



# BUILDINGS

# ACCELERATE RENOVATION OF BUILDINGS ACROSS EUROPE BY INCORPORATING MORE ENERGY-EFFICIENT COMPONENTS; ENSURE 100% OF NEW BUILDS ACHIEVE NET-ZERO EMISSIONS.

## Current situation and challenges

Residential properties account for 75% of all European buildings, providing homes for 221 million households, with the rest being a mix of wholesale and retail premises, offices, factories, schools, universities, hotels, sports facilities, hospitals and other public buildings.

More than 40% of all residential buildings were constructed before 1960, when energy efficiency and other regulations were very limited. As a result, the building sector is one of the most significant CO<sub>2</sub> emission sources in Europe, with 28 billion m<sup>2</sup> of floor space generating 1,100 MtCO<sub>2</sub>e (600 MtCO<sub>2</sub>e direct emissions, 500 MtCO<sub>2</sub>e for electricity), to be cut down to 200 MtCO<sub>2</sub> in 2050. Of this, 430 MtCO<sub>2</sub>e of direct emissions come from 20 billion m<sup>2</sup> of residential space.

A crucial factor for Europe's net zero emissions target is that 75% of today's building stock will still exist in 2050. As a result, the renovation of almost all existing buildings to achieve a near-zero emission status is a top priority. In addition, from 2020 all new buildings, both residential and non-residential, must be near-zero, both for immediate low emission performance and to avoid retrofitting of these buildings before 2050.

## Solutions

Fast and early progress must be made to achieve the following targets:

- **A minimum annual renovation rate of at least 3%** – about 360 million m<sup>2</sup> in the residential sector, or 4.4 million households per year<sup>1</sup>.
- **Cut buildings' emissions from 1,026 MtCO<sub>2</sub> today to 81 MtCO<sub>2</sub> in 2050** – through energy efficiency measures (insulation), on-site energy production facilities (PV and geothermic systems), electrification (heat pumps) including smart sensors and meters.
- **Achieve an average deep renovation cost per m<sup>2</sup> of €310 in residential buildings and €465 in public buildings.**

The projects proposed on the next page are concrete enablers to meet these targets, helping to:

- **Increase the renovation rate from around 1% today to 3%** – through large-scale residential renovation programs, one-stop-shops to empower citizens<sup>2</sup> and smart procurement for public buildings.
- **Maintain the renovation rate at 3%** – in dense and expensive urban areas.
- **Maintain the performance of retrofitting operations** – in medium performance buildings.

*"With heat pumps, we have a clean technology with enormous potential. Governments need to focus on the renewable heat industry like they did on renewable electricity, and offer recovery financing and funding packages as well as end-user information to accelerate adoption and build-up of market leadership."*

**Thomas Nowak**, General Secretary EUROPEAN HEAT PUMP ASSOCIATION (EHPA)

## Projects and scale-up

### 2021 onwards: Begin retrofitting the least efficient buildings, by

- Launching between 1,000 and 2,000 neighborhood projects<sup>3</sup> across Europe, each renovating between 20,000 m<sup>2</sup> and 50,000 m<sup>2</sup>.
- Promoting large scale renovation programs, utilizing the Energiesprong model, and one-stop-shop approaches to empower citizens.
- Targeting at least 50 passive hospitals and 100 passive schools by 2025, per country, leveraging off-site construction techniques.

### 2021 for action from 2030 onwards: Accelerate development of innovative renovation solutions, to

- Deliver next-generation renovation packages by 2030, for retrofitting in medium energy efficient buildings.
- Showcase smart energy independent buildings across Europe by 2030.

## Impacts

- **€245 billion total market (turnover + investments) per year in 2030.**
- **4.5 million permanent jobs in 2030.**
- **355 MtCO<sub>2</sub> avoided per year in 2030.**

## List of projects - BUILDINGS

### Deep renovation

#27 - DEEP RENOVATION OF RESIDENTIAL BUILDINGS  
Programs to increase the energy performance of renovations and increase the rate of renovations to cover 100% of the European building stock, starting now

#28 - DEVELOP NEXT-GENERATION EQUIPMENT TO INCREASE PERFORMANCE OF DEEP RENOVATION  
Next-generation easy-to-use and low-cost equipment such as vacuum insulation panels and windows, PCM, aerogels, PV windows and PV façades, smart sensors

