for the company to be able to produce the waste duvet insulation material in an economically viable way. Once company taxes and profit margins are accounted for, the gap between the target selling price and unit costs net of duvets widens even more. The estimates suggest that the insulation company would have to be paid 2.53€, 1.81€ or 0.61€ per kilogram of duvet if the insulation product is to be sold at 4, 10 or 20€ respectively, as shown in Table 5 below. One should also note that for a selling price of 25.04€, the duvet price achieves almost exactly zero.

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6 Margin and markup are closely linked, in the sense that margin is expressed relative to the selling price, while markup is expressed relative to unit production costs, as a percentage that must be applied to unit costs to derive the selling price. For \( m \) = margin rate; \( p \) = selling price and \( c \) = unit production cost, we have: \( m = \frac{p - c}{p} \times 100 \Rightarrow p = \frac{1}{1-m}c \Rightarrow price = (1 + markup) \times unit\ costs\), where \( markup\ (in\ %) = \frac{margin\ rate}{1-margin\ rate\).
Table 4: Pricing of duvet-based insulation using different target prices

This result may seem puzzling at first, because in general inputs are bought by the producer from a supplier: they represent a cost. However, in this case, the production company would be providing a service to waste management operators who are looking for re-use and recycling opportunities for their stocks of waste. In the extended producer responsibility (EPR) framework, waste management operators will receive funding from the producer responsibility organisation (PRO – eco-organism) in charge of organising waste management for the furnishing items waste stream. Waste management operators will use this funding to reach the various waste treatment goals set by the PRO, some of which will focus on recycling and re-use rates for certain types of waste products. To attain these objectives, they may sign a contract with a company such as the one modelled in this study that will develop re-use or recycling projects for a specific waste stream. In this context, the company that re-uses or recycles waste products would therefore be paid by the waste management operator to carry out this task.
7. Conclusion

University of Brighton and ESITC Caen have developed an innovative, polyester-based insulation material that is obtained by reusing waste duvets. Duvets are received and cleaned at the factory, but their size remains unchanged, since they will be adapted to fill a typical timber stud module afterwards.

To estimate the unit production cost and final price of insulation based on reused polyester duvets, a model based on a top-down approach, starting from the typical final price of current biobased and conventional insulation materials back to the purchase price of the duvet, was developed. It should be noted that the present simulation exercise relies on certain assumptions and on the available data, hence results and prices presented in this report should not be taken at face value. Rather, they give an indication of the distribution and magnitude of the various costs associated with the production process. The model that was developed is a simulation tool that can easily be modified to explore how changes in production parameters affect unit costs.

The manufacturing process for polyester-based insulation material is capital-intensive because 20 washing and drying machines must be acquired according to the simulation performed. These machines account for almost a half of unit production costs. Thus, fixed costs, hereby accounted for variable costs but including the consequent amortisement of the machines, represent a large share of total costs compared to variable costs, which implies that there are opportunities for economies of scale.

Taking into account a distributor gross margin of 27% and a producer net margin of 20% (equivalent to markups of 37% and 25%, respectively), and aiming to sell the reused duvets at typical market prices for similar products of 4€ (straw bale and glass wool), 10€ (cellulose wadding and mineral wool) and 20€ (wood fibre, sheep wool and hemp wool) per m² and for a thermal resistance ("R") of 5 K.m².W⁻¹, the duvets (already collected, sorted and hygienized) should be supplied for free and a subsidy of 2.53€, 1.81€ or 0.61€ per kilogram of duvet, respectively, should be granted to the producing company. It should be noted that a final sell price of 25.04€ per m² and R=5 K.m².W⁻¹ would allow the producer to run its business without receiving any subsidy, but still receiving the duvets for free.

In order to optimize or engage in a cost-minimization strategy, this semi-industrial activity could be registered as a part of a social and solidarity economy framework that would enable the producer to benefit, on one hand from cheaper workforce and on the other hand, from complementary subsidies.
8. Limitations

The results presented in this report should be treated with caution, as they are estimates derived from a simple modelling exercise. Cost and price estimates are inaccurate because some of the data we use and some of the assumptions and calculations we have made are imprecise. These issues are inherent to any modelling or forecasting work. One should bear in mind that the polyester-based insulation module remains at the prototype stage, it is not yet produced or commercialised. The goal of this economic assessment was simply to produce a first approximation of production costs, and hence of the selling price, to compare it with competing insulation materials, and to explore cost-reduction strategies.

Below are some reasons why production costs might be inexactly estimated.

- Unit input costs might be reduced if raw materials, packages, machinery etc. are bought in large quantities to earn discounts.
- The washing and drying processes may be further optimised or simplified (lower costs). These processes have been modeled using a typical launderette. Using equipment of industrial size would minimize costs.

Production costs may be underestimated:

- Due to time, resource and data constraints, the modelling exercise is not perfectly exhaustive. Some cost categories and components may be missing (e.g. some tools, equipment etc.). However, the most significant and relevant ones have been accounted for.
- Taxes were excluded from the analysis, as they are proportional to the company’s profits, which themselves depend on costs, prices, quantities and turnover. Indeed, the estimation of taxes with a reverse model reaches a complexity level beyond the scope of the present study.
- The modelling did not take into account the potential heterogeneity of the size of the duvets. This heterogeneity could increase costs.
9. Bibliography


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