# Heat Pumps in Heritage Buildings

*A Seven Step Guide for Architects*

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Futur*Hist*

## ABOUT THIS LEAFLET

The information in this leaflet is part of the research project *FuturHist – An integrated typology-based approach to guide the future development of European historic buildings towards a clean energy transition*.

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# Welcome!

Retrofitting our cultural heritage buildings isn't just about preserving the past – it's about preparing for the future.

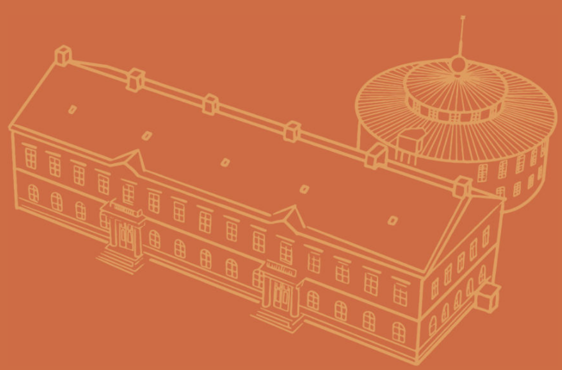
The FuturHist international research project explores new ways to increase the energy efficiency of heritage buildings, retrofitting existing buildings in a way that respects their historic values.

As a part of that work, we have produced this leaflet which describes a seven step process for working with heat pumps in historic buildings. They cover several aspects that are essential when dealing with historic buildings.

After following these steps, an architect should have a clearer idea about whether a heat pump system is a feasible and proper solution for the building considered and what are the main next steps to follow, in alignment with the project's stated goals.

There is no blanket solution that fits every building, but the steps in this guideline will be the same for a 20th century terrace and a 17th century manor.

Sincerely,
The FuturHist team



# 1 Define what you want

**Every properly planned project starts with a well-defined set of goals. In the case of historic buildings, these goals are not only the clients', but also, in some cases, those of the heritage officer and other stakeholders such as end users, heritage NGOs, neighbours.**

Keeping these in perspective when following this set of guidelines can lead to a beneficial outcome.
What does your client want to achieve?

There might be several objectives, and they will vary between projects. Important to consider here is how different alternatives should be assessed later. Think about the criteria that could be used to measure and compare your options and alternatives and how much each criterion matters in the project. Consider weighting these criteria and using a decision support method.

The list of objectives may vary depending on the project, but it is important to be explicit about the project objectives and that these are communicated to everyone involved in the planning process.

**These objectives could be:**

- Being environmentally friendly – Consider metrics like greenhouse gas emissions.
- Saving money – Consider the total cost across the system's life cycle.
- Improve the indoor climate – Monitor temperature and humidity, ask users if they're satisfied with the current state.
- Preserving character – Consider presenting alternatives to stakeholders so they can rate this.
- Reversibility – your heritage officer or specialist may guide you in whether and where this is important.

### Outcome

By the end of this step, the project goals and their priorities should be clearly defined.

*Heat pump installations can impact the character of a building, but there are strategies to minimise the impact.*

# 2 Check what you have

Assess the building's characteristics, including the technical condition of the building and its heating system. A survey of the building and its existing heating and ventilation systems is needed to determine its suitability for a heat pump system. As a minimum, the assessment should cover:

### I Quantitative aspects

**Insulation levels:** Assess insulation and identify areas of heat loss, such as windows, walls and roof spaces.
**Thermal mass:** Consider how solid materials such as brick and stone store and release heat, as this affects heat pump selection and sizing.
**Airtightness:** Identify gaps and drafts that may reduce efficiency.
Thermal needs: Define demand for space heating, cooling and domestic hot water.
**Fabric improvements:** Review whether upgrades could reduce thermal loads, plant size, running costs and carbon impact.
**Energy Performance Certificate:** Check whether an EPC has been issued for the building.

### II Qualitative aspects

**Building use:** Consider how occupancy and patterns of use affect thermal performance, including intermittent use.
**Thermal requirements:** Identify whether different parts of the building have different thermal needs.
**Space for equipment:** Check whether there is space for heat pump components, such as a balcony or plant room.
**Thermal envelope:** Assess the condition of the envelope and whether repairs are needed.

### III Existing HVAC system

**Heat source(s):** Identify the type, status, configuration and, if possible, nominal thermal power of the existing heat source.
**Heat distribution system:** Check whether a distribution system is present, whether it is insulated, where it is located, and which fluid it uses.
**Heat emitters:** Identify the emitter type and whether it can be used for both heating and cooling.
**Mechanical ventilation:** Check whether a system is present, its status, configuration and whether it includes heat recovery.
**Energy performance and indoor climate:** Assess current energy use for heating and cooling, compare space use with required indoor climate conditions, and identify unjustified energy use.

### IV Heritage significance

For listed buildings, identify heritage significance and protected elements with the relevant conservation authorities. For non-listed historic buildings, assess significance and identify elements worth preserving using the heritage assessment methods commonly applied in your country.

### V Budget constraints

Define the budget limit for the project. Keep this in mind when assessing options.

### Outcome

A comprehensive understanding of the technical status of the building and its heating, cooling, and ventilation systems. An initial understanding of the heritage significance of the building and what building elements are in need of preservation. A baseline assessment of energy performance and indoor climate. Preliminary budget.