#29 - DEEP RENOVATION OF PUBLIC BUILDINGS  
Public exemplarity through procurement programs to reach the required level of performance of the public building stock (administrative buildings, hospitals, educational buildings)

### Low-cost renovation and new build process

#30 - AUTOMATE, DIGITIZE AND STREAMLINE CONSTRUCTION PROCESS AND METHODS FOR RENOVATION AND NEW BUILD  
Overhaul construction sector's obsolete renovation models to reduce costs, lighten the disturbance of occupants and increase renovation rate

### Green and flexible energy in buildings

#31 - MASSIVE ELECTRIFICATION OF HEAT WITH LOW-COST HEAT PUMPS  
Multiply the number of installed heat pumps and bet on synergies with the electric vehicles industry to launch low-cost heat pump factories

#32 - DEVELOP NEXT-GENERATION BUILDINGS ALLOWING ULTRA-LOW CONSUMPTION AND FULLY FLEXIBLE ENERGY MANAGEMENT  
Highly autonomous buildings based on onsite storage facilities (hydrogen, thermal storage, geothermal, batteries), heating pumps and smart energy management

<sup>1</sup>For comparison purposes, the successful Energiesprong program performed in the Netherlands completed about 10,000 renovation projects in a country with about 7.8 million households, achieving more than 15,000 kWh of final energy savings per house.

<sup>2</sup>In addition to stronger policies and regulations towards buildings' energy efficiency and GHG emissions

<sup>3</sup>Comprehensive neighborhood renovation programs in Europe enable economies of scale (through design, procurement, transports and logistics), make the deep renovation easier (addressing networks, grids, eco-conception and urban planning) and facilitate ESCOs involvement.

# DEEP RENOVATION OF RESIDENTIAL BUILDINGS

Programs to increase the energy performance of renovations and increase the rate of renovations to cover 100% of the European building stock, starting now



## BUILDINGS

### Deep renovation

## IN A NUTSHELL...

- **Issue:** The current 0.2% deep renovation rate<sup>1</sup> remains too low (at least 3% is required and going to appropriate depth)<sup>2</sup>
- **Solution:** Massively replicate successful renovation programs and regional initiatives at scale, based on standard methodologies and industrialized components to reduce investment per m<sup>2</sup>
- **Key impacts:** 46.4 MtCO<sub>2</sub>e, €111 billion total market, 2.1 million jobs in 2030



Innovation bet



Acceleration and scale-up



Drive to market scale

## Project opportunity and ambition

Standardized methodological and technical renovation programs such as Energiesprong must be massively scaled to national level, in each EU country. Building energy performance is proven to be very low and can be almost net zero energy (nZEB, passive buildings and similar proofs).

Similarly, new renovation technologies can be deployed through the renovation process: scan-to-BIM, BIM, 3D printing, prefabricated components and off-site construction, as well as much more efficient heating and cooling equipment, including heat pumps<sup>3</sup> and solar water heaters.

The programs can also install PV systems (panels, solar roof tiles), a deployment of smart appliances and smart meters to enable optimization, flexibility and demand response schemes in all buildings.

Financing schemes can rely on promotional public money and future energy savings and involve ESCOs, banks, utilities, municipalities' tax schemes<sup>4</sup>, subsidies and dedicated blended funds managed by specialists using thousands of accredited experts such as KfW's home efficiency program in Germany.

### Project type 1: Neighborhood scale replication of industrialized renovation

Local authorities can mobilize relevant neighborhoods and create regulatory sandboxes to launch massive renovation calls for tenders to initiate neighborhood renovation

programs (20,000 m<sup>2</sup> to 50,000 m<sup>2</sup> each). Regional project coordinators can be identified and empowered, including PPPs<sup>5</sup>, to manage an ecosystem of suppliers, manufacturers, designers, architects, urban planners, BIM editors, engineers, public and finance bodies. Beyond economies of scale (through design, procurement, transport and logistics), neighborhood level interventions will enable local networks, grids, eco-conception and better urban planning. Energy savings are worth billions and will facilitate investments.

Launch 40 to 50 million m<sup>2</sup> of area retrofits through 1-2,000 projects across the EU in 2021.

