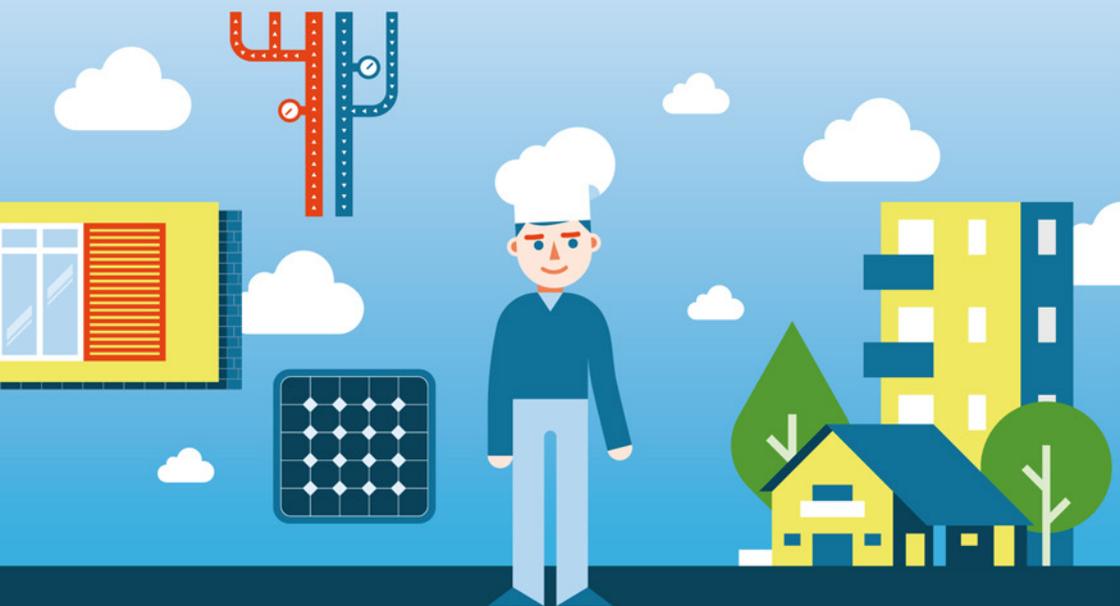




4RinEU

Reliable models for deep renovation



DEEP RENOVATION RECIPES FOR YOUR BUILDING



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Project information

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4RinEU is a project funded by the European Commission under the Horizon 2020 Programme and has been running for five years from 2016 to 2021.



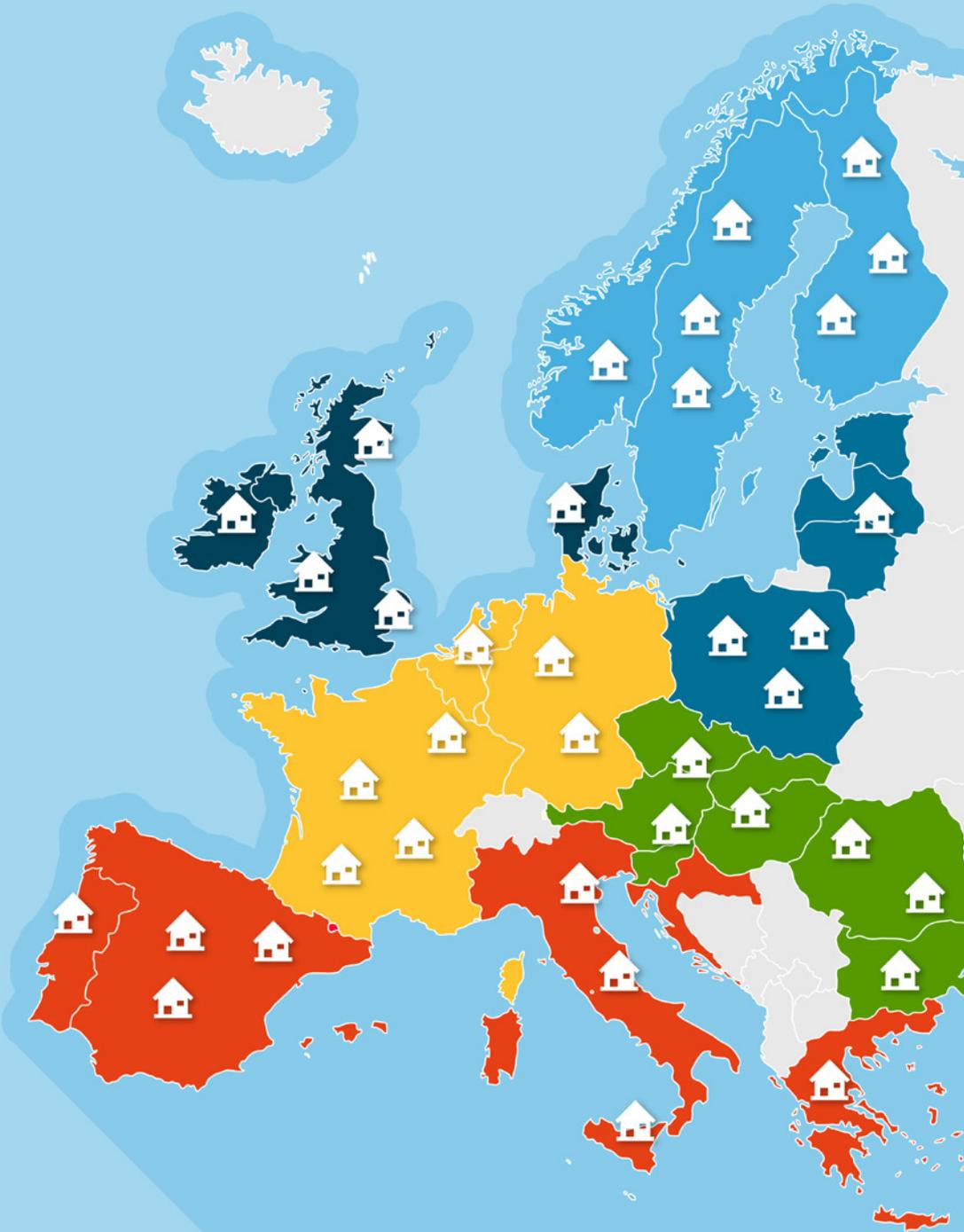
Reliable models for deep renovation



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INTRODUCTION



Renovating your home can boost its value and add comfort to your life.

