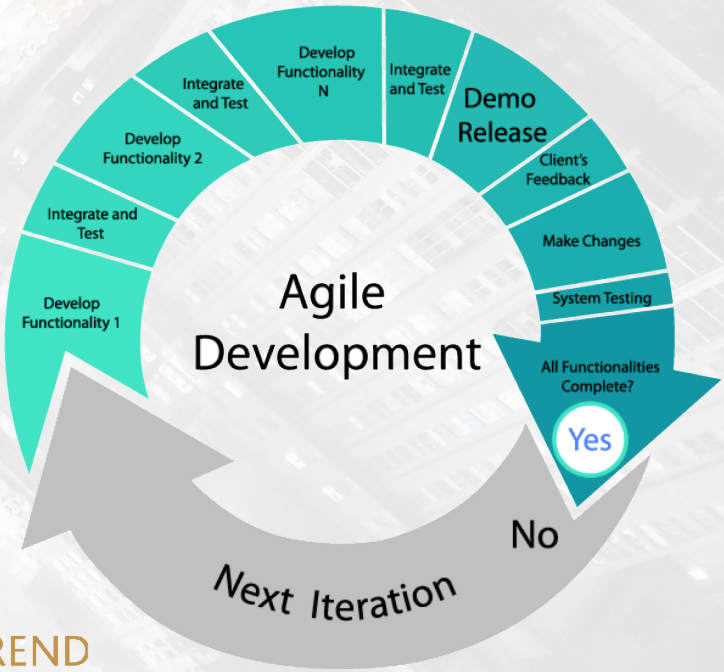
Retrofit Technologies

Booklet 3



NewTREND

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Retrofit Technologies.

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Published August 2017

http://newtrend-project.eu/home-it/

1. Introduction

In the last years, a deep knowledge has been created on energy efficient retrofit technologies at both building and district level across various research projects at European and national level. The NewTREND project aimed at leveraging on this knowledge and complement it to develop a comprehensive Library of technologies and business models for refurbishment at different scales (building in the context of the district). To do so, two specific tasks within the project were dedicated respectively to data collection and library implementation. The tasks were:

- Renewables, design options and energy schemes for buildings and districts;
- Technology Library Implementation

The main added value of the NewTREND technology Library is on one side the richness and accuracy of information provided, which is not only qualitative and descriptive but also quantitative. On the other side, specific attention was dedicated to the layout and user interface in order for the technology Library to be used also separately from the NewTREND platform and hub as an informative tool for occupants to showcase case studies where a technology was successfully applied, in order to engage them in the selection. The list of fields to be included in the Library for each technology was designed to facilitate the use of this information by the other software tools developed between the project. For district level technologies, criteria for connecting different buildings as part of a single energy network were analysed and quantified according to the different available technologies in order to be easily taken into account in the decision-making phase.

This short document summarises the work completed for the two tasks. The data collection work was focused on retrieving, processing and organizing all the information related to available retrofit technologies at building and district level (starting from already existing technology repositories created with other research projects), in order to enable the development of a comprehensive library of retrofit technologies to be used also to showcase successful applications and impacts of each technology. Initially, previous outputs from other EU funded projects were reviewed, and retrofit technologies were divided into active and passive and split at building and neighborhood/district levels. Research was also carried out to understand which technologies would be appropriate in the various climatic and weather conditions across the demo sites in the project. The information required to be obtained through research on each technology was defined and a set field of criteria was agreed. The final part of the work

involved a strength and weaknesses analysis for each technology. In total, 133 technologies were investigated, and were broken down further into 289 separate classifications depending on size and applications for use.

The goal of the library implementation task was the creation of the NewTREND technology library starting from the structured information collected in the previous task. In particular, the data collection activity gave the inputs related to the content of the library, while meetings of local advisory teams of experts (LATs) allowed to review the compliance of the library functionalities with the needs of the project stakeholders. Moreover, a lot of effort was put into the contextualization of the Library within the NewTREND software toolset. The NewTREND consortium is developing a web tool kit for Building Information Modelling (BIM) supported building energy retrofit. NewTREND tools including the Technology Library (shown in Figure 1) shall support all stakeholders of building retrofit projects during all project phases from design/data collection phase to validation/operation. In this context, the expression "stakeholders" includes all people involved in or affected by the retrofit project including experts like architects or energy consultants as well as non-experts like building owners or tenants.

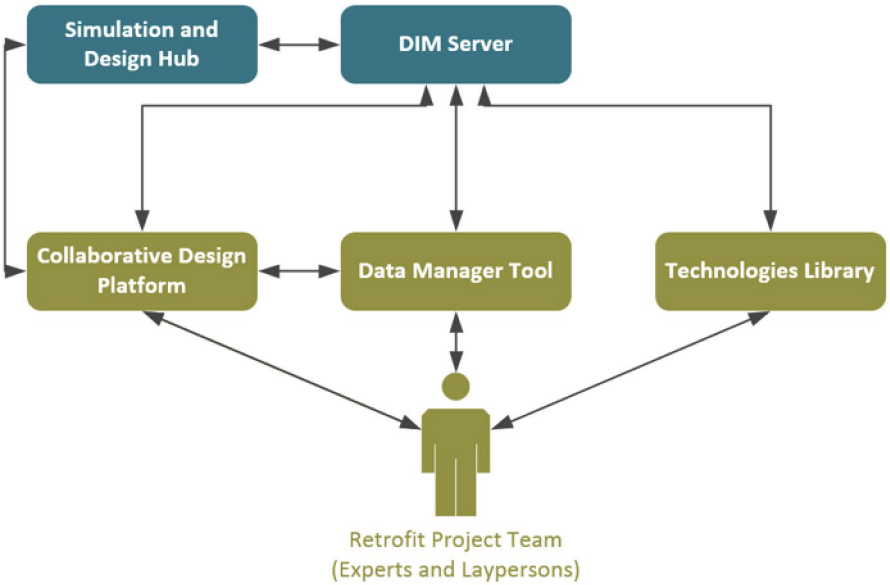


Figure 1 Overview of the NewTREND web tool kit (green boxes show tools which have a graphical user interface (GUI), while blue boxes show tools which users don't interact with actively)

In this framework, the specifications for the Library were defined in conjunction with the stakeholders and specific feedback on that were collected both among the partners and among the stakeholders involved in demo sites so that the technology Library could also be used as an informative tool for occupants to showcase case studies where a technology was successfully applied, in order to engage them in the selection.

Building Retrofit and Environment analysis

2. Building and district retrofit technologies review and characterisation

Section 2 of this document describes the main outcomes task 4.1, called "Building and district retrofit technologies review and characterisation" of the NewTREND project. The content was elaborated by the task leader JER and the project partners MUAS, REGENERA, GC, STAM and IES. The main goal of Task 4.1 was to collect all relevant information about available retrofit technologies on district and building level. Both passive and active technologies were considered and characterised in terms of technical parameters, suitability for different building typologies and climatic conditions, ease of application, specific installation procedures and criteria for applicability. A list of fields has also been defined in order to facilitate the use of this information by the Simulation and design hub. As a base to define suitable technologies the data collection of three pilot projects in Europe are available. Those projects are discerning among other things in location, construction, user behaviour and the heat supply system. To satisfy the needs of all participants of the district or housing complex the choice of the right retrofit technologies is very important. Besides the data bank with qualitative and specific information for the brought-up technologies this document details each technology category. Those were split in two categories: passive and active strategies for building and district level. An evaluation of the technologies by different factors is very important to generate retrofit variants that can be rated by diverse criteria. The structure of section 2 is divided as follows.