### Project type 1: Building level comprehensive program replication

Replicate existing deep renovation models at relevant scale. Leverage one-stop-shop and platform approaches to accredit and pay experts which empower homeowners and guide them through the process.

Target: 0.3-0.4% in overall renovation rate based on this type of programme<sup>6</sup> in 2021 in all EU regions focusing on collective and individual housing (against 0.2% today).

*Inspirational projects and stakeholders: Energiesprong, Superhomes, HEART, ACE Retrofitting (Energy cities), Ile de France Energies, Save the homes, Fithome, Turnkey retrofit, KfW, BPIE.*

## Why this technology and project are needed to reach net-zero

Buildings account for around 40% of EU energy use of which about half is required for heating and cooling. Europe will not reach net-zero emissions unless buildings are much more efficient and carbon-neutral. Three quarters of Europe's buildings will still be standing in 2050 and so the energy-efficient renovation of these buildings needs to happen at scale and be prioritized.

The current residential building deep renovation rate is just 0.2%<sup>7</sup> in a market of 221 million residential households<sup>8</sup>. This is far too slow to reach 2030 and 2050 targets. Starting with the worst-performing buildings, home renovation needs to cover 6.6 million households a year. This ambitious objective requires large projects, now.

The buildings sector is fragmented and organized for new construction and therefore must reorganize for renovation rates and approaches to reach net-zero targets: coordinated renovation programs using digital tools and aggregating actors from the industry to help standardize and industrialize the renovation process. This would lead to faster and more efficient processes as well as lower cost operations. High upfront renovation costs are also an obstacle that can be removed by smart finance facilities linked to high-quality industrialization and economies of scale. Renovated homes also command higher market values (comfort, extension, layout, etc.) that are also benefits for the projects.



## Impacts

	2030	2050
CLIMATE IMPACT	46.4 MtCO <sub>2</sub> e avoided	139.3 MtCO <sub>2</sub> e avoided
ECONOMIC IMPACT	€111 billion total market €111 billion turnover	€111 billion total market €111 billion turnover
JOB	2,109,000 total jobs	2,109,000 jobs

#27 <sup>1</sup>[https://ec.europa.eu/energy/sites/ener/files/documents/1.final\\_report.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf)

<sup>2</sup>Taking the 3% EU target for public building renovation ([https://ec.europa.eu/energy/content/setting-3-target-public-building-renovation\\_en](https://ec.europa.eu/energy/content/setting-3-target-public-building-renovation_en))

<sup>3</sup>Geothermal HP in Northern/Central Europe or aérothermal in Southern countries

<sup>4</sup>See FITHOME project's financing scheme

<sup>5</sup>Private public partnerships

<sup>6</sup>In the Netherlands, Energiesprong has achieved ~10,000 renovations in several years in a 7.8 million households country (0.13%). An EU rate of, 0.3% to 0.4% represents some 800,000 households.

<sup>7</sup>[https://ec.europa.eu/energy/sites/ener/files/documents/1.final\\_report.pdf](https://ec.europa.eu/energy/sites/ener/files/documents/1.final_report.pdf)

<sup>8</sup><https://www.statista.com/statistics/868008/number-of-private-households-in-the-eu/#:~:text=Europe%3A%20number%20of%20private%20households%202017&text=This%20statistic%20shows%20the%20number,amounted%20to%20approximately%20221.3%20million.>

# DEVELOP NEXT-GENERATION EQUIPMENT TO INCREASE PERFORMANCE OF DEEP RENOVATION

Next-generation, easy-to-use and low-cost equipment such as vacuum insulation panels and windows, PCM, aerogels, PV windows and PV facades and smart sensors



## BUILDINGS

### Deep renovation

## IN A NUTSHELL...

- **Issue:** Up-front investments for promising new technologies in insulation and building renovation are too high
- **Solution:** Boost the development of early TRL technologies improving insulation and renovation performance with new standardised materials and high-performing electric equipment at lower costs
- **Key impacts:** 1.4 MtCO<sub>2</sub>e avoided, €1.1 billion total market, 21,000 jobs in 2030