However, many homeowners are scared of renovating because it may lead to stress, delays, and high costs.

4RinEU is a project funded by the European Union that focuses on transforming the renovation process to make refurbishments cheaper and easier.

The project developed sets of **packages** that will make building renovation more effective, allowing you to save energy and improve comfort inside your home.

4RinEU renovation packages combine innovative solutions and standard products to ensure **reliable and robust results**.

THE TECHNOLOGIES USED INCLUDE

- a **prefabricated timber façade** system integrating several components like ventilation units, smart windows, and shadings to keep the temperature inside your home at a comfortable level
- an **Energy Hub** that optimises heating and cooling
- a **smart ceiling fan** that automatically adapts its speed depending on indoor and outdoor conditions
- a **photovoltaic** system that can be integrated on the roof and/or the façade of the building.

4RinEU solutions are modular and can be produced in an industrialised way. This means that the amount of work on-site can be reduced by a large extent without affecting the quality and performance of the renovation.

Moreover, residents can stay home during the whole process.

Keep reading to learn more about the 4RinEU deep energy renovation approach.



HOW TO READ THIS COOKBOOK

The technologies used to renovate buildings can be thought of as the ingredients of a recipe: they can be combined in different ways to create tasty dishes with a unique flavour.

With this cookbook we want to reveal to you **4RinEU recipes to renovate your home** depending on your taste and the ingredients you have at hand.

In the following pages you will find information on the ingredients (technologies) to use and the steps to take to reach the desired outcome. Each recipe contains tips that will help you master the 4RinEU method.

Considering that Europe is a vast and diverse continent, at the end of each recipe we added a series of graphs that will help you compare the results you can obtain in areas with different building types and climates.

To learn more about the climatic zones we considered in the 4RinEU project, go ahead and read the chapter “Geo-clusters”.

All figures contained in this cookbook are based on the simulation of the energy performance of a single-family house before and after renovation.



SINGLE-FAMILY HOUSE
228 m²

GEO-CLUSTERS



Demo-Cases



Early Adopters

4RinEU divided Europe into six areas, called geo-clusters, according to the most common type of construction that can be found there and their climatic conditions. Here is a description of each geo-cluster:

GEO-CLUSTER 1

Northern European countries with a cold climate and a prevalence of single-family houses.

Reference country: Norway

GEO-CLUSTER 2

North-Eastern European countries with a cold climate and a large amount of multi-family houses built between 1960 and 1990 with prefabricated concrete panels.

Reference country: Poland

GEO-CLUSTER 3

Western continental countries and central countries with a continental climate. The building stock is mainly composed of single-family houses, with no prevailing construction period. The building stock presents different construction features, like masonry, concrete, or prefabricated structures.

Reference country: The Netherlands

GEO-CLUSTER 4

Eastern continental countries. The main building typology is single-family with a significant amount of multi-family houses built after the 2nd World War with a prefabricated concrete structure.

Reference country: Hungary

GEO-CLUSTER 5

Mediterranean countries with a warmer climate, where the building stock is split almost equally in single and multi-family houses built in different construction periods mainly with masonry or concrete structures.

Reference country: Spain

GEO-CLUSTER 6

Atlantic zone with a cold oceanic climate and single-family houses as the main building type.

Reference country: the UK

THE RECIPES



RECIPE 1

PREFABRICATED FAÇADE

🕒 TIME ON CONSTRUCTION SITE: between 55 and 118 hours

🌍 PERFORMANCE:

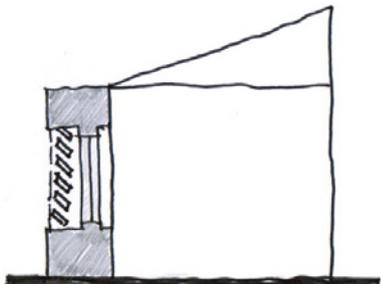


Prefabricated façades are **modular wooden systems** that allow to renovate buildings in a quick and efficient way. These modules are produced in a manufacturing site and then transported to the construction site ready to be installed.

They do not replace the existing façade of the building but are added externally to create a new layer. Each prefabricated façade module can be integrated with different technologies to increase the energy performance and comfort of the building.

Be aware:

this recipe is the basis for all other preparations in the cookbook!



Hand-drawing illustration: Linda Toledo, Eurac Research

INGREDIENTS

- Insulation material
- Windows
- Shading system



4RinEU prefabricated façade modules waiting to be installed on the Dutch demo
Credits: Trecodome - Woonzorg Nederlands

PREPARATION

1

Design the prefabricated façade modules and set up your anchoring strategy. When doing so, consider the needs of the building and its features. Ask yourself questions like: does it require a lot of insulation? What are the users' needs? Is it going to be too heavy?

2

Build the timber frame. Make sure it is the right size and configured so that it can host the technological components you decided to include.

3

Fill in the frame with insulation material. If you want to be more eco-friendly, use recyclable materials. This will reduce the carbon emissions of your renovation project.

4

Install the windows. You can either keep the old windows you had before or mount new ones. Pay attention during the installation phase to prevent uncontrolled infiltration.

5

Add the shading system. Automatic shading systems can help you keep your home cooler in summer and prevent overheating. Study the solar exposure of the building during the year to choose the right angle of the lamellae.

6

Bring the prefabricated façade modules to the construction site and anchor them to the building. It's quick and easy! You won't need any scaffolding. People can stay inside their apartments during all the phases of the renovation work.



TIPS

Design your prefabricated façades in collaboration with a team of experts, like architects, structural engineers, energy designers, manufacturers, and installers. Remember that you won't be able to make any changes in the construction phase!

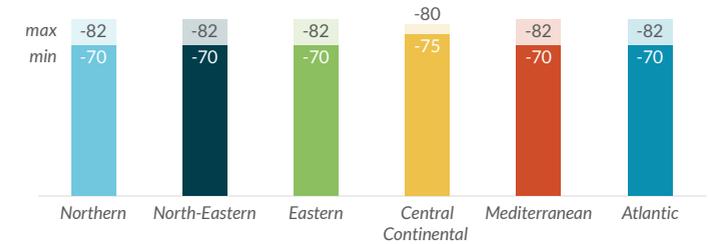
This solution may seem quite expensive compared with the initial investment needed for a traditional renovation, but in the long run it is actually more convenient because it reduces some of the costs related to the construction site by cutting time and increasing the efficiency of the renovation work and it will make your building live longer and with better indoor conditions.