First the structure of the Task4.1 is explained in Figure 2. The work was done in four steps. While the work on this task, there are links to other tasks within the NewTREND project. Step 1 provides the base for the investigation of the retrofit technologies. The defined data requirements of Task 2.1 are very important to get an overview about the starting points for the retrofit, potentials and the selection of the fitting technology. Therefore, the template for the data collection of T2.1 was used and adapted for the technology library for Task 4.1. The second step is about the investigation and definition of the database of retrofit technologies from already completed projects. They are on building level as well as on neighbourhood level. Important for the discussion and choice is the Structure of the task with the interaction to other tasks within the project:

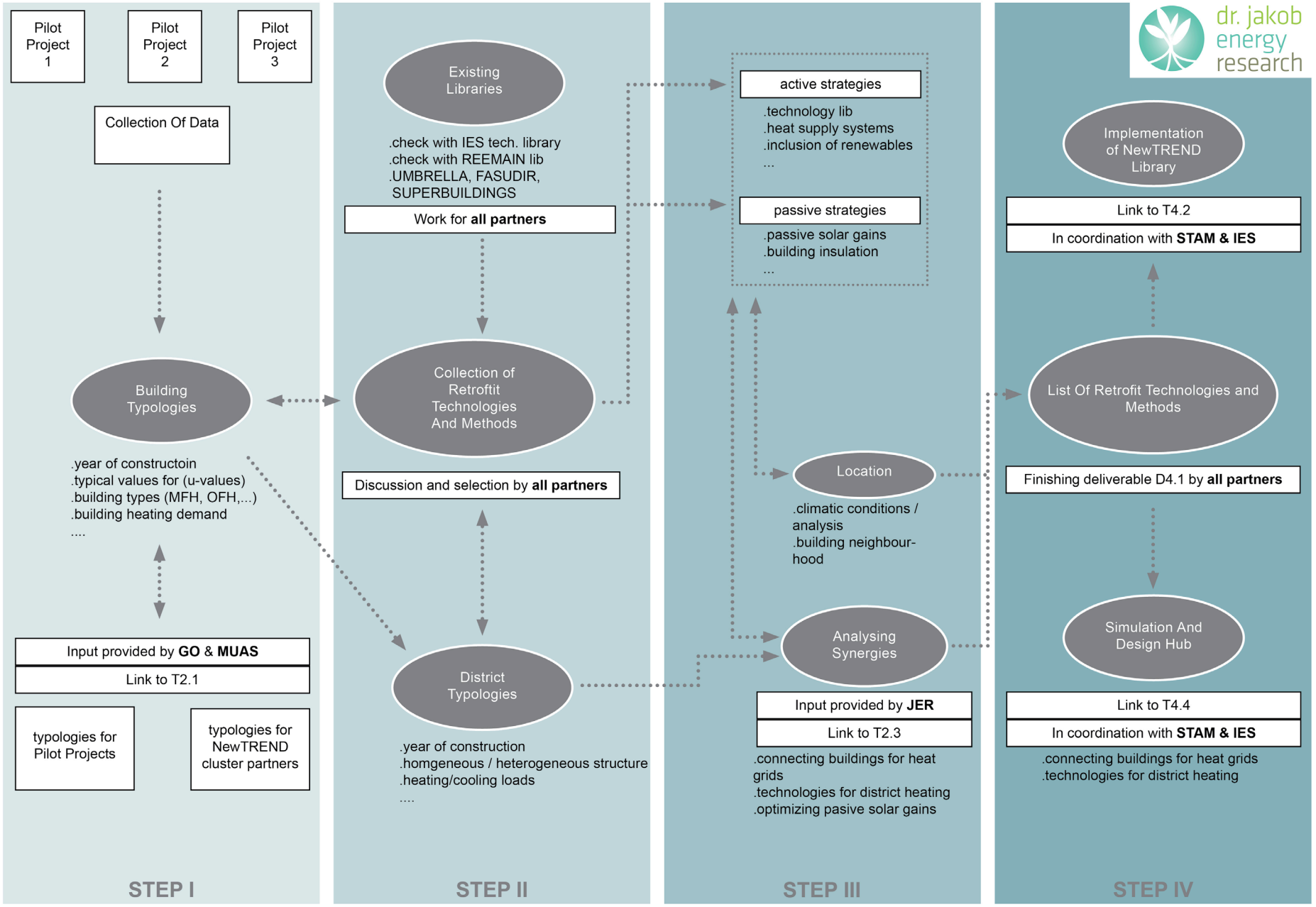


Figure 2 – Task 4.1 Structure

In step 3 out of the collected retrofit interventions a selection is made with suitable technologies for the NewTREND scale. After that a subdivision into passive and active technologies is done. At the same time the input from other tasks, especially Task 2.3, is added. In parallel to this the final technology library is completed with the specific data for each technology so they can be used in the further Tasks of WP4 and implemented in the NewTREND tool. For the success of this implementation an untimely agreement and communication with the partners of the subsequent tasks is necessary (step 4). For the analysis of the data collection and the structuring of the technology library, selection of fitting technologies and considerable parameters for the scope of NewTREND, already existing projects were investigated. Besides projects where other partners were involved, like UMBRELLA or SUPERBUILDINGS the main output came from FASUDIR. The scope of this EU-funded project was a bit rougher than the scope of NewTREND, so a few technologies and structures could be adjusted and adopted for NewTREND.

2.1 Climate and Environmental Analysis

To get a general overview of the climate conditions of a specific location it can be helpful to classify the location using the Koeppen-Geiger-Classification. It is the most frequently used classification map. The classification of the climate results from three different climate factors - main climate, precipitation and temperature. Therefore, the classification via the Koeppen-Geiger-Map allows a general statement about temperatures, precipitation and the main climate of the investigated location. As well as seasonal climatic differences which might influence the use of renewable energy potentials.

TEMPERATURE AND HUMIDITY CONDITIONS

Besides general climatic conditions, as it can be analysed via Koeppen-Geiger-Classification, also a more detailed examination of temperature and humidity can be quite reasonable. Therefore, the course of the dry ambient temperature and the wet bulb temperature of one year will be analysed. Both parameters may influence significantly the climatic and comfort conditions as well as the use of renewable energy potentials and technologies at a site. The wet bulb temperature describes the lowest achievable temperature by evaporating water into the air. However, the relative air humidity is dependent on air temperature and can also be indicated by the dew point temperature. A relative humidity percentage of 100% is called saturated air. Below the dew point temperature air condenses.

A detailed weather analysis for all pilot project locations was carried out. The benefit of the analysis is to understand the information about the climatic conditions and the potential of the implementation of renewable energy systems. For builder-owners or investors it is then easier to understand the reasons for the choice of measures and the strength and weaknesses of their building or district location.

2.2 Technologies data Collection

In order to obtain relevant, consistent and accurate data, Task 2.1 outputs were reviewed and enhanced to produce a defined list of fields required for each technology. These can be seen in the figure below:

Figure 3 - Fields for the structure of the technology library (CREDT BY: ©DR. JAKOB ENERGY RESEARCH GMBH & CO. KG)

The list of fields above was used to form an Excel file. As this file is too large to include in this report, it is available upon request, and will also be used to facilitate the collected data in Task 4.4, which works on the Simulation and Design Hub (SDH). Technologies were then divided between partners to research, with the information obtained to be entered into both the excel file and also technology description templates.

	Passive Technologies	Active Technologies
Building Scale	23	84
District Scale	2	20

New integrated methodology and **T**ools for **R**etrofit design towards a next generation of **EN**ergy efficient and sustainable buildings and **D**istricts

NewTREND

Technology description - building scale / neighbourhood scale

Name of the technology / material:

This row contains the name of the technology for a clear identification

Category referring to technology library:

This row is referring to the structure of the technology library and defines the classification of the technology

Images:

of the technology / material	of use / built-in
Here will be a image / scheme / photo of the technology function or the material itself	Here will be a image / scheme / photo of the technology function or the material in the build in or use

Short description:

WHAT

The short description contains information about:
- the function and benefit of the technology
- capacity and specific value range of the retrofit technology

Advantages, disadvantages:

WHY

Pros of the technology in general and retrofit use	Contras of the technology in general and retrofit use

Specific applications / where to use it:

WHERE

Description of the specific application and the intended use

Under which conditions can it be used:

WHEN

Description of boundary conditions and example scenarios when the implementation is feasible

Typical technical characteristics

Specific characteristics of the technology (For instance: volume [m³]; capacity [kW], specific heat capacity [kJ/(kg•K)], e.g.)

