DEMONSTRATION CASE STUDIES

D3.2

CONNSENSYS – CONNECTING SMART SENSOR SYSTEMS FOR THE FOOD INDUSTRY
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ABSTRACT

In this document 2 practical examples have been elaborated to show how sensor-based solutions and, in a wider meaning, digital technologies can be introduced in the food processing sector, thanks to European interregional cooperation. With this document we want to inspire food processing companies (in particular, SMEs), digital providers, public agencies and other stakeholders linked to the food sector.

For that purpose, 2 demonstration case studies are described and analyzed:

- the first study refers to the collaboration between food Living-labs and technology providers, for the integration and validation of a IoT solution in an industrially relevant environment. It involves 5 organizations from 4 European regions: Asturias (ES), Flanders (BE), Galicia (ES) and Provence-Alpes-Côte d'Azur (FR)
- the second study describes the collaboration between food companies and technology & equipment providers and for the application in a real food processing environment of a new digital solution, based on computer vision. It involves 3 organizations from 2 European regions: Flanders (BE) and South-Holland NL).

The 2 case studies also represent potential projects that can look for investments after the end of CONNSENSYS.

Our final aim is to provide a source of inspiration for other interregional cooperation projects dealing with digitalization of the food sector.

CONTENTS.

1. OBJECTIVES AND METHODOLOGY

In this document practical examples have been elaborated to show how sensor-based solutions and, in a wider meaning, digital technologies can be introduced in the food processing sector, thanks to European interregional cooperation. With this document we want to **give good examples** to food processing companies (in particular, SMEs), digital providers, public agencies and other stakeholders linked to the food sector, as well as emphasize the added value of **interregional cooperation**. Its final objective is **to inspire** food companies and technology providers in the design of their own collaborative interregional projects. And, at the same time, to provide regional authorities with a pathway of the kind of projects they can support to foster the digitalisation of the food sector.

For that purpose, the document describes **2 demonstration case studies** that have been designed and analyzed in the framework of the CONNSENSYS project. They show two different kind of collaborations:

- **CASE STUDY 1** refers to the **collaboration between** food **Living-labs and technology providers** for the integration and validation of a IoT solution in an industrially relevant environment.
- **CASE STUDY 2** refers to the **collaboration between Food companies and technology & equipment providers** for the application of a novel digital solution based on computer vision in a real food processing environment.

Considering the different characteristics of the case studies, **two different methodology approaches** have been used for the design of the showcase. In CASE STUDY 1 we linked organizations from 4 European regions, which put together their knowledge and expertise to define a potential collaboration project, that may be implemented and funded after the end of CONNSENSYS. In CASE STUDY 2 we analyzed an already on-going interregional collaboration project and identified potential follow-ups, which consist in the application of the same technology in new domains of the food sector or its use for additional challenges/needs of the food companies. In both cases the main result achieved is an interregional collaboration project, which has the potential to go for investment after the end of CONNSENSYS.

For the recollection of information, a **preliminary desktop research** was carried out by ITG and ASINCAR for the design of both case studies. This was done in collaboration with the companies involved in each case study and with the other CONNSENSYS partners. After that, ITG and ASINCAR elaborated the case studies, which later on received additional **contributions and feedbacks** from the companies involved and from the CONNSENSYS partners.

Each case study addresses a **specific need/demand** of the food sector and proposes a **specific digital technology** to address that need/demand. For that purpose, we **used tools that were previously developed in the CONNSENSYS project**, such as the *Strategy of the of the Smart Sensors 4 Agri-food (SS4AF) platform* and the list of digital technologies for the food sector included in the *Technology Catalogue*. In addition, for CASE STUDY 1, we also referred to the *Framework for Operating the Network of Living Labs*.

Once the food demand and the digital technology were defined, an analysis was made for each case study on the **potential innovation and impact** for the food sector, the **benefits of the interregional cooperation** and **the business model(s)** that can be used for the commercial exploitation of the technological solution.

2. DESCRIPTION OF CASE STUDY 1.

IMPROVEMENT OF FOOD SAFETY AND QUALITY: VALIDATION OF A LOW-COST PORTABLE DIGITAL DEVICE.