RECIPE 1 IN DIFFERENT CLIMATES



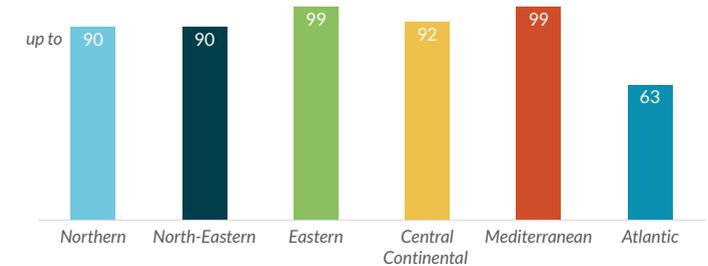
Energy Demand

% of energy used to heat and cool the building after the renovation



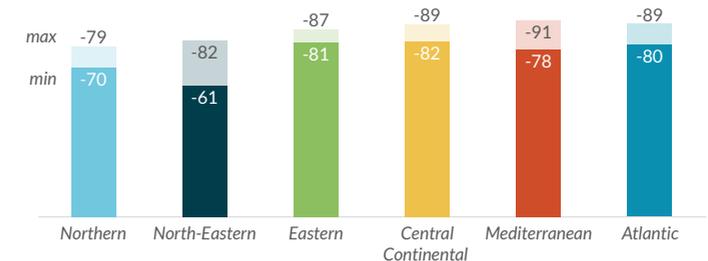
Comfort

% of hours spent in optimal thermal conditions



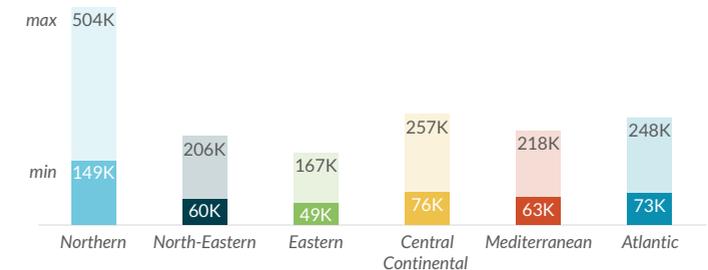
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs

Investment cost expressed in thousands of euros



RECIPE 2

PREFABRICATED FAÇADE WITH DECENTRALISED VENTILATION

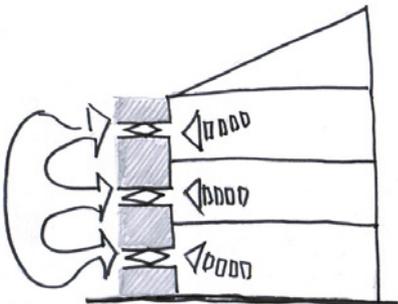
🕒 TIME ON CONSTRUCTION SITE: between 58 and 122 hours

🌐 PERFORMANCE:



Decentralised ventilation machines are used to **ensure air exchange** in each room or apartment. These devices can be equipped with a heat exchanger to recover heat from exhaust air and warm up the fresh air entering the room.

These machines require no additional space inside the building because they can be integrated in the prefabricated façade modules, taking advantage of the holes where the windows will be placed.



Hand-drawing illustration: Linda Toledo, Eurac Research



4RinEU demo case in Soest (the Netherlands) after renovation
Credits: Trecodome - Woonzorg Nederland

INGREDIENTS

- Prefabricated façade
- Ventilation machines
- Heat exchanger

PREPARATION

1

Choose the right location for your ventilation machine. They can be placed beneath the new windows to avoid drilling new holes in the wall. Check if there is sufficient space to house the machine, to let the light in and open the window.

2

Insert the ventilation machine in the prefabricated façade. Go back to recipe 1 to read how to integrate the machine in the prefabricated façade modules.

3

Add the heat exchanger. Having pre-heated air entering indoor environments is very important to ensure tenants' comfort and to reduce the amount of energy needed to warm up the apartment.

4

Install the façade and plug-in the machine. Follow the installation guidelines provided in recipe 1. The ventilation device can also be powered by photovoltaic panels integrated in the façade modules.



TIPS

The ventilation machines might be a bit noisy. Consider integrating some noise protection in the prefabricated façade.

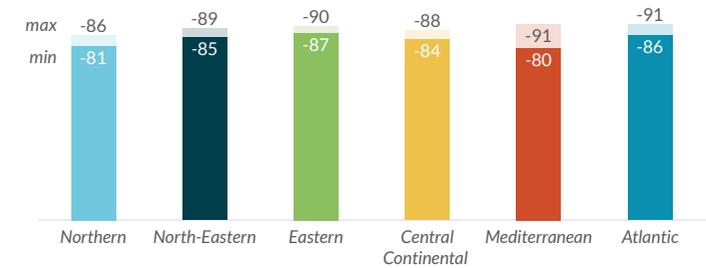
Install the ventilation machines in a place that is easy to reach to change the air filters and to inspect the device in case of malfunctioning.