Average/general cost or return of investment (Euro/m²; Euro/kW; Euro/unit):

Typical costs of the technology (without VAT and costs for build in or necessary technicians)

Influence on inhabitants / building owners / building management:

Influence on the inhabitants (have they to move out, no water for a certain time, e.g.); building owners (lack of rental income, e.g.); building management (implementation of an BMS system, e.g.)

Impact on the environment:

Impact on the environment by the implementation of the technology (possive aspects referring to the CO2 emissions, use of harmful operation media, e.g.)

Maintenance / Operation aspects (frequency, timing, auxiliary resources, qualified technicians, etc.):

Frequency of maintenance in years and the necessary of qualified technicians to maintain the technology

Expected lifetime:

Expected lifetime of the technology in total years

Aesthetical issues:

Mention of aesthetical issues of the technology and the influence on facades, characteristic of the building, e.g.

Ease of application:

Ease of application in the rating from easy (1) to high (5) effort, referring to the technology library

Restriction criteria of applicability:

Restriction criteria such as governmental regulations, building regulations or technology specific standards, e.g.

Potential of combination with other technologies:

Description of possible combinations with other retrofit technologies within the mentioned technologies in NewTREND

Hint for suboptimal practies:

Mention of problems that can occur by false use of the technology (Input from Task 2.4)

Compatibility with historical buildings: ☑ Compatibile — Can the technology be used with historical buildings / neighbourhoods ? (Yes / No)

Figure 4 - Technology description template

In total, 133 technologies were investigated, and were broken down further into 289 separate classifications depending on size and applications for use. Besides conventional technologies and described measurements, furthermore innovative technologies are affiliated to raise this report to the state of the art. An overview on the investigated active and passive retrofit technologies is shown in Table 3. This only shows the main categories of the technologies. More detailed distinctions, like different types of fuel, chillers, heating systems, insulation variants or electrical systems are in the same consistent structure as in the chapters in this report. Because of the enormous number of description sheets only 10 sheets can be found in Annex 1 as an example.

Table 2 - Summary of Technology Types included in the library

	Passive Technologies	Active Technologies
Building Scale	• Thermal insulation • Doors • Windows • Shading • Natural ventilation	• Alternate fuels • Conventional heating systems • Combined heat and power (CHP) • Heat pump • Solar thermal collector heat distribution systems • Cold generation • Heat exchanger • Storage • Forced ventilation • Photovoltaic • Micro wind turbine • Small hydro power • Electrical battery storage • Electric and motors • Lighting • Light control • User specific control • General control
District Scale	No technologies were described in detail because the energy simulation of these is considered out of scope of this project.	• Local cooling networks for neighbourhood • retrofitting • Storage • Electricity • Control

Table 3 - Main technology features to be included within the TL

Feature Name	Allowed Values - Examples
Category	Building envelope; Building interior; Building service; Neighbourhood service.
Aim of Intervention	Energy consumption reduction; Energy efficient supply; Renewables; Comfort.
Type of Intervention	Replacement; Modification; Addition; Removal; Behavioral Intervention;
Scale of Application	Room; System; Building; Site / neighbourhood;
Description of element	Sun shading; Piping; Door.
Description of technology	Between rafter insulation; Over-rafter Insulation; External insulation with new roof seal.
Detailed description of item / material	Can vary
Suitability for heritage protected building	Can vary
Ease of application	1-5 (1 is easy, 5 most difficult)

Restriction criteria of applicability	Technical and legal restrictions.
Potential with combination with other technologies	Which technologies are suitable.
Density ρ	[kg/m³]
U-value	[W/(m²*K)
g-value	
luminous efficacy	[lm/W]
Illumination value	[lx]
Coefficient of thermal conductivity λ	[W/(m*K)]
Total weight per unit	[kg]
Efficiency	[η] (For PV, Solar thermal collectors, heat pumps, etc.)
Electrical COP	Coefficient of Performance
Thermal COP	
Typical Payback	[year]
Replace Time	[year]
Maintenance cycle	[times/year]
Investment cost&Unit	[€/m²; €/m³; €/kW; €/unit]
Maintenance cost&Unit	[€/m²; €/m³; €/kW; €/unit]
Influence	On Inhabitants and on building owner

NewTREND Technology Library

3. NewTREND Technology Library

3.1 Technology Library Content

To further proceed with requirement collection, inputs from T4.1 were analysed, namely the list of technologies to be included in the library, their main features and the SWOT analyses for the technologies. The process to define these elements is described in detail in D4.1 and is schematized in Figure 4.

This workflow allowed for the definition of the following elements:

List of Technologies: in total, 133 technologies were investigated, and were broken down further into 289 separate classifications depending on size and applications for use. An overview on the investigated active and passive retrofit technologies is shown in Table 2, and it should be noted that whilst this only shows the main categories of the technologies, more detailed distinctions are detailed in D4.1;

Technology Features: For the analysis of the data collection and the structuring of the technology library, selection of fitting technologies and considerable parameters for the scope of NewTREND, already existing projects were investigated during T4.1. Besides projects where other partners were involved, like UMBRELLA or SUPERBUILDINGS the main output came from FASUDIR. The scope of this EU-funded project was a bit rougher than the scope of NewTREND, so a few technologies and structures could be adjusted and adopted for NewTREND. The output of this analysis was a list of features presented and explained in Table 3.

Technologies SWOT analyses: one of the main outputs of task 4.1 was to complete a strength and weakness assessment of each high-level technology, which was completed during task 4.2 and reported in the TL.

3.2 Library Structure

A common practice when collecting functional requirements for any type of software tool is to proceed with a hierarchical approach, widely used for requirements collection and analysis.

These levels represent 3 distinct but interactive hierarchical Levels of analysis, where:

- Level 1 Scope and Use Case: what is the ultimate output that has to be provided to the user?
- Level 2 Algorithmic: how is the desired output going to be provided? In particular, what is the representation for the input and output, and what is the algorithm for the transformation?
- Level 3 Physical: How can the representation and algorithm be realized physically?

This approach was adopted in the requirements collection of the technology library. In particular, Level 1 and Level 2 identified the library functional requirements and had as the main input the project DOW and the work performed during Task 4.1. Level 3 allowed the definition of technical requirements, based on the defined functional requirements.

The output of the functional analys Table 3 - Main technology features to be included within the TL is (Level 1 and 2) is described in Table 4.

Table 4 - TL Functional requirements

Level	Description	Source	Requirement
Level 1: what is the ultimate output that has to be provided to the user?	[...] list of the technologies developed in T4.1, presenting descriptive, qualitative and quantitative information.	DOW	1. The output provided to the user shall be a Web Application, allowing the visualization of the main technologies and their key features.
	[...] specific attention will be dedicated to the layout of a user interface in order for the technology Library to be a self-standing tool to be used also separately from the NewTREND platform and hub.		
	[...] main added value of the NewTREND technology Library was on one side the richness and accuracy of information provided.		2. The library won't simply include a list of technologies but will present information about pros, cons of the technologies also through some examples and case studies.
	[...] (to develop) a comprehensive library of retrofit technologies to be used also to showcase successful applications and impacts of each technology.		
Level 2: how is the desired output going to be provided?	What technologies shall be included in the library?	T 4.1	3. The library will include the technologies and the main features collected during T4.1
	What technology parameters shall be stored and presented to the user?		
	How is the user going to navigate through the technologies?	T 4.2	4. The library will allow filtering and searching functionalities to facilitate the user in navigating through the technologies.