2.1. Objectives and impacts.

Food demand addressed: safety and quality control.

Food Safety and Quality are two of the most critical parameters to be controlled during the industrial processing of food. Effective food safety and quality control systems are key not only to safeguarding the health and well-being of people, but also to fostering economic development and improving livelihoods by promoting access to domestic, regional and international markets. In addition to the system audits carried out by the European Union and the official control systems established by Member States at national level, food companies are requested to carry-out documented self-controls in their own facilities. For that reason, one of the key issues for these companies is to guarantee that the control is as reliable as possible and, at the same time, reduce its cost.

The **automatization of food controls** and the development of **non-invasive rapid analytical tools** is a possible way to achieve both aims: it contributes to reduce time for the control, increase the number of products controlled (quantitative control) and the accuracy of the control (qualitative control).

Case Study objective: automatization and effectiveness of the control.

Contribute to **improve the effectivity** of **safety** and **quality control** in the **food processing**, through the use of an innovative, smart technology solution which allows to **automate** and **increase the effectiveness** of the whole process, independent on the personal skills or training/expertise of a human interaction

Technology solution proposed: NIR sepctroscopy + IoT + Artificial Intelligence.

An innovative **monitoring tool** is proposed, based on the combination of a **miniaturized and portable NIR-based camera** with a **web-based Decision Support System (DSS)** for data management and analysis, through the use of **chemometric models**.

The tool **is validated** through the simulation of 2 **application cases** (meat shelf-life application and fruit ripeness), to be carried out in **2 food pilot plants** (living labs).

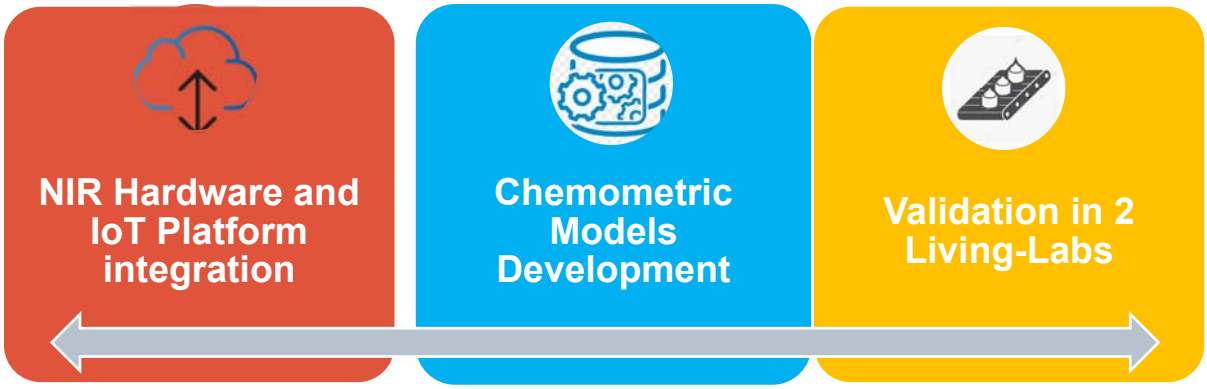

Figure 1. Work-flow of CASE-STUDY 1

Main impacts on the food industry: better quality/safety monitoring + food waste reduction + solution usable in industrial environment.

CURRENT SITUATION	NOVELTY FOR THE FOOD INDUSTRY
The most common approach for the determination of food quality is destructive lab analysis, but it´s really time consuming. Moreover, due to their cost, these methods are not accessible to most food companies and especially not SMEs.	A **rapid**, **accurate** and **non-destructive** estimation of shelf life and ripeness, through a **low-cost technology**. In addition, the device can be also used by non-technical staff. All these aspects will represent a competitive advantage for the company
Shelf life determination by producers is often set rather conservatively to ensure food safety. Conservative shelf life setting can cause unnecessary waste at retailers and increases when consumers are selective about the use-by dates	The solution will allow to determine product-specific freshness and expiration in **a fast and cheaply way**, without jeopardising safety. By that mean, it will contribute significantly to **reduce the food waste.**
The use of portable NIR-based devices for routine food analysis in industrial settings is still low.	Go **beyond the lab scenario** and develop a portable smart device able to **operate in a food industrial setting** and under the needs of the daily operations.