Innovation bet



Acceleration and scale-up



Drive to market scale

## Project opportunity and ambition

- Launch the next-generation renovation packages, in a similar way as project Surefit<sup>9</sup>, with additional targets.
- Technologies to include in the packages: bio-aerogel panels integrated with PCM, PV vacuum glazing windows, roof and window heat recovery devices, solar-assisted heat pumps, ground source heat pumps, evaporative coolers, integrated solar thermal/PV systems and lighting devices. These are prefabricated for rapid retrofit with minimal disruption to occupants, ensuring high levels of occupant comfort/indoor environmental quality as well as low risk of moisture-related problems and summer overheating.
- Replicate the initiative in five European clusters with specific local focus (especially regarding heating and cooling issues) and extend the package with:
  - » Additional smart tools integrated to the equipment (sensors, meters, adaptative windows etc.).
  - » The identification and incorporation of eco-materials<sup>10</sup> to be used for insulation purposes and integrated into the package.
- Develop specific packages tailored to specific building profiles (who uses the buildings, the climate of the area they're located in, equipment availability and type of building), to cover 15 to 20 different building configurations for several climate zones.
- Include and coordinate key stakeholders: research institutes (such as Fraunhofer Institute), chemicals and refrigerant suppliers, glass, concrete and steel manufacturers, PV developers and installers, heat pump producers, eco-material suppliers, BIM editors and off-site constructors.
- Ensure coordination and communication between clusters and actors in order to avoid duplication, leveraging best practices and tackling transversal technical barriers.
- Target 15 to 20 renovated buildings using leading-edge technologies, to be easily replicated by 2025.

*Projects that inspired this analysis: Surefit (coordinated by the Portuguese Instituto de Soldadura e Qualidade), INNOVIP, Prefab LT Cluster, Fraunhofer Institute.*



## Why this technology and project are needed to reach net-zero

Europe's renovation rate needs to be above 3% to deliver a net-zero emission housing stock by 2050. The kgCO<sub>2</sub>e/m<sup>2</sup> savings are harder to deliver in many homes without better-performing materials and techniques at a lower cost. Promising technologies such as PCM and heat recovery devices need to scale up dramatically to optimize energy consumption, heating and cooling management, saving additional kgCO<sub>2</sub>e/m<sup>2</sup>.

In dense urban areas thin insulation materials are required for space conservation (maintaining asset value), otherwise renovation operations will not be undertaken by these property owners. Cities also need to deploy PV systems to harvest enough solar energy (while allowing them to keep roof space for green roofs). To achieve this, PV systems integrated to the windows or walls must be included in the next-generation renovation packages.



## Impacts

	2030	2050
CLIMATE IMPACT	1.4 MtCO <sub>2</sub> e avoided	61.9 MtCO <sub>2</sub> e avoided
ECONOMIC IMPACT	€1.1 billion total market €1.1 billion turnover	€11.1 billion total market €11.1 billion turnover
JOBS	21,000 jobs	211,000 jobs

#28 <sup>9</sup><https://cordis.europa.eu/project/id/894511>

<sup>10</sup>Ecomaterials such as straw and hems are inherently 100% recyclable

# DEEP RENOVATION OF PUBLIC BUILDINGS

Public exemplarity through procurement programs to reach the required level of performance of the public building stock (administrative buildings, hospitals, educational buildings)



## BUILDINGS

### Deep renovation

## IN A NUTSHELL...

- **Issue:** Many public buildings were built before the implementation of energy efficiency regulations and do not meet current standards
- **Solution:** Involve public players to activate large economies of scale through group public procurements and collective campaigns
- **Key impacts:** 44.8 MtCO<sub>2</sub>e, €34.8 billion total market, 660,000 jobs in 2030



Innovation bet



Acceleration  
and scale-up



Drive to market  
scale

## Project opportunity and ambition

### Project type 1: Deliver low-emissions net-zero 2050 hospitals across EU

Deliver passive energy hospitals (nZEB or similar ambitious low-GHG targets) by 2030, all integrated with smart meters and responsive equipment.

Lever shared procurement platforms campaigns and make use of prefabricated components.

In each country:

- Define country specific procurement guidelines.
- Start with 10 hospitals in 2021, building on the past Klinikum Frankfurt Höchst experience.
- Capitalize on the lessons learned from the first ones to launch the 40 additional renovations until 2030.

NB: Some specific adjustments and/or exceptions in the current national public market rules can be considered in some countries to encourage tight collaboration among suppliers (open BIM solutions or digital twins are key for such matters).