These four high-level requirements represented the cornerstone for the development, describing the 'What' and the 'How'. In particular, requirement 1 gives a guideline on the type of software to be developed, which will be a DataBase based web application. Requirements 2-4 define the information to be presented and the functionalities that must be provided to the user to have the most benefits from the library.

After defining the type of software tool to be developed and the guidelines for the content and functionalities to be implemented a first mock-up of the library content and basic functionalities was developed to verify the first requirements collection (Figure 5).

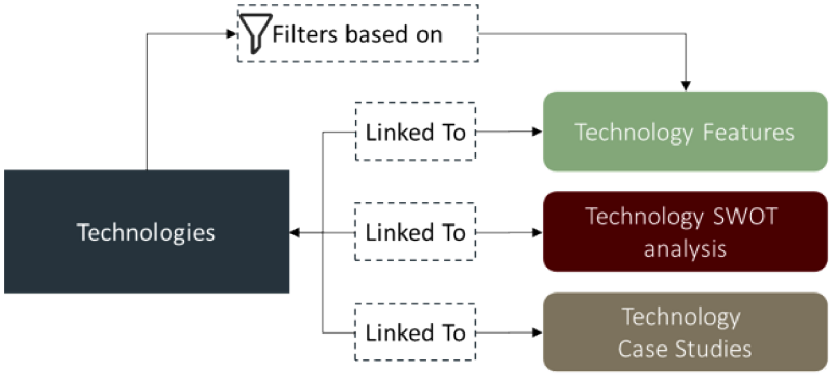


Figure 5 - TL first content and functionality mock-up for requirements verification

3.3 Library Implementation Process

The implementation of the library was carried out using the agile approach Figure 6. The development of each functionality was followed by some sort of demo presentation to the partners and, when possible, to stake-holders in order to collect feedbacks and assure that all requirements were met and that the library was user-friendly.

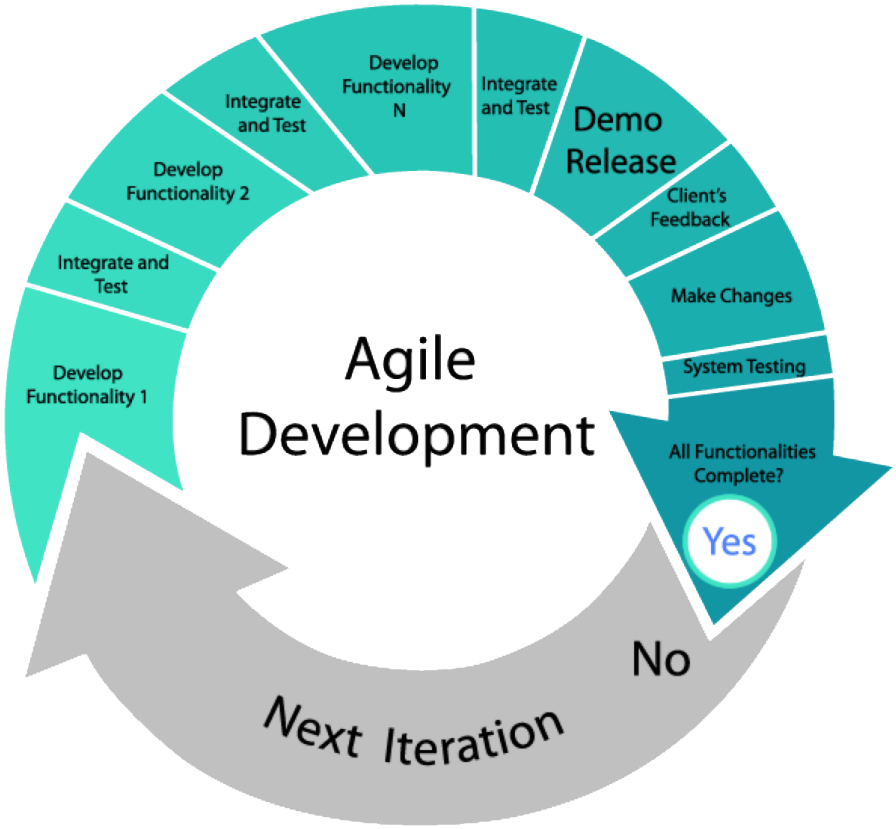


Figure 6 - AGILE development workflow

Based on the content requirements and on the general overview of the system features, another valuable input for the development of the NewTREND TL was given by feedbacks from the LAT meetings. During each meeting specific aspects of the technology library implementations were discusse and the latest update of the state of implementation was presented. This allowed a continuous tuning of the functional requirements. In te following, the main outcome of LAT meetings where the library was discussed at different phases of development are described.

The collection of requirements built the base for designing and implementing the system. The functional requirements allowed to detail the technologies that needed to be included within the library while the technological requirements defined the domain of programming environments and tools to be adopted. The first step to proceed with the implementation was then to define a workflow, representing the user action and the expected library responses to allow the target functionalities. The workflow is sketched in Figure 7.

This laid down the basic implementation units to be developed both for front-end and back-end functionalities. Moreover, as it had become clear that it would be an important feature of the library to describe the use of some of the technologies for real application, in order to allow the user to assess potential benefits and impacts of the intervention, several use cases were collected between partners.

Based on the designed workflow, the library architecture was designed. The main objective of this step was to define the front-end elements, such as buttons, controls, dialog boxes and pages to allow the user to be able to perform the actions envisioned in the workflow and to visualize the results in the most compact, effective and pleasing way. This was done, once again, using a hierarchical approach, firstly defining the high-level architecture, presented in Figure 8, and eventually proceeding with a more detailed design of each component.