Table 1. Main impacts of the technology solution on the food industry

2.2 Interregional cooperation.

Partners involved and main role.

PARTNER	REGION, COUNTRY	TYPOLOGY	MAIN ROLE
Easy Global Market (EGM)	Provence-Alpes-Côte d'Azur, FR	SME	NIR camera provider; hardware integrator; production of the hardware and software; commercial partner for the South-West area.
Galicia Institute of Technology (ITG)	Galicia, ES	RTO	Management of the wireless communications; development of the IoT framework.
NORMEC	Flanders, BE	SME	Provider of food safety management platform, for data management and analytics; expertise on food safety and quality control; commercial partner for the Benelux area.
Asincar (ASIN)	Asturias, ES	Living-Lab	Chemometric model for the forecasting of shelf life in meat products; testing of the whole technical solution in its food pilot plant.
Food Pilot	Flanders, BE	Living-Lab	Chemometric model for the forecasting of fruit ripeness; testing of the whole technical solution in its food pilot plant.

Table 2. Partners involved in CASE STUDY 1 and their role

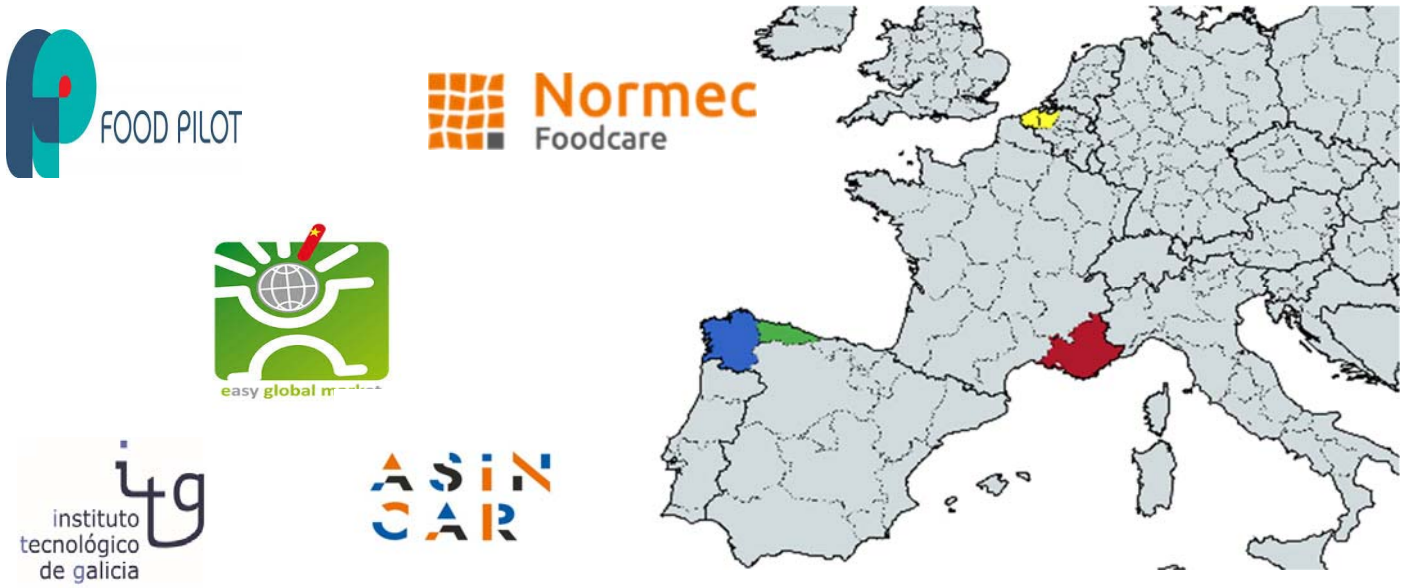

Figure 2. European regions involved in CASE STUDY 1

Benefits of the interregional cooperation.