### Project type 2: Lever modular construction to build 100 passive/near-zero schools in every EU country

- Deliver 100 passive energy schools per country using a comprehensive modular approach, starting in 2021 with the most energy-inefficient schools. Integrate smart meters and responsive equipment.

- Define country-specific procurement guidelines.
- Follow the inspiring British school cases implemented with McAvoy.
- Leverage shared procurement platforms and campaigns.

*Projects that inspired this analysis: EU PUBREP coordinated by South Pole, RenoWatt (Belgium), PEDIA school retrofitting program (Cyprus), UK's schools modular program in around 15 weeks (McAvoy and others.), Powerskin+ (Portugal, Czech Republic, Slovenia), Frankfurt Höchst Klinikum (Germany) - passive hospital, The Green Lighthouse (Denmark) (first public carbon neutral building, built in less than a year in a close public-private partnership). Older inspiring initiatives include RES hospitals (2011-2013) and the DEEP project (2006-2007).*



## Why this technology and project are needed to reach net-zero

Public buildings represent significant volumes of total buildings at national and European scale. They have large energy demand and can be upgraded through industrialized approaches, through common procurement campaigns. EU27 tertiary buildings emit 250 MtCO<sub>2</sub>e per year, with 75 MtCO<sub>2</sub>e coming from public buildings.

Many public buildings were built before the implementation of energy efficiency regulations and so there are great savings available by adapting them, and many also require modernization to increase comfort. Specifically, schools and hospitals are known to be very energy-inefficient making them unnecessarily significant energy consumers (with 3-4 times the consumption of residential buildings per square meter) and they have long utilization periods, thus making a strong economic case for energy efficiency modernization.

Furthermore, governments need to show leadership in energy efficiency. Given strong regulatory and negotiation power, public authorities can shift the construction industry, requiring specific performance, materials and technologies (supporting technologies such as BIM tools and 3D printing, prefabricated and off-site construction, ground-source heat pumps, air-source heat pumps (in South Europe), and green cool roofs (to avoid heat island effect and include eco-materials).



## Impacts

	2030	2050
CLIMATE IMPACT	44.8 MtCO <sub>2</sub> e avoided	134.5 MtCO <sub>2</sub> e avoided
ECONOMIC IMPACT	€34.8 billion total market €34.8 billion turnover	€52.1 billion total market €52.1 billion turnover
JOBS	660,000 jobs	991,000 jobs

# AUTOMATE, DIGITIZE AND STREAMLINE CONSTRUCTION PROCESS AND METHODS FOR RENOVATION AND NEW BUILD

Overhaul construction sector's obsolete renovation models to reduce costs, lighten the disturbance of occupants and increase renovation rate



## BUILDINGS

### Low-cost renovation and new build process

## IN A NUTSHELL...

- **Issue:** Efficient construction, renovation tools and processes are being developed but the adoption rate is too slow
- **Solution:** Demonstrate the benefits of various technologies using five clusters and coordinate clusters to spread skills in a collaborative way
- **Key impacts:** 67.4 MtCO<sub>2</sub>e avoided, see #15 and #28 for total market and jobs in 2030



Innovation bet



Acceleration and scale-up



Drive to market scale

## Project opportunity and ambition

This program will involve five clusters across Europe, working on close to 200 buildings before 2023.

The portfolio of projects will include:

- Renovation projects (around 150) and new buildings (around 50).
- Residential (collective and individual) and non-residential (malls, offices, universities, and others) buildings.
- Replicable types of buildings (social housing, schools, standardized buildings, swimming-pools and gymnasiums, and others).

The objective is to accelerate construction process automation and improve the reliability and the efficiency of digital tools which are useful for renovation and construction processes.

Digital tools will have strong potential to improve building sustainability and lower the environmental impacts:

- Scan to BIM using Lidar or drones, etc.
- BIM 6D features to integrate lifecycle information.
- Integration of BIM data with building sensors to improve energy and indoor environmental performance.
- EnerBIM/BIMsolar solutions which integrate solar panels sizing with ROI information.
- Open BIM approaches to ease software interoperability, as promoted by BuildingSMART at the global level.

- Digital twin technology for at least five projects, inspired by SPHERE project which gathers 20 partners from 10 EU countries (target -25% GHG emissions, -25% construction time).
- Digital building pass gathering all key information on the building lifecycle (like CN BIM).