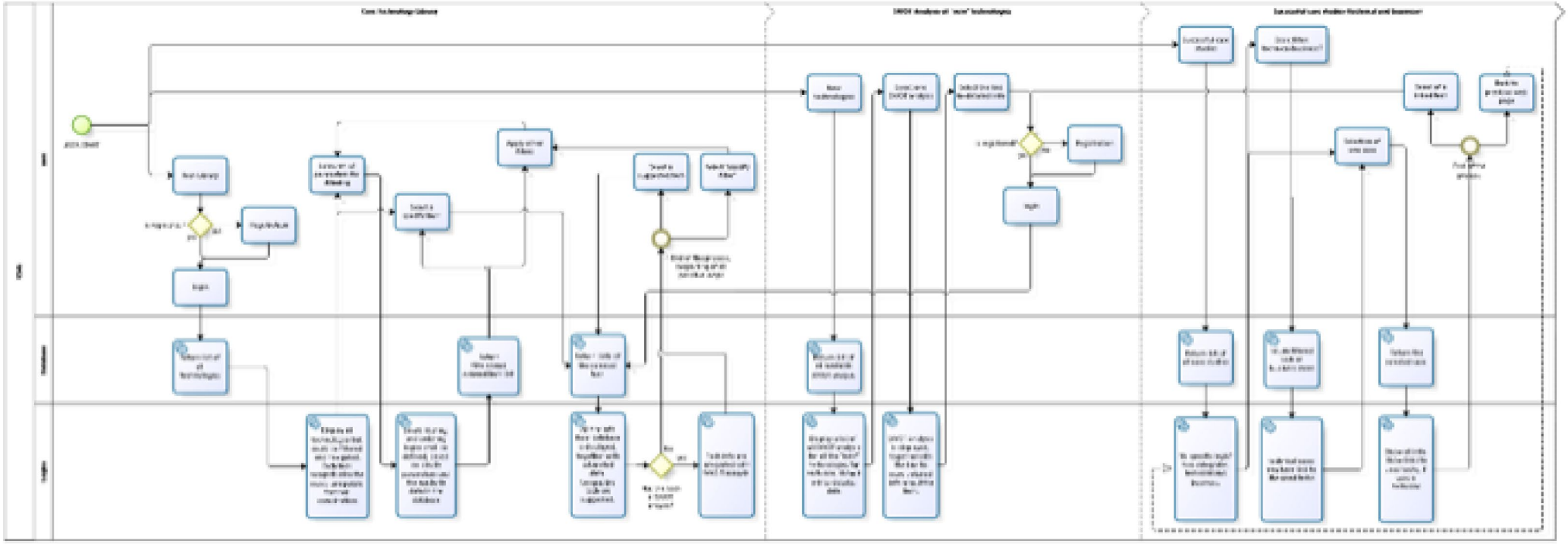


Figure 7 - TL functional workflow

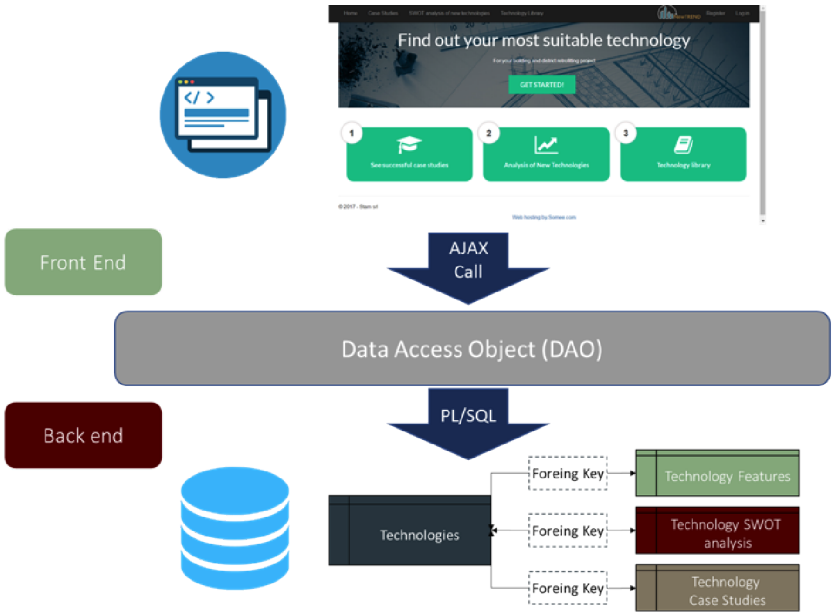


Figure 8 - High level Library Architecture

The sketched architecture can be broken down into the two standard elements composing a web app, namely the front-end section and the back-end section. The front-end section consists of HTML pages that the user can interact with through a web browser in order to use the library. The back and consists of the SQL queries and the PL/SQL procedures needed to extract, store, update and delete the information. The Data Access Object (DAO) is the interface layer, allowing the two levels to interact and converting front-end controls into DB-friendly instructions.

Following this high-level definition of the library architecture, the design phase further developed the needed front-end elements and the relative back end SQL queries and procedures. This activity was carried out in parallel with the start of the implementation.

HUNGARY LAT MEETING - ABUD

During the LAT meeting in Hungary, a specific session was dedicated to the presentation of the mock-up of the technology library. Moreover, feedbacks were collected from the participants, that spanned from City managers to energy councillor to legal associates responsible for municipality projects. The main topics discussed were:

- **Competitors:** it was generally acknowledged that technology information can be gained from the internet or from journals. It was pointed out how crucial it is for the NewTREND technology library to strengthen its functionalities such as filtering and searching as well as the 'strategic/planning-related' sections such as the use cases and the SWOT analysis ones.
- **Library GUI:** the current mock-up was appreciated as it was well collected, thorough, generally including all categories which are needed and relevant to an architect or an engineer.
- **Content** requirements: it was pointed out the need to include financial information for the technologies, approximate budget at the most. Moreover, another additional information that was brought up as relevant was the applicability to building type (heritage, free-standing, building function) and the type of intervention etc. With this regard the Details included on the mock-up seemed satisfactory.
- **Filtering requirements:** it was unanimously stated that the filtering options are important in order to set up the users' preferences. Budget, building category, category of intervention, typical payback period, replacement time, maintenance issues were the most important.

Moreover, it was pointed out that information regarding building type and building function are a nice-to have-functionality as well as 'tagging', which would be useful with "default keywords" to select families of interventions.

- **Case Study information:** they are site and situation specific (by country, by legislation, by climate, and so on), which requires the user to keep these factor into account to fully benefit from the information.

An additional, general comment, was the need of the Technology Library to be enabled to upload and expand the library further with additional content and have the possibility to define the content.

FINLAND LAT MEETING - GO

There were several suggestions regarding the technology library which were though listed as nice-to-have functionalities:

- Technologies which could have different financing schemes (e.g. support for installing PV panels) should have information on it;
- Possibility to input technologies currently in use, to aid result filtering and propose corresponding replacement technologies;

A general comment for the NewTREND ecosystem was that it should guide uses completely through the project: collecting the data, identifying problems, propose the solutions to the problems (for common technology problems and sub-optimal use) and promote long-term perspective (continuous monitoring of performance and giving feedback to users). This raised particular focus on the importance of searching functionalities and on the logical connections between elements within the library (e.g. the possibility to visualize case studies involving a certain technology).

3.4 Library description

The library through its intermediate releases and at the current state is hosted my some.com and is accessible at http://newtrendlibrary.somee.com/. The home page, displayed in Figure 9, is designed to give users and visitors the chance to get an overview of the library functionalities even before accessing it. On the top navigation bar 6 tabs are included:

- Home: if clicked takes the user back to the Home Page;
- Case Studies: if clicked takes the user to the section including the Case Studies, that give practical example of retrofitting technologies uses and applications and the achieved impacts. This section is not accessible before logging in;
- SWOT analysis of new Technologies: if clicked takes the user to the SWOT analysis section where, for each technology, strengths, weaknesses, opportunities and threats are described. This section is not accessible before logging in;
- Technology Library, if clicked takes the user to the main library page, where all the technologies are listed and specific solutions can be filtered and searched. This section is not accessible before logging in;
- Register: allows new users to get username and password to access the library;
- Log in: allows registered user to input their username and password and to access the library functionalities.

The main three section of the library, namely the Library itself, the Case Studies Section and the SWOT analysis section can also be accessed via the buttons numbered 1, 2 and 3 in the body of the home page. The library section, is also accessible by clicking the 'GET STARTED!' button.

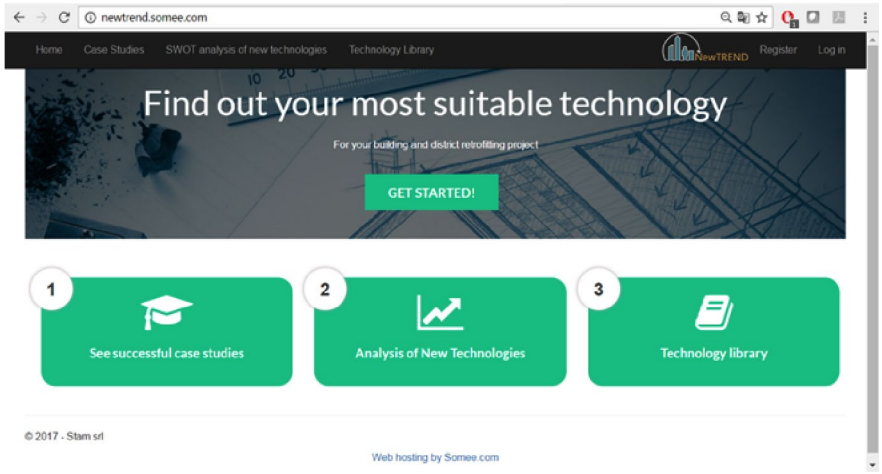


Figure 9 - Library Home Page

3.4.1 Library Content and Functionalities

After registering and logging in to the library the main functionalities can be accessed. In the following the features of the library three main pages, Technology Library, Case Studies and Technology SWOT analysis will be described.