The case study highlights and foster the collaboration between technology providers and food living-labs at European level. The interregional collaboration allows to achieve the following aims:

- **Join technical competences** and **expertise** from different part of Europe, to address a common challenge of the food sector.
- **Test** the technical solution developed through the project in **2 living-labs** (ASIN and FOOD PILOT), that allow to **recreate a real industrial scenario**. Each living lab will provide 2 different application cases. These cases reflect, in a certain way, the needs of the food companies in the regions where the pilot plants are located.
- **Achieve a wider range of food companies** – not only at regional level, but also at European one – which will have the opportunity to see the practical functioning of the technical solution, through its testing in the 2 pilot plants.
- **Increase the business exploitation** of the technical solution in different regional markets.
- **Highlight how technology providers could be supported by living labs to scale-up and bring to the market their solutions**. A living lab offer a demonstration place to test the technological solution in an environment that simulate a real factory: by this mean, it allows the assessment of performances and the implementation of adjustments in the solution, if needed. Moreover, a living lab can contribute to promote the solution in the food sector, by demonstrating its functionalities to potential clients.

2.3 Business Model.

The business model defined for the CASE STUDY 1 includes **on one-off payment** of the NIR portable device and the **Software as a Service (SaaS)** model for the IoT platform, based on a yearly subscription. The main distribution channel is the **Business to Business (B2B) relationship**, through the use of European distributors.

The **Business Model Canvas** included below resumes the main items of the business model defined for this case study:

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
➢ Suppliers and distributors (whole team, other: Cloud supplier, outsourcing partners) ➢ Commercial partners (i.e NORMEC for BENELUX) ➢ Influencers over target customers, as Federations, associations, clusters representing farmers, fruit and meat industry, (i.e clusters in Connsensys) ➢ Institutes for certification and standarisation ➢ Food safety, quality regulators (i.e specific regional, national authorities, EFSA)	➢ Production (EGM) • Smart portable device • Cloud platform • Mobile application ➢ Product and service provision (NORMEC+distributors) ➢ Sales and business development (NORMEC+distributors) ➢ Client relationship (i.e client service (NORMEC+distributors), maintenance (EGM)) **Key Resources** ➢ Facilities and equipment to produce and test the portable device (EGM) ➢ High qualified and experienced human resources (engineers, technicians, ..) (EGM) ➢ Experienced related to food quality and analysis as well as a Food lab (NORMEC+distributors) ➢ Experience in business, administrative, contractual, financial and legal aspects (NORMEC+distributors)	A. Instant quality check of produced, incoming and outgoing goods B. Continuous monitoring of freshness, matureness and ripeness C. Prediction of shelf life and/or ripeness for the optimization of operations and sales through: timing, tuning storage conditions and foresee when to post-process to lesser value products D. Prediction of expiration dates for correct labelling E. No need of professional personal for food quality assessment	• Direct sales (NORMEC in BENELUX) • Commercial partners and distributors (other EU conuntries) • Fairs, workshops and professional contact with clients (i.e SIAL, ANUGA, ALIMENTARIA FoodTech, Hanover Messe) • Open demonstrations (i.e in an activity promoted by a cluster) • Online (i.e website, social media, ..) **Channels** • B2B mainly, looking for local distributors offering products to your target clients • B2C in countries where comercial partners are well established from a sales perspective • Online (minor)	➢ Fruit industry (could be extended to vegetable): • Farmer (pre-harvest) • Distributor (post-harvest) • Processor (post harvest) ➢ Meat industry • Meat handling SMEs • Food service • Butcher • Retailer, with own butcher within supermarket Initial target geographical areas: BENELUX (NORMEC), France (EGM could facilitate the distributor identification), countries covered by Connsensys clusters (facilitation of clusters for distributor identification)

Cost Structure	Revenue Streams
➢ Fixed costs: salaries, facilities and equipment, stocking, outsourcing ➢ Variable and indirect costs: temporary employment, oursourcing ➢ IPR protection	Business version (target price 3.000-5.000 €) i. Selling of the handheld device ii. Subscription to service for the prediction of the food quality (periodical: monthly, yearly, freemium, …). Target year fee 250-300 € Science version (target price 1.000-2.000 €): similar to the business one but for scientists with the main aim of improve the embedded algorithms In the future a Consumer version could also be considered

Figure 3. Business Model Canvas of CASE STUDY 1

3. DESCRIPTION OF CASE STUDY 2.

IN-LINE QUALITY CONTROL SYSTEM FOR BAKING PROCESS.