Construction techniques will favor ready-to-use and fit-for-purpose components:

- Prefabricated/off-site or even modular components.
- 3D printing/additive manufacturing, like Batiprint3D™ technique used on Yhnova project.

The project will follow a regulatory sandbox approach to test collaborative ways of working between stakeholders (as underway in the UK and the Netherlands) instead of a segmented approach with diluted responsibility and lack of coordination, often linked to inadequate regulatory rules and enforcement (e.g. France).

*Projects that inspired this analysis:*

- *BIM-SPEED: Harmonized Building Information Speedway for energy-efficient renovation, 13 demonstration cases, 22 partners*
- *BIM4EEB: BIM-based fast toolkit for Efficient renovation of residential buildings, six BIM tools, demo cases in Italy, Finland and Poland*
- *BIMERR: BIM-based holistic tools for energy-driven renovation of existing residences*

## Why this technology and project are needed to reach net-zero

The construction industry has not evolved to use automated processes in recent decades, while other industries such as the automotive industry have:

- Transport and logistics to and from the site are not optimized, leading to high indirect GHG emissions.
- Productivity has not increased for years and may be decreasing in some countries due to a lack of skills, more complex buildings (due to regulations and technologies) the retaining of old processes and tools.
- The sector produces a lot of waste (construction and demolition waste are the largest waste streams in the EU: 374 Mt in 2016, 36% of EU waste<sup>11</sup>).

Additionally, renovation projects are labor-intensive and long lasting.

To tackle these issues, the construction industry needs a deep transformation of its methods, tools, processes and ways of working:

- The automation of the construction process will enable anticipation, optimization, scale-up and fast on-site deployment.

- Off-site construction reduces work duration, footprint and cost while improving quality and safety.
- Building Information Modelling (BIM), and especially Open BIM, is a powerful tool for collaboration, anticipation, information sharing and follow-up on construction phases. Its penetration on European construction sites is a key challenge.
- All actors need upskilling to gain knowledge about the current possibilities offered by modern technologies to apply them in practice. This can be reached by mobilizing competitive clusters for training, encouraging interactions between companies and local consortia, easing access to training for SMEs (95% of the European construction market).

## Impacts

	2030	2050
CLIMATE IMPACT	<b>67.4 MtCO<sub>2</sub>e avoided</b>	<b>121.3 MtCO<sub>2</sub>e avoided</b>
ECONOMIC IMPACT	<i>See #15 and #28 (no double counting)</i>	<i>See #15 and #28 (no double counting)</i>
JOBS	<i>See #15 and #28 (no double counting)</i>	<i>See #15 and #28 (no double counting)</i>

#30 <sup>11</sup><https://www.eea.europa.eu/themes/waste/waste-management/construction-and-demolition-waste-challenges>

# MASSIVE ELECTRIFICATION OF HEAT WITH LOW-COST HEAT PUMPS

Multiply the number of installed heat pumps and bet on synergies with the electric vehicles industry to launch low-cost heat pump factories



## BUILDINGS

Green and flexible energy in buildings

### IN A NUTSHELL...

- **Issue:** Heat pumps have higher upfront investment requirements than gas boilers
- **Solution:** Industrialize heat pump manufacturing to decrease investment requirements
- **Key impacts:** 192.9 MtCO<sub>2</sub>e avoided, €28.6 billion total market, 429,000 jobs in 2030



Innovation bet



Acceleration and scale-up



Drive to market scale

## Project opportunity and ambition

### On the supply side:

The project aims to provide EU27 countries with enough heat pump equipment for the renovation wave and for new buildings by 2050. Megafactories will increase productivity and lower investment requirements. As a result, heat pumps will be more competitive and accessible.

- Build 36 heat pump megafactories by 2030 (each with ~150,000 units per year capacity), for example in Northern Italy and Poland<sup>12</sup>. Existing manufacturers and car manufacturers shifting some production lines to heating pumps (very accessible for the assembly phase) can compete for these.
- These megafactories will manufacture the components as well as assemble the heat pumps.
- They will include smart devices and modular production lines, following the Japanese Daikin factory Texas Technology Park which achieved a productivity increase of close to 50%.
- The new megafactories will specialize to cover the specific need for heat pumps in Europe (geothermal and water in Western, Central and Nordic Europe, aerothermal in Southern Europe) and several heat pumps sizes (residential, electric cars and industrial).