RECIPE 2 IN DIFFERENT CLIMATES



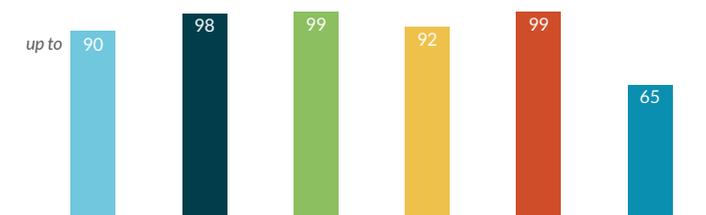
Energy Demand

% of energy used to heat and cool the building after the renovation



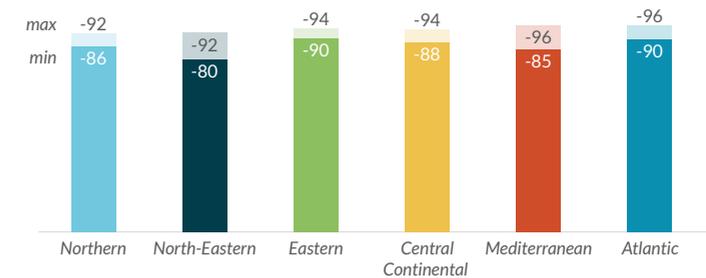
Comfort

% of hours spent in optimal thermal conditions



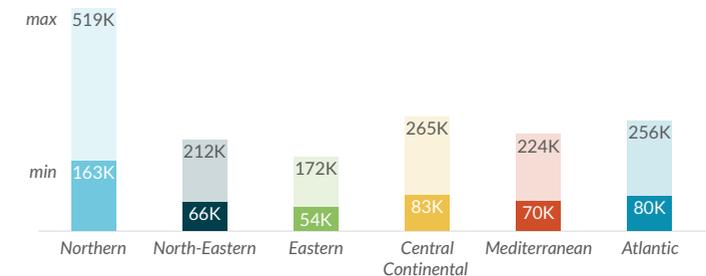
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs

Investment cost expressed in thousands of euros



RECIPE 3 PREFABRICATED FAÇADE WITH CENTRALISED VENTILATION AND BUILDING INTEGRATED PHOTOVOLTAIC (BIPV) PANELS

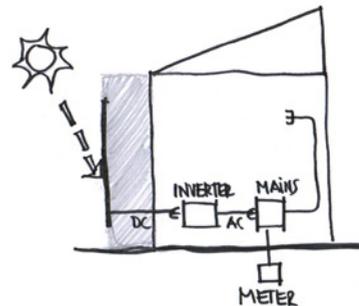
🕒 TIME ON CONSTRUCTION SITE: between 135 and 199 hours

🌍 PERFORMANCE:

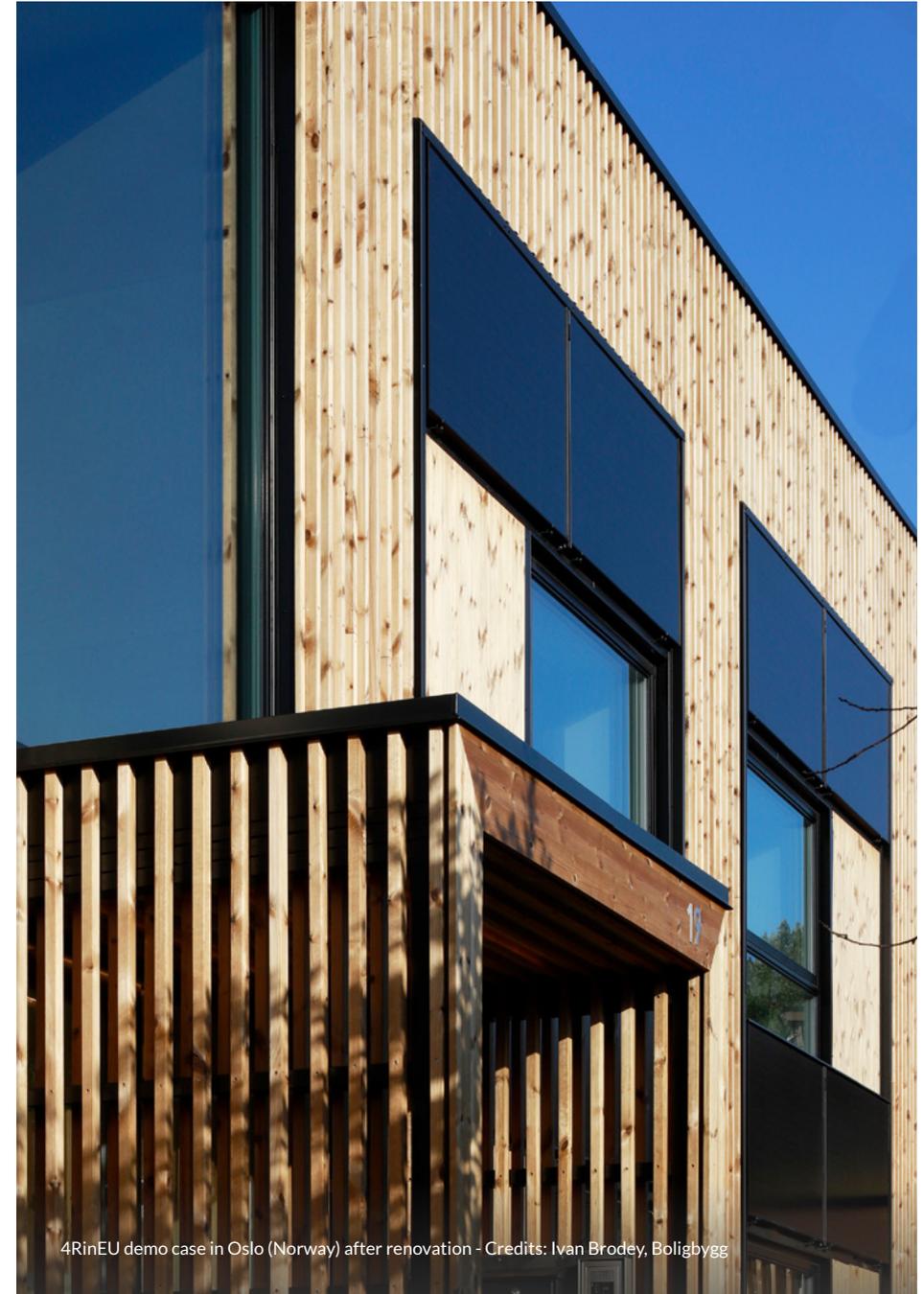


A centralised ventilation system consists of a big **air handling unit (AHU)** that is connected to the apartments to **provide ventilation with heat recovery**.

Photovoltaic (PV) modules produce **renewable energy** that can be used to power appliances or to cover part of or the whole energy demand of a building.