3.1 Objectives and impacts.

Food demand addressed: food quality control.

La Confiance is a Belgian industrial bakery producing various types of high-end biscuits. Currently, in La Confiance´s production line, the quality of the produced biscuits (baking level and visual aspect) is determined manually by taking samples at regular intervals and, if required, manually adjusting the production settings from their defaults, starting with the conveyor speed (reducing or increasing the baking time) and, as a second step, the oven temperatures.

This **manual quality control** has the following disadvantages, such as: it is **non-continuous**, and therefore it can take **considerable time** for suboptimal settings to be detected and remedied; it is **subjective**, which leads to **unnecessary quality variations** but also discussions among personnel; the adjustments made to the line settings are based on judgement and experience, which is a **fragile procedure** because knowledge can disappear with departing employees.

Case Study objective: automatize the quality control during the baking process in the oven.

This collaborative project aims to achieve a **comprehensive solution**, by combines different already-existing technology that are currently used separetely for setting the production parameters. The combinantion of sensors (camera images) with AI allows to close the loop and **automatize the whole quality control process**.

Technology solution proposed: Computer vision.

The technology solution proposed combines **in-line industrial cameras and intelligent software using artificial intelligence (AI)** to process the images. Both components are linked to the company ERP server (Enterprise Resource Planning), for data storing and recipe setting, and to a PLC for the control of the oven setting.

The aim is to create an **objective** and **continuous quality control** system. Additionally, the output of this quality control system will be directly and continuously used to **update and optimize the production settings**.

Figure 4. Work-flow of CASE-STUDY 2

Main impacts on the food industry: better and faster quality control + better use of resource + reduction in the food waste.

CURRENT SITUATION	NOVELTY FOR THE FOOD INDUSTRY
Manual, non-continuous control produce variation in the product quality.	Automatize control produce low variations in quality, thanks to the real-time adjustments of the oven settings, based on the data captured by the AI system.
Manual control is time-spending and, due to the lack of accuracy, there is an unnecessary use of raw material and energy in the in-line process.	Better use of resources, thanks to 1) a reduction of the raw material loss, usually produced by the food waste; 2) the increasement in the energy efficiency, due to an optimal control of the production process; 3) the reduction in the human efforts needed for the quality control (efforts that can be reallocated to other tasks).

Table 3. Main impacts of the technology solution on the food industry

3.2 Interregional cooperation.

Partners involved and main role.

PARTNER	REGION, COUNTRY	TYPOLOGY	MAIN ROLE
La Confiance NV	Flanders, Belgium	SME	Problem owner and end-user: it provides the demo-site and expertise in the baking process.
Yazzoom BV	Flanders, Belgium	SME	Technology solution provider; Business exploitation of the final solution.
Goldstream Oven Construction FA	South-Holland, Netherlands	SME	Provider of expertise on oven building and automation; Business exploitation of the final solution.