### On the demand side:

- Support heat pump markets through funding schemes, subsidies or tax reductions.
- Objective: from about 1.3 million heat pumps sold in 2018 to about 5.5 million units in 2030.

## Why this technology and project are needed to reach net-zero

Electrification of heating and cooling equipment is necessary to reach near zero emissions for buildings. A way to do this is by powering infrastructure with renewables (geothermal or PVs). According to the IEA, heat pumps can save 50% of the buildings sector's CO<sub>2</sub> emissions and 5% from the industrial sector's.

Heating pumps are key components within the net-zero solution set. However, up-front investment requirements are still relatively high compared to oil or gas equipment. Over time, prices will decrease with the industrialization of production accompanied by a massive demand boost.

The goal is to manufacture of 55 million heat pump units by 2030 for three sectors: residential, commercial buildings and industry.

This missing supply gap will require 36 megafactories (each producing 150,000 units per year) by 2030, and at least five of these must be built by 2025. In order to seize the opportunity, the automotive industry can shift part of its production lines (plants) to produce heat pumps in just a few months.

Over the medium term, small heat pumps will be required for heating and cooling in electric cars, and so there is a synergy. Non-residential buildings can provide a demand of about

40% of the residential requirement but size varies (less units are required with a larger capacity; this makes them more efficient in terms of investment/m<sup>2</sup>). For non-residential, an additional manufacturing capacity of  $40\% \times 6.1 \times \frac{1}{2} = 1.2$  million units equivalent is required (an extra demand equal to the current European heat pump market size).

## Impacts

	2030	2050
CLIMATE IMPACT	<b>192.9 MtCO<sub>2</sub>e avoided</b>	<b>481.4 MtCO<sub>2</sub>e avoided</b>
ECONOMIC IMPACT	<b>€28.6 billion total market</b> €12.8 billion investment by 2030, €1.3 billion yearly average (2020-2030) €27.3 billion turnover	<b>€27.4 billion total market</b> €39.3 billion investment by 2050, €0.9 billion yearly average (2020-2050) €39.3 billion turnover
JOBS	<b>429,000 jobs</b> 19,000 construction jobs for investment 410,000 production jobs for turnover	<b>604,000 jobs</b> 14,000 construction jobs for investment 590,000 production jobs for turnover

#31 <sup>12</sup>For industrial, strategic, economic and geographic reasons (skills, capacities, logistics and needs); further detailed location studies may suggest additional regions.

# DEVELOP NEXT-GENERATION BUILDINGS ALLOWING ULTRA-LOW CONSUMPTION AND FULLY FLEXIBLE ENERGY MANAGEMENT

Highly autonomous buildings based on onsite storage facilities (hydrogen, thermal storage, geothermal, batteries), heating pumps and smart energy management



## BUILDINGS

Green and flexible energy in buildings

### IN A NUTSHELL...

- **Issue:** Today's state-of-the-art buildings are passively optimised. Next challenge is to manage volatile consumption and production flows, increase positive decarbonized energy balance and optimize need for grid connection investment
- **Solution:** Energy-independent and flexible buildings based on smart energy management systems, on site RES, heat pumps, storage facilities (hydrogen, thermal storage, geothermal storage, batteries)
- **Key impacts:** 2 MtCO<sub>2</sub>e, €69.1 billion total market, 1,314,000 jobs in 2030



Innovation bet



Acceleration and scale-up



Drive to market scale

## Project opportunity and ambition

The target is to launch 10 regional clusters of expertise across Europe and create a total of 500 energy-independent buildings by 2025, before the prototypes can be replicated at a European scale. The main objectives are next-generation flexibility, thermal and power load management, energy performance and total cost ownership reduction, covering all buildings specifics across European regions.

Such high-performance buildings are created through integrated solutions combining PV systems, batteries, hydrogen storage, thermal storage, geothermal power, and heating pumps, with smart management systems and/or responsive energy systems.