Hand-drawing illustration: Linda Toledo, Eurac Research



4RinEU demo case in Oslo (Norway) after renovation - Credits: Ivan Brodey, Boligbygg

INGREDIENTS

- Prefabricated façade
- Building integrated PV
- Centralised ventilation machines
- Heat exchanger

PREPARATION

1

Find the location for your centralised ventilation machine. Due to its size, the centralised ventilation machine is usually placed in a special technical room.

2

Place the air ducts. You can either integrate them in the prefabricated façade or position them inside the building. If you decide to integrate the ducts in the façade, add proper insulation to avoid condensation. You may use sound absorbers to reduce noise, in particular near bedrooms.

3

Install the façade. Check recipe 1 to find out how.

4

Install the PV panels. They can be placed on the roof or the prefabricated façade. Choose the optimal orientation to maximise exposure to the sun. The power produced can be stored, sent to the electric grid, or delivered to the components integrated in the façade (like the ventilation machines or the shading systems). Connect the panels to your active technologies to power them.



TIPS

Making the air ducts go through the prefabricated façade modules instead of rooms and corridors leaves more space that can be used for other purposes. This increases the value of the building.

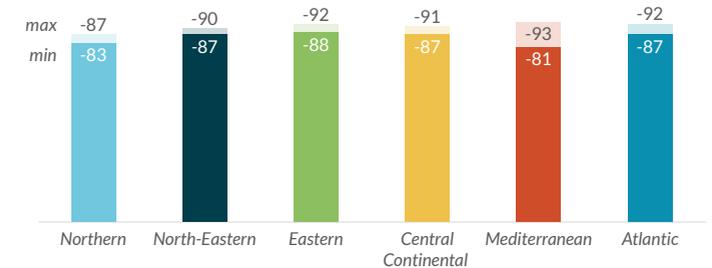
New PV technology comes in different colours and can adapt to curved shapes. As a result, all external surfaces of the building can be considered to generate renewable energy.

RECIPE 3 IN DIFFERENT CLIMATES



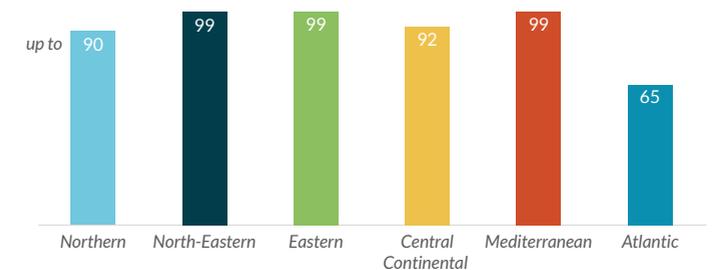
Energy Demand

% of energy used to heat and cool the building after the renovation



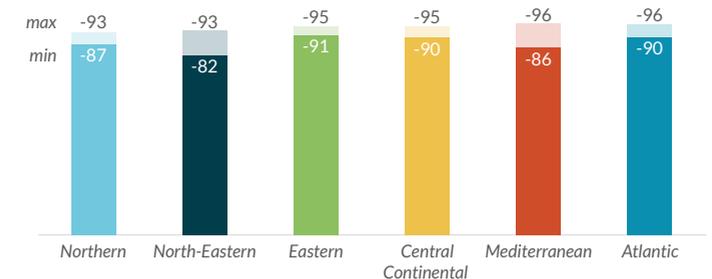
Comfort

% of hours spent in optimal thermal conditions



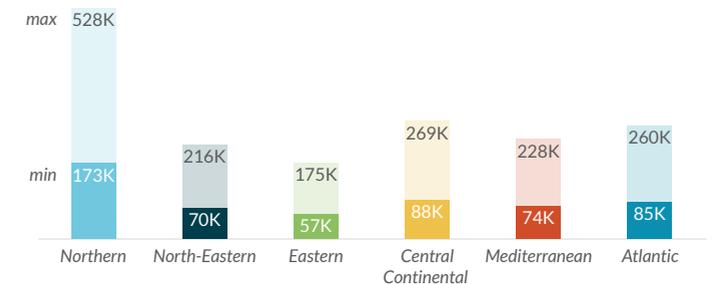
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs

Investment cost expressed in thousands of euros



RECIPE 4 PREFABRICATED FAÇADE WITH DECENTRALISED VENTILATION, PV PANELS AND A SMART CEILING FAN

 TIME ON CONSTRUCTION SITE: between 62 and 125 hours

 PERFORMANCE:

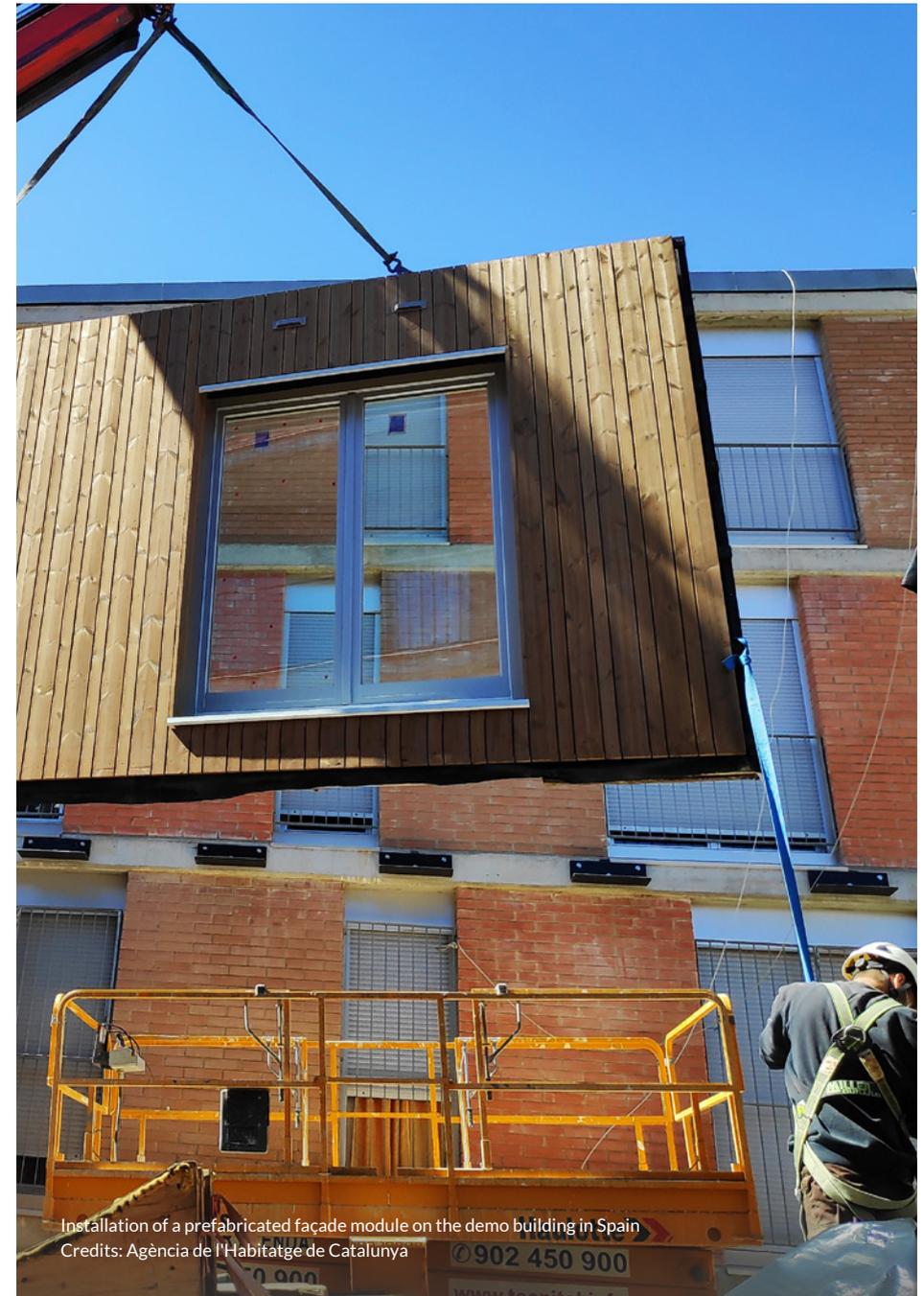


The 4RinEU smart ceiling fan has been developed to ensure a high level of comfort for tenants and reduce the cooling demand of the building when the outdoor temperature gets higher. The system consists of a **ceiling fan that automatically adjusts its speed**

according to the room temperature and humidity. This data is collected by sensors and sent to the remote-control unit. Information about the room's condition is then processed by the algorithm that controls the fan.



Hand-drawing illustration: Linda Toledo, Eurac Research



Installation of a prefabricated façade module on the demo building in Spain
 Credits: Agència de l'Habitatge de Catalunya

INGREDIENTS

- Prefabricated façade
- Decentralised ventilation machines
- PV panels
- Smart Ceiling Fan

PREPARATION

1

Prepare your prefabricated façade.

Read the previous recipes to know how to integrate decentralised ventilation machines (recipe 2) and PV panels (recipe 3) into the prefabricated façade modules (recipe 1).



2

Install the smart ceiling fan and sensors.

The fans should be placed where cooling is most needed. To meet users' needs, sensors should be positioned in key points of the room to measure temperature and relative humidity.

TIPS

Be sure the room's ceiling is high enough to install the smart ceiling fan.

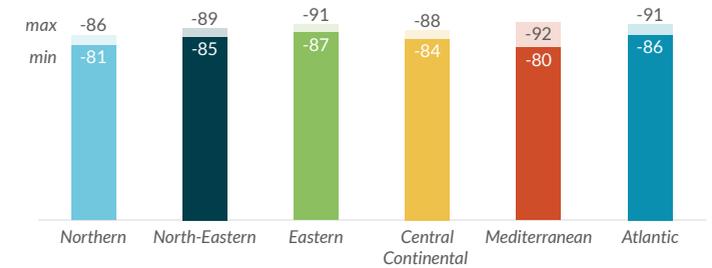
For safety reasons, the space between the room's floor and the fan blades should be at least 2.3 meters high.

RECIPE 4 IN DIFFERENT CLIMATES



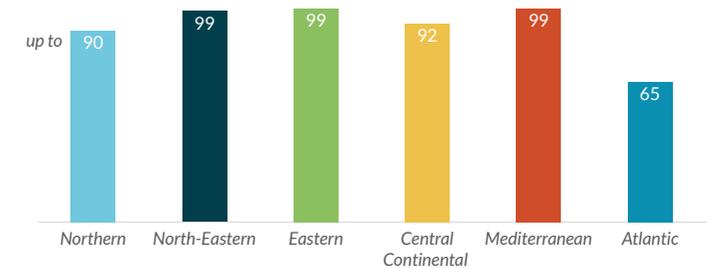
Energy Demand

% of energy used to heat and cool the building after the renovation



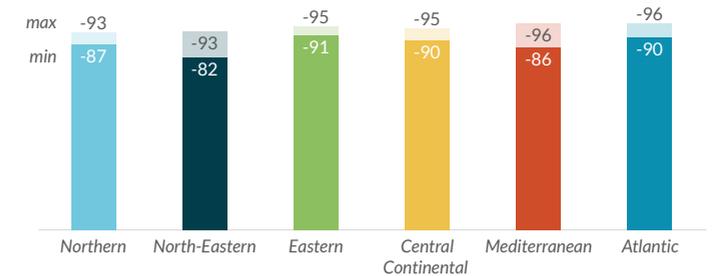
Comfort

% of hours spent in optimal thermal conditions



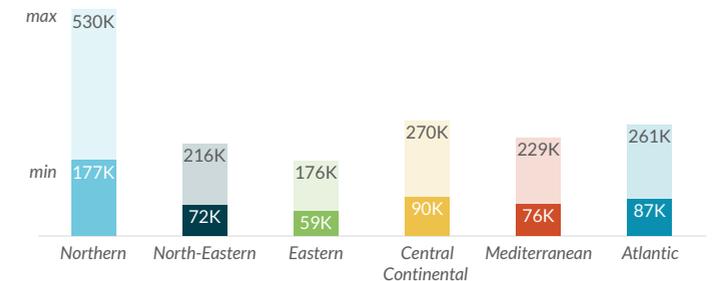
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs

Investment cost expressed in thousands of euros



RECIPE 5 PREFABRICATED FAÇADE WITH ENERGY HUBS AND BUILDING INTEGRATED SOLAR THERMAL (BIST) MODULES

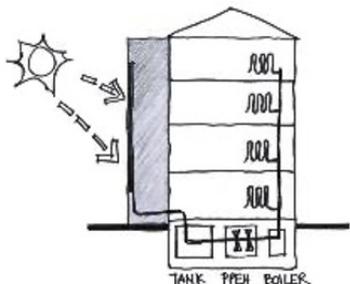
 TIME ON CONSTRUCTION SITE: between 55 and 118 hours

 PERFORMANCE:

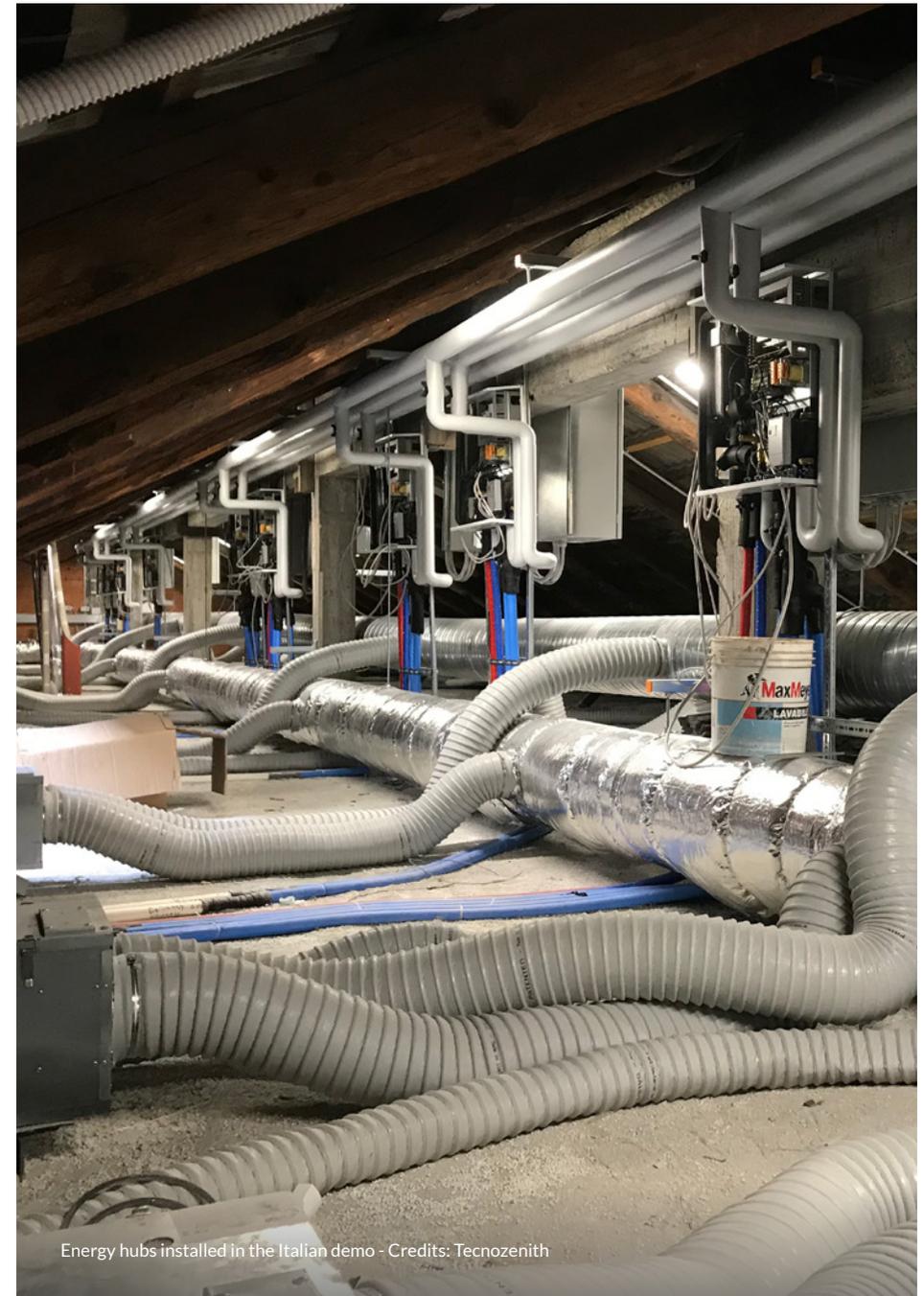


Solar-thermal (ST) modules allow to **produce hot water in a sustainable way**. The energy generated by exposure to the sun is used to power a heat pump that warms up the water

for both domestic use and heating. They can be coupled with an Energy Hub, a system that controls the heat fluxes in the building to **optimise heating and cooling**.



Hand-drawing illustration: Linda Toledo, Eurac Research



Energy hubs installed in the Italian demo - Credits: Tecnozenith

INGREDIENTS

- Prefabricated façade
- Solar-thermal modules
- Plug&Play Energy hub

PREPARATION

1

Design your solar-thermal system. Solar thermal modules can be placed on the roof or the façade. To achieve their fullest potential, they should be installed in a very sunny place.

2

Integrate the ST modules in the prefabricated façade. Go to recipe 1 and follow the procedure.

3

Install the Energy Hub. It can be installed in a special technical room, inside the apartments as a normal heating boiler, or integrated in the prefabricated façade.

4

Connect the hot water tank to the Energy Hub. That's it, you are done! The Energy Hub will match the demand for hot water with the supply, increasing the building's energy efficiency.



TIPS

To avoid thermal losses, keep the ventilation behind the ST modules at a very low level. This will improve the efficiency of the system.

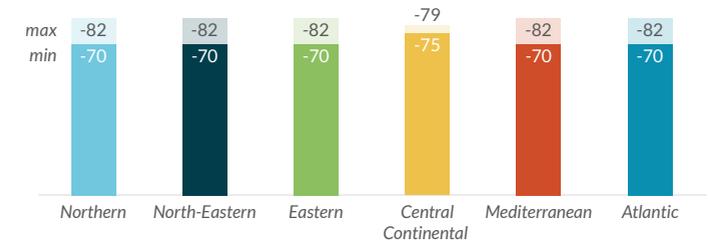
In case you decide to integrate the energy hub in the prefabricated façade, remember to put it in an accessible place to facilitate maintenance operations.