Table 4. Partners involved in CASE STUDY 2 and their role

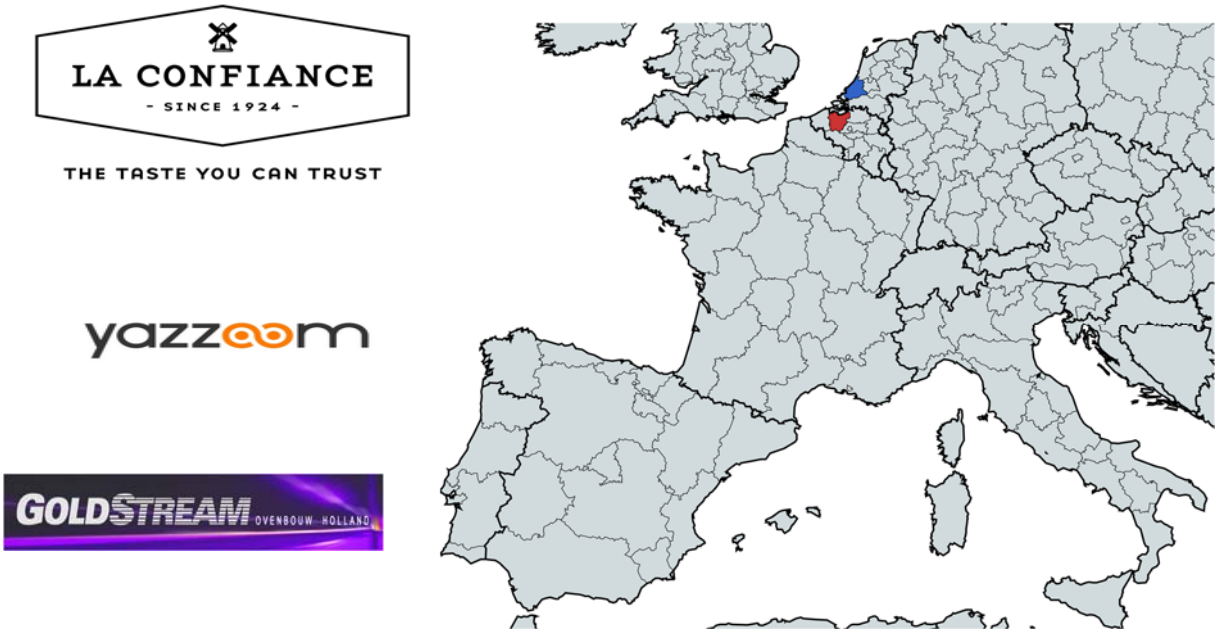

Figure 5. European regions involved in CASE STUDY 2

Benefits of the interregional cooperation.

The interregional collaboration allows to achieve 3 main results:

- **Join technical competences** and **expertise** from different part of Europe, to address a common challenge of the food sector.
- **Increase** the opportunities for **business exploitation** of the final technical solution on different regional markets.
- **Spread** at European level the innovations and impacts that the project produces for the food sector.

3.3 Business Model.

The commercial exploitation of the technology solution in CASE STUDY 2 combines the **one-off payment** with the **yearly service level agreements**. In the 1st year the client will pay for the initial installation of the intelligent software platform. Starting from the 2nd year, a subscription will be offered, which will include the use of the software and its maintenance.

Regarding the distribution, it will combine **direct sales (B2C)** by YAZZOOM (software provider) and GOLDSTREAM (oven provider) in Belgium and Netherlands and **commercial agreements with distributors (B2B)** in other European countries.

The following **Business Model Canvas** resumes the main items of the business model defined for this case study:

Key Partners	Key Activities	Value Propositions	Customer Relationships	Customer Segments
➢ Suppliers and distributors (cameras provider, cloud supplier, outsourcing partners) ➢ Commercial partners (i.e distributors) ➢ Influencers over target customers, as Federations, associations, clusters representing farmers, fruit and meat industry, (i.e clusters in Connsensys) ➢ Institutes for certification and standarisation ➢ Food safety, quality regulators (i.e specific regional, national authorities, EFSA)	➢ Production (Yazzoom) • Intelligent quality control system • Feedback to the oven, belt ➢ Product and service provision (Yazzoom and/or Goldstream + distributors) ➢ Sales and business development (Yazzoom and/or Goldstream +distributors) ➢ Client relationship (i.e client service (Yazzoom and/or Goldstream + distributors), maintenance (Yazzoom and/or Goldstream)	A. Instant quality check of produced cookies B. Continuous monitoring of the food quality without the mediation of operators C. Automatic actuation (alert, fine-tuning the oven configuration, modify configuration of the belt) if needed D. Objective and reproducible measurement of the product quality E. Increased knowledge and insight into using computed quality metrics for direct control of food production processes F. Future exploitation of acquired data for improving business operations through their analysis	Direct sales (Yazzoom, Goldstream) Commercial partners and distributors (other EU conuntries) Fairs, workshops and professional contact with clients (i.e SIAL, ANUGA, ALIMENTARIA FoodTech, Hanover Messe) Open demonstrations (i.e in an activity promoted by a cluster) Online (i.e website, social media, ..)	➢ Biscuit companies Initial target geographical areas: EU countries (especially England, Germany, Belgium, Italy, France, Spain and the Netherlands). In Belgium (Yazzoom) and Netherlands (Goldstream) take advantage of current commercial resource of partners
	Key Resources ➢ Facilities and infrastructure to produce and test the new digital tool (Yazzoom and/or Goldstream) ➢ High qualified and experienced human resources (engineers, technicians, ..) (Yazzoom and/or Goldstream) ➢ Experience in business, administrative, contractual, financial and legal aspects (Yazzoom and/or Goldstream + distributors)		**Channels** • B2B mainly, looking for local distributors offering products to your target clients • B2C in countries where comercial partners are well established from a sales perspective	