TECHNOLOGY LIBRARY

The library main page, which can be accessed from the navigation bar and through dedicated buttons and links is the technology library page, shown in Figure 10. This page lists all the technologies stored within the DataBase and gives a preview composed by the main feature that the user might be interested in at a first glance, such as:

- Technology Name, and an image representing the technology;
- Scale of the intervention: could be building or district scale;
- Category of the intervention: could be building envelopes, shading and so on;
- Climate Zone: describes the applicability of such intervention for specific climatic areas;

- Ease of application: on a 1-5 scale describe the ease of application of the technology;
- Investment cost: specifies the indicative cost of the technology and the corresponding unit (e.g. €/m2).

As the library features several hundreds of technologies it is impossible for the user to select or find the one of interest simply by scrolling through the list. For this reason, search (Figure 11) and filtering (Figure 12) functionalities are available on the Technology Library page.

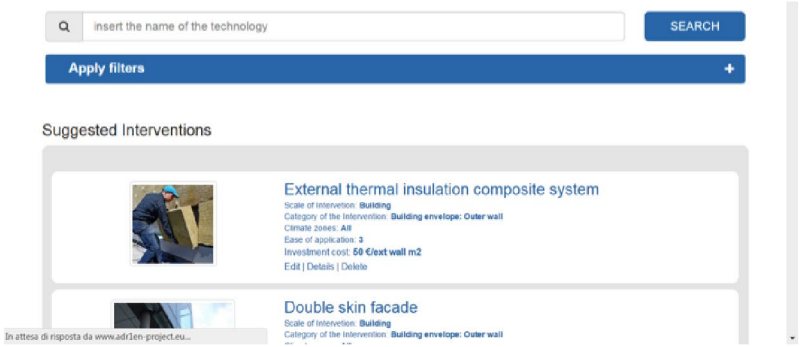


Figure 10 - Technology Library main page

Searching allows the user to insert the technology name in order to visualize the wanted solution.

Figure 11 - Search by technology name

If the user has not selected the needed intervention, or is just in the design phase and wants to see what is available and in line with his needs, he can tune the displayed technology by adding filters to the search. The filtering parameters are:

- Project Budget: total budget available for the intervention;
- Type of Building: through a drop-down list the building type can be selected;
- Gross floor area of the building, in m2;
- Desired Scale of application, whether it is building or district;
- Climate Area;
- Information regarding the required power of the system:
    - Power of the system [kW];
    - Watt-peak of the system [Watt];

Optional parameters:

- Ease of Application, on a 1-5 scale;
- Category of Interventions.

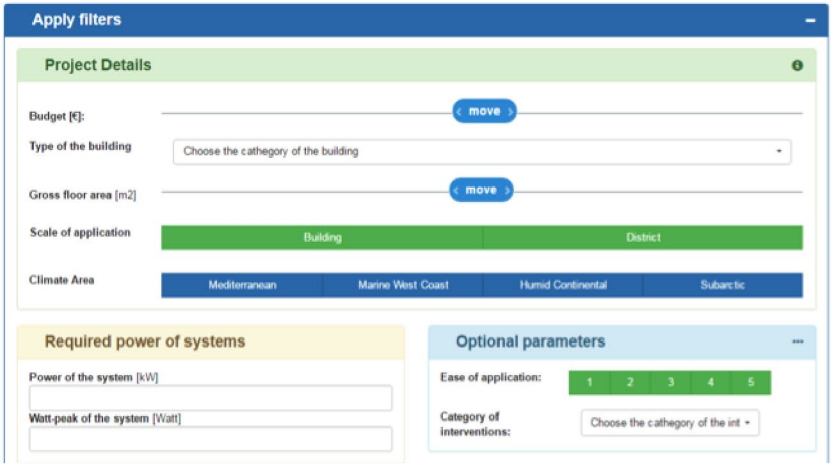


Figure 12 - Filters for the technology library

After searching and/or filtering the list of interventions, the list of technologies displayed in Figure 10 is trimmed to the results responding to the queries inserted by the user.

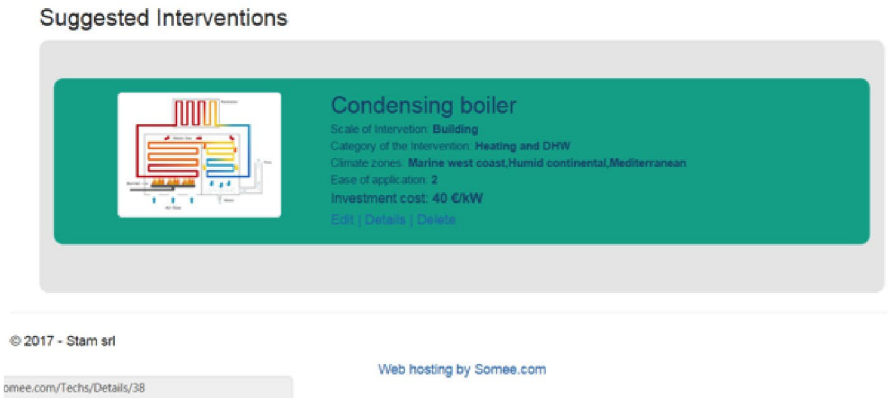


Figure 13 - Filtered technologies list

By clicking on the technology box the user accesses the section including the detailed information on the technologies itself, shown in Figure 14. This page includes all the relevant parameters selected during task 4.1 and listed in Table 3.

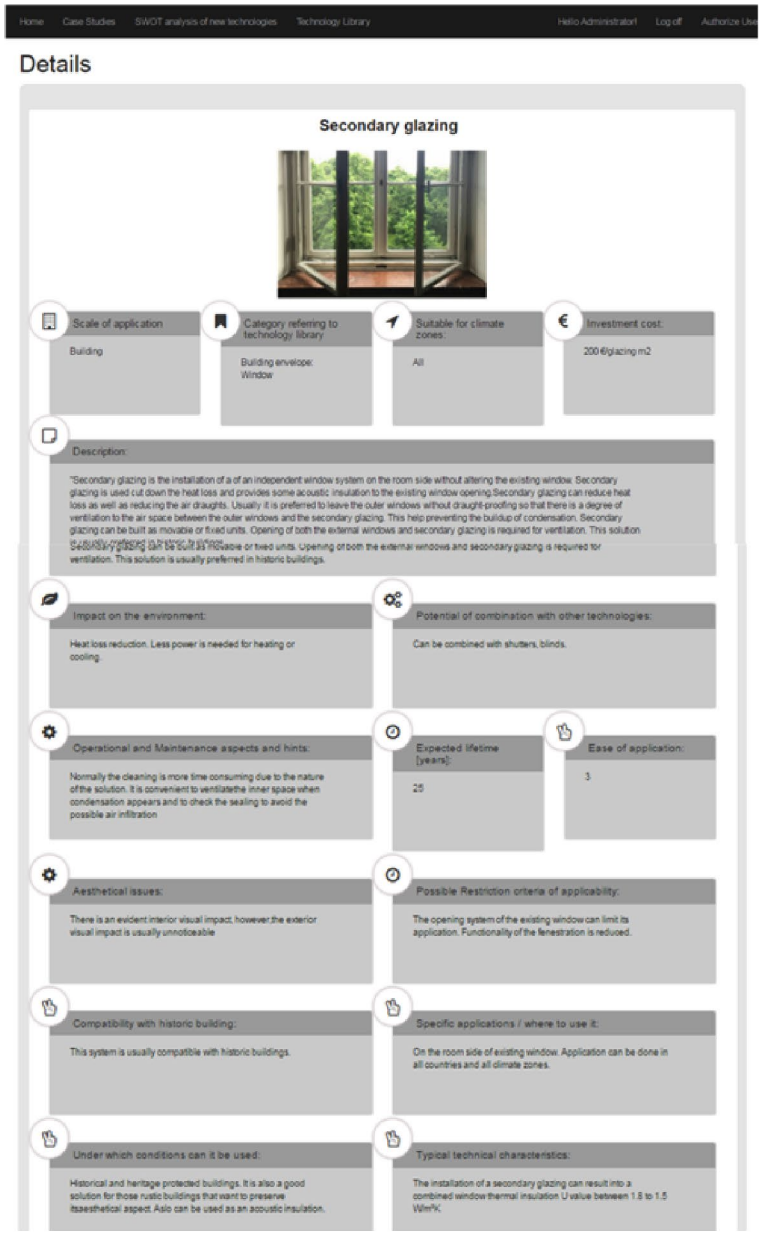


Figure 14 - Technology Details

Moreover, below the technology details, a specific SWOT analysis of the technology is shown as displayed in Figure 15.