- Identify 10 regional clusters across Europe, each gathering research, construction and renovation companies, energy cleantech providers, digital firms, social scientists and industry.
- Build a total of 1,000 new buildings or 8,000 lodgings for the 10 clusters (100 buildings and 800 lodgings per cluster), with a representative mix of collective or individual housing in urban and suburban zones.
- To ensure each building remains low-carbon, new technologies will be utilized, including: photovoltaic (PV) solar facades/windows, high-performance batteries, hydrogen/combined heat and power/hydrogen fuel cells,

and less mature thermal storage technologies (phase change material (PCM), thermochemical energy storage).

- Building regulations will have to be adjusted accordingly.
- Establish key learnings from the expertise clusters in order to replicate at a lower cost this solution on a larger scale across the EU.

*Projects that inspired this analysis: Heat4Cool, PowerSkin+, REFLEX, Sylfen's Smart energy hub, Celsius, CombioTES, HybridGeoTABS, the Create project, Smartflex.*



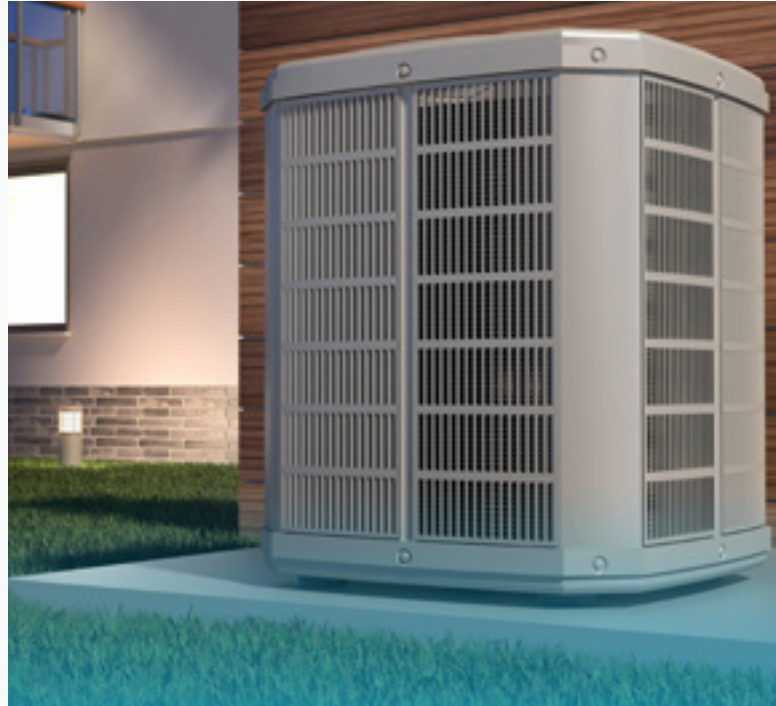
## Why this technology and project are needed to reach net-zero

Thermal end-uses (space heating, hot tap water, and cooling) represent a major part of energy consumption in Europe, and buildings emit over a third of European GHG emissions.

Several new low-carbon energy technologies are ready and must be digitally integrated to create flexible, low-emission buildings able to produce and store increased shares of own energy using thermal and electric renewables, as well as optimize their energy use and the need for grid capacity. The intermittency of renewable energies such as solar makes it necessary to link them with storage systems, such as batteries, hydrogen storage, or thermal storage through geothermal energy.

Recent pilot projects, such as the French startup Sylfen associating digital and reversible electrolyzer/fuel cell stack demonstrate that 70% energy autonomy can be achieved in urban buildings, requiring less grid and being more flexible towards both on-site and external intermittent grid supply.

The optimization of energy use needs to be considered at a building, at neighborhood level (smart districts), in relation with both local resources and national and European gas and power systems. It relies on the integration of smart energy management systems, which optimize auto-consumption and storage, and predict consumption patterns based on weather data and historical consumption behavior.



## Impacts

	2030	2050
CLIMATE IMPACT	<b>2 MtCO<sub>2</sub>e avoided</b>	<b>5.9 MtCO<sub>2</sub>e avoided</b>
ECONOMIC IMPACT	<b>€69.1 billion total market</b> €69.1 billion turnover	<b>€207.4 billion total market</b> €207.4 billion turnover
JOBS	<b>1,314,000 jobs in 2030</b> 1,314,000 production jobs for turnover	<b>3,941,000 jobs in 2050</b> 3,941,000 production jobs for turnover