RECIPE 5 IN DIFFERENT CLIMATES



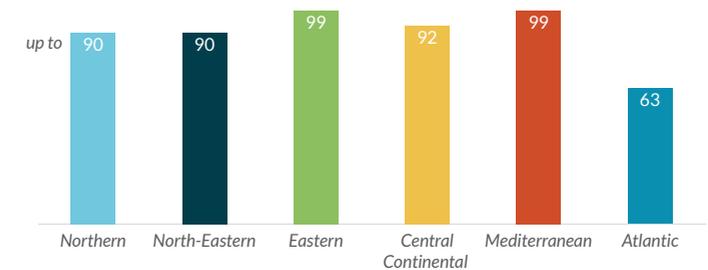
Energy Demand

% of energy used to heat and cool the building after the renovation



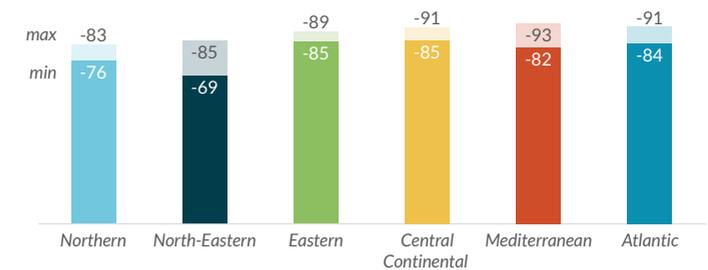
Comfort

% of hours spent in optimal thermal conditions



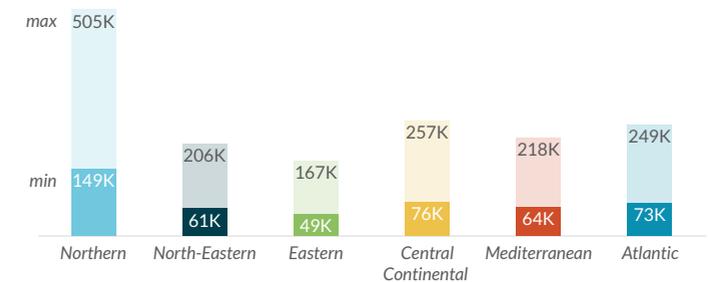
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs*

Investment cost expressed in thousands of euros



* Data on the cost savings generated by the energy hub were not available at the time this cookbook was written.

RECIPE 6 PREFABRICATED FAÇADE COUPLED WITH A SMART CEILING FAN

TIME ON CONSTRUCTION SITE: between 55 and 118 hours

PERFORMANCE:



This is a bonus recipe!

4RinEU technologies can be mixed together to create multiple combinations.

Use the knowledge you have gained from the previous recipes to install the prefabricated façade with integrated shadings (recipe 1) and place smart ceiling fans in the rooms (recipe 4).

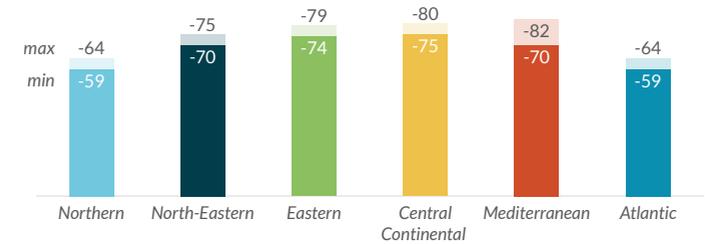
INGREDIENTS

- Prefabricated façade
- Integrated shading
- Smart Ceiling Fan

RECIPE 6 IN DIFFERENT CLIMATES

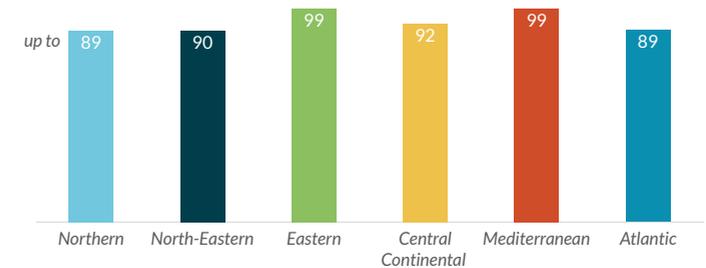
Energy Demand

% of energy used to heat and cool the building after the renovation



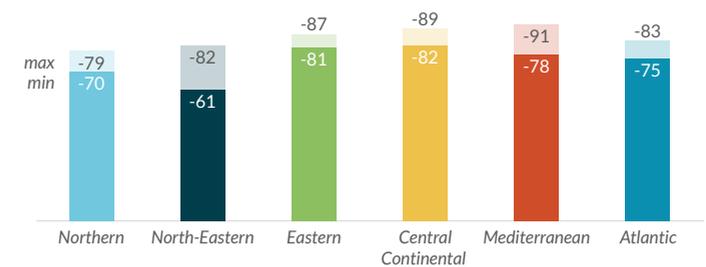
Comfort

% of hours spent in optimal thermal conditions



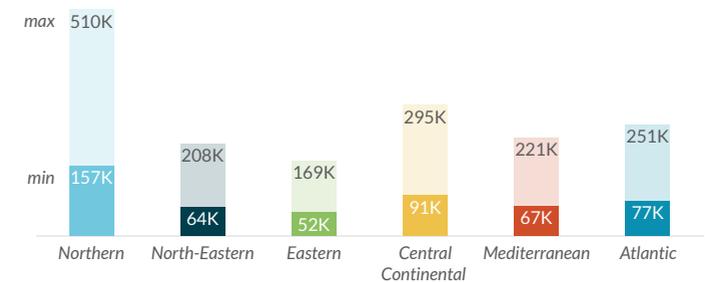
CO₂ Emissions

% of CO₂ emissions per year caused by heating and cooling



Costs

Investment cost expressed in thousands of euros





4RinEU demo case in Oslo (Norway) after renovation - Credits: Ivan Brodey, Boligbygg

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Coordinator / Italy



Norway



Italy



The Netherlands



Spain



Germany



Italy



UK



Spain



Italy



Spain



Italy



Norway



The Netherlands



EARLY ADOPTERS

Poland



Ireland



Latvia



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