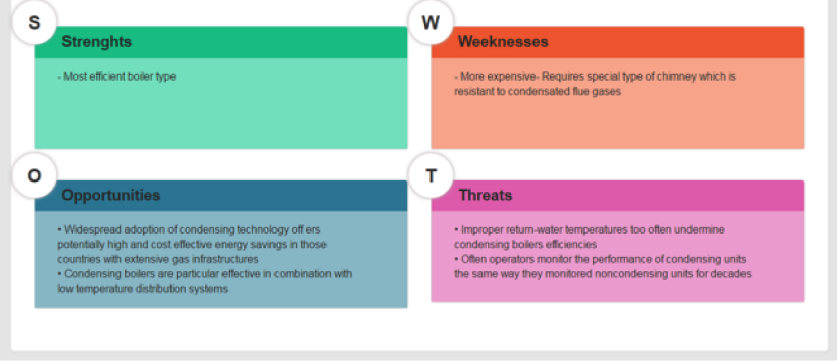


Figure 15 - SWOT analysis of a technology in the technology details page

At the bottom of the 'Details' page there are the two experience based sections, namely 'Read about the case study application' and Detailed Examples (Figure 16).

The first one links to the case studies section, specifically to the case studies in which the selected technology was used. The latter gives real figures for the technology main parameters for a real case example.

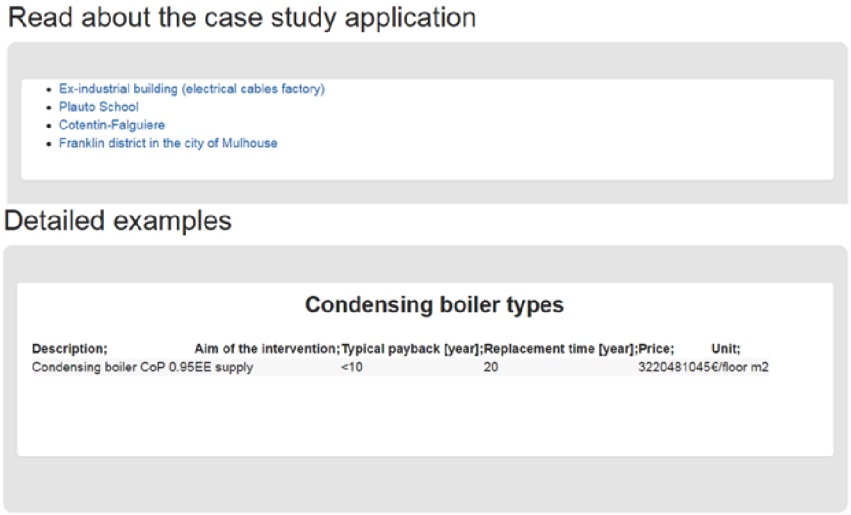


Figure 16 - Link to related case studies and Detailed Examples

SWOT ANALYSIS OF NEW TECHNOLOGIES

The user can navigate directly to the SWOT analysis section, where all the technologies are listed and, by clicking on them, he can access to the sole SWOT analysis for that technology.

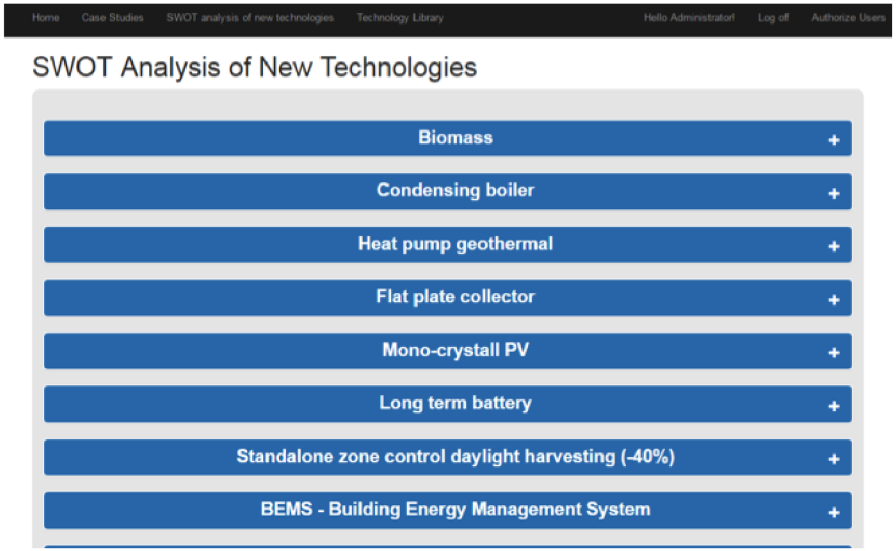


Figure 17 - SWOT analysis page

The displayed result is a short version of what is shown in the Technology Details page, and includes an image of the technology and its main strengths, weaknesses, opportunities and threats. Moreover, within this section, by clicking on the 'SEE MORE DETAILS!' button, the user can access the technology details page of the selected intervention.

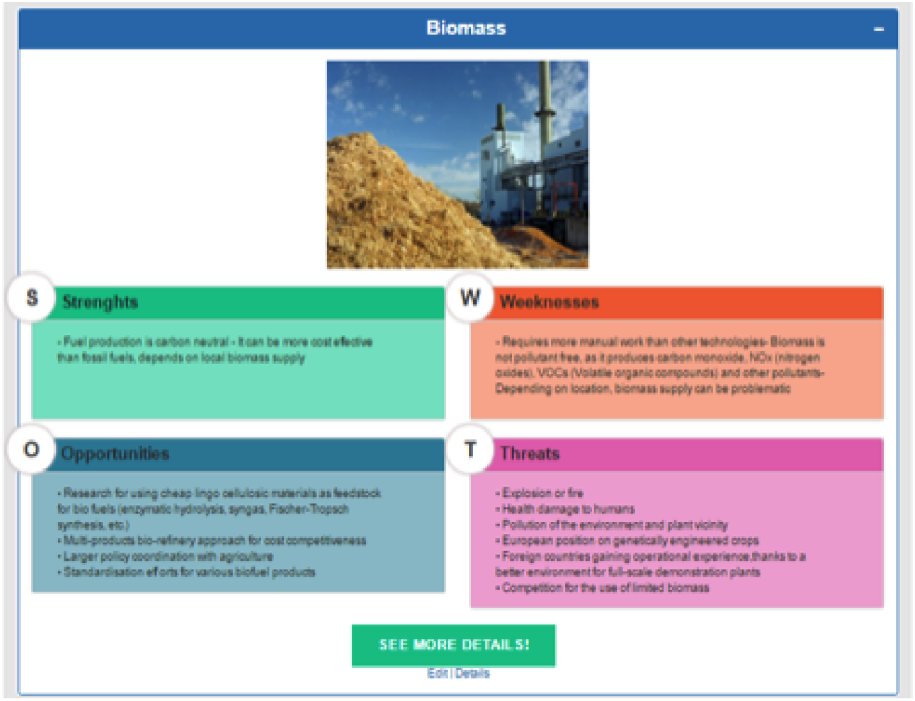


Figure 18 - SWOT analysis details page

CASE STUDIES

The third section of the library is the 'Case Studies' section, where case studies of interventions adopting the technologies within the technology library are presented. The look of the Case Studies list is in line with that of the other library pages: the name of the Use Case is displayed in a blue, clickable button box (Figure 19). Figure 19 - Use Cases Main Page

Figure 19 - Use Cases Main Page

By selecting a specific Case Study the user access the detailed section where the application is presented. The detail section is divided into:

- Case Study name;
- Involved interventions: what technologies were used for this application. This section links directly to the technology details page;
- Location: gives geographical reference of the application and weather information;
- Description: is a description of the location, may include pictures, figures, tables and so on;
- Project Description: is a description of the retrofitting project that included the interventions;
- Performance Before the intervention: describes the energy performance before the intervention in terms of energy demand and efficiency;
- Performance after the intervention: describes the energy performance after the intervention in terms of energy demand and efficiency;

- Energy and costs savings: is the difference in energy consumption and the relative cost saving;
- Resources and links: includes links to additional documentation on the topics and on the retrofitting project.