Cost Structure	Revenue Streams
➢ Fixed costs: salaries, facilities and equipment, stocking, outsourcing ➢ Variable and indirect costs: temporary employment, outsourcing ➢ IPR protection ➢	➢ One-off payment (initial implementation, HW+SW) ➢ Intelligent software platform for in-line quality control of cookies and optimization of process control, several options (Subscription Business Model, incl. service maintenance): • License for 1 year • Freemium • License for shorter than 1 year • Product as-a service, …. ➢ New technical functions

Figure 6. Business Model Canvas of CASE STUDY 2

3.4 Follow-up: potential new technical developments.

Starting from the already on-going collaborative project, La Confiance, Yazzoom and Goldstream may consider **2 new pathways** to scale-up its results:

1. Consider **additional fields of application** for the technology solution in the bakery domain or in other domains of the food sector.
2. **Widen the technological scope** of the collaboration.

Additional application fields.

The solution coming out from the project may be applied to food products whose production process and setting needs are similar to the biscuit production, such as: **bread, dried fruit, pizza and oven-baked dishes.**

Widen the technological scope.

Two additional needs of the bakery industry can be addressed:

- the continuous **monitoring and management of energy consumptions in the oven**, with the aim of increasing the energy efficiency during the production process. Energy cost is steadily becoming one of the main items in the economic sustainability of bakery industry, so there is an increasing interest by companies to manage this issue in a proper way.
- the **predictive maintenance of the oven**, in order to reduce the maintenance costs. Equipment maintenance is also essential to energy efficiency.

For this purpose, remote-control sensors can be installed in the production line and connected to an IoT cloud platform, including artificial intelligence to process and analyse energy and production data.

IoT helps to capture real-time data through sensors and uses cloud-based analytics to gain critical insights. A vast magnitude of data is captured to help the company identify areas of improvement that include, for instance, the most economical way to use gas or electric ovens. Through these insights, the company is able to keep track of costs related to daily energy consumption or equipment wear.

4. WRAP-UP AND CONCLUSIONS

The demonstration case studies described in this document are two examples of how food companies, in particular SMEs, can collaborate with ICT providers and Living lab at European level to introduce and uptake digital technologies in their production processes. They are meant to be a **source of inspiration** for other interregional cooperation projects in the food sector.

The 2 case studies also represent **potential projects that will look for further investments** after the end of the CONNSENSYS project.

At this respect, the organisations involved in CASE STUDY 1 are currently assessing the possibility to submit a proposal to EU calls, such as H2020-European Innovation Council, ERA-NET calls, "cascade-funding" instruments or the next framework programme HORIZON EUROPE.
As for CASE STUDY 2, the current implementation of the project is funded through an "innovation voucher" provide by the H2020-INNOSUP project "S3FOOD" (https://s3food.eu/), aiming to provide funding opportunities for innovation projects in the food sector. In addition, the partners are also considering the opportunity to look for new funding opportunities, with the aim of scaling-up the solution basing on the pathways identified in Section. 3.4.