Cotentin-Falguiere

Involved interventions

- Flat roof insulation / Polyurethane hard foam (PUR)
- Perimeter insulation / Foamglas
- Double glazing
- Condensing boiler
- Mech. ventilation zone exhaust vent
- OLED (100 lm/w)

Location

Location: Corner of Rue du Cotentin and Rue Falguière, Paris, France. 48° 50' 18'' N, 2° 18' 41'' E, 55 m elevation
Weather: Winter 5 °C; Summer 20 °C; average temperature 11.5 °C

Description

The building, built around 1950 in the centre of Paris, is a seven-storey residential block composed of 87 apartments. All dwellings have small balconies, while the 7th floor dwellings have a large terrace.

In 1993, the building was renovated with outer insulation, double glazed windows, two gas boilers for heating and individual electric boilers for hot water. However, within the context of becoming a pilot for the BEEM-UP Project, the previous retrofit was insufficient, and therefore the housing company owner of the building performed a new retrofit of the 87 dwellings. After the diagnosis of the building and design phase, the works started in 2013.

Figure 20 - Case Studies Details 1

Project description

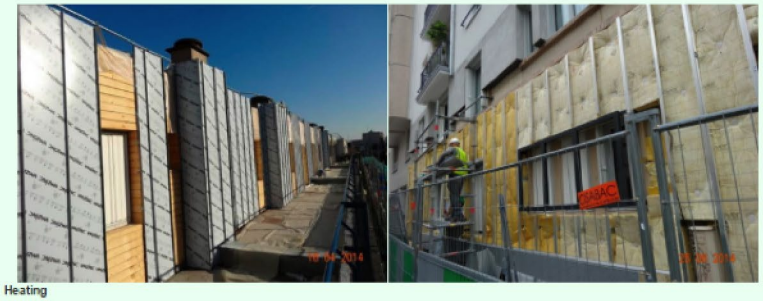
Envelope

The façade on the street side of the building consisted in concrete with 2 centimetres of sandwich thermal insulation. A 20 cm layer of ETCIS polystyrene was added. On the back side, the walls were made with concrete, 2 cm of sandwich insulation and 8 cm of ETICS polystyrene. In this case, the ETICS polystyrene insulation was substituted by a new 20 cm layer.

The basement insulation, which simply consisted in concrete, was improved with 10 cm of EPS (expanded polystyrene). The old 5 cm thermal insulation in the roof was replaced by a 10 cm polyurethane thermal insulation.

The windows of the building, 20-years old PVC double glazing, were also replaced with new ones.

	Before	Interventions
Wall street side	Concrete + 2 cm sandwich insulation	Added 20 cm ETICS EPS (λ = 0,032 W/m·K)
Wall back side	Concrete + 2 cm sandwich insulation + 8 cm ETICS EPS	New 20 cm ETICS EPS (λ = 0,032 W/m·K)
Basement	Concrete	Added 10 cm EPS (λ = 0,032 W/m·K)
Roof	Concrete + 5 cm insulation	New 10 cm PUR (λ = 0,024 W/m·K)
Windows	PVC double glazing (20 years old)	New PVC double glazing (U = 1,5 W/m²K)



Heating

Heating system consisted in two centralized gas boilers, which were replaced by two new **condensing boilers**.

Hot water

Individual electric boilers were maintained, but tenant's awareness-raising was expected to help to reduce energy consumption.

Ventilation

Natural ventilation grids were upgraded to a controlled mechanical ventilation.

Lighting

Existing incandescent light bulbs were replaced with low-energy light system in all public spaces.

Renewable Energy Sources

A Water Heat Recovery System was installed in the basement for heat recuperation from waste water, which is usually released directly to sewers

Figure 21 - Case studies details 2

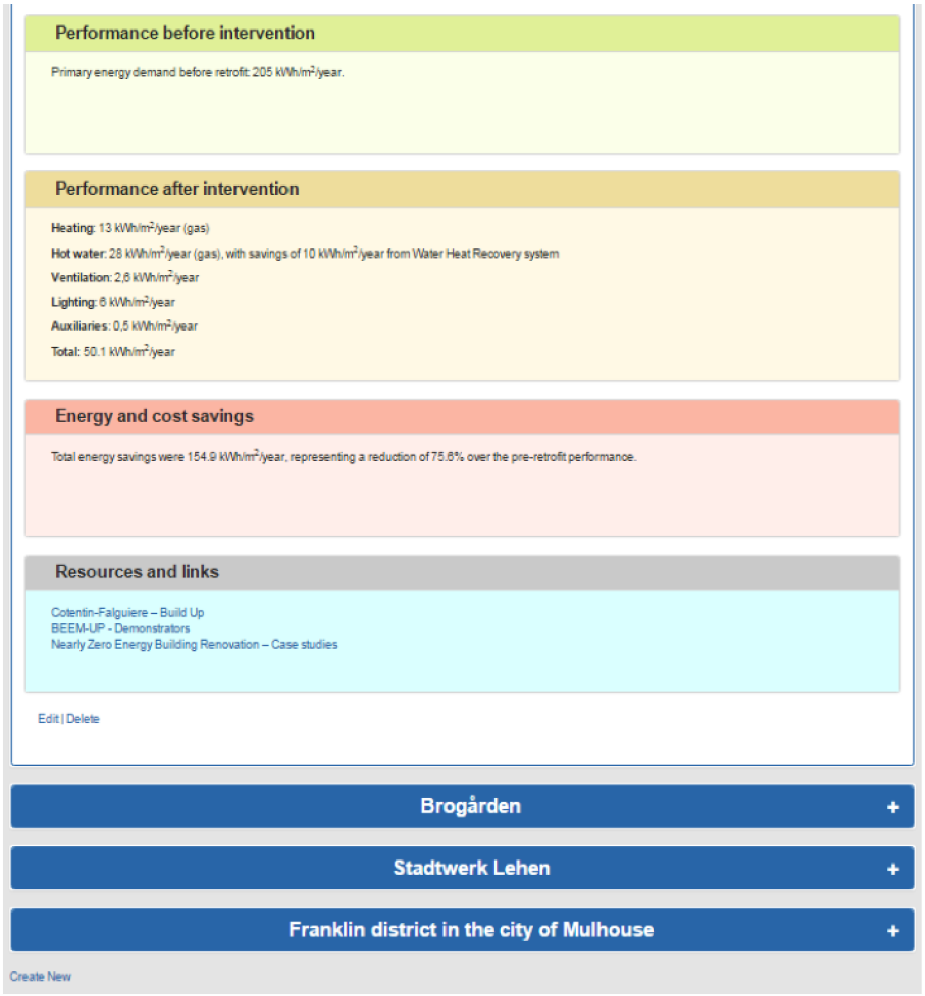


Figure 22 - Case studies details 3

Project Partners

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The research leading to these results has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement 609222.

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