# 3 Understand your constraints and potentials

Identify limits and circumstances that either positively or negatively affect heat pump system selection.

### I Constraints

Are there constraints that limit what you can do and where you can do it? These can generally be divided into legal, technical, economic, and heritage-related constraints.

**Legal constraints:** Identify key legal constraints the local building code places on interventions inside and outside the building, such as minimum distances, nuisances, etc.

**Technical constraints:** Identify key structural and technical obstacles like poor load-bearing capacity or the need for additional repairs or reinforcement that could strain the budget, which is an economic constraint.

**Heritage-related constraints:** Elements under protection or that are of value must be defined, and any interventions designed to take these into account.

### II Potentials

Potentials are features or circumstances that either enable you to do something, expand your range of options, or enhance certain options, making them perform better.

Some features of the building or the site can inform the available set of heat pump systems as options. The presence of water bodies, watercourses, or groundwater can make water-source heat pump systems feasible, while an overall large site can make a ground heat exchanger viable.

Certain heritage features or the building's overall form may facilitate the hiding of external and internal system elements from view so as not to unduly disturb the building's character.

### III Evaluate interventions

Evaluate a series of interventions that would be beneficial for heat pump system operation:

Always start considering energy efficiency first. Before designing the heat pump system evaluate the possibility of reducing the building's thermal needs by improving thermal envelope efficiency.

If the existing emitter system uses water at high temperatures (radiators), assess the feasibility of replacing the radiators with a radiant system (floor/ceiling/wall) that operates at lower water temperatures.

The new heat pump system should be designed to cover the updated building's thermal demand after the thermal envelope improvements and, preferably, using a radiant system operating at low water temperatures as heat pumps operate most efficiently with such systems.

### Outcome

It should become clear what the legal, technical, and heritage-related constraints of the project are. Interventions that can improve the building's performance without violating the constraints should emerge.

*Air source heat pump can have an outdoor unit that can be difficult to accommodate for aesthetic reasons. However, there are new products that try to mitigate the visual impact.* ▶

# 4 Identify your options

There are different heat pump system types available. **Ground- and water-source systems** are more efficient but generally more costly and need specific works. For these kinds of systems, the contribution of a specialist is needed starting from the beginning of the planning phase.

In contrast, **air–water and air–air heat pump systems** are simpler to assess and can often be initially evaluated by architects during the conceptual design phase. These systems are simpler and are seen as lower-cost variants.

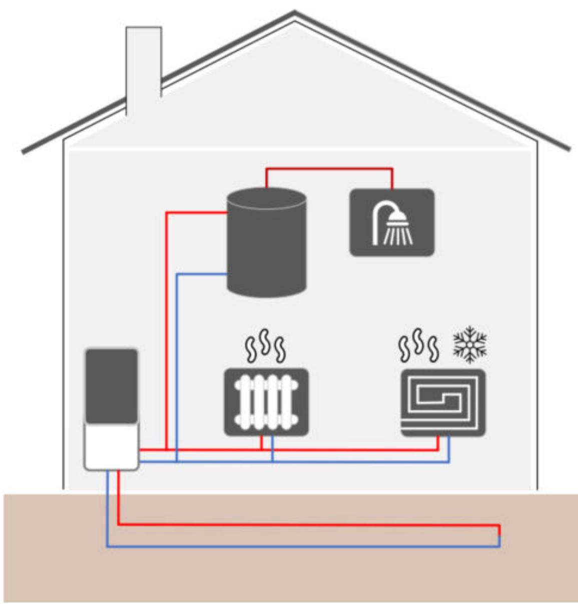
**Check heat pump options that meet your building's heating demand and assess:**

▶ Visual impact – and how it can be reduced
▶ Noise generated by the system
▶ Reversibility / impact on the building fabric – including effects on heritage values and occupants
▶ Shared solutions – whether a centralised unit in a less sensitive location could serve several buildings and reduce the need for multiple façade-mounted units

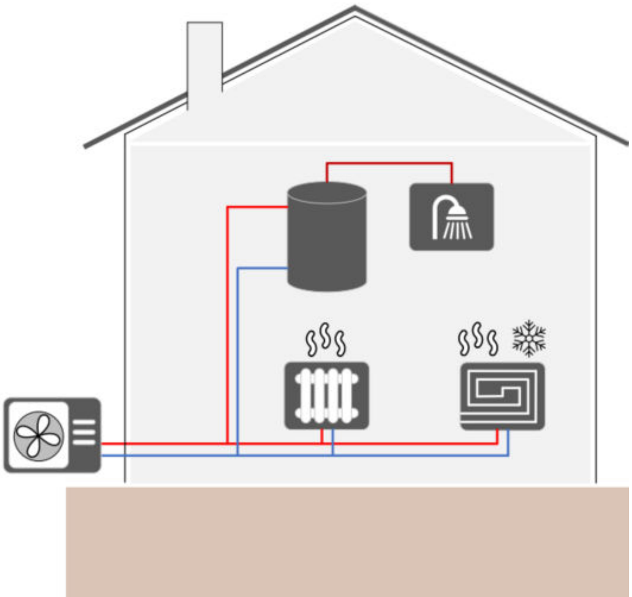
Also consider requirements for training, installation expertise, inspections, maintenance, and remote monitoring. A clear maintenance plan is essential to support reliable operation over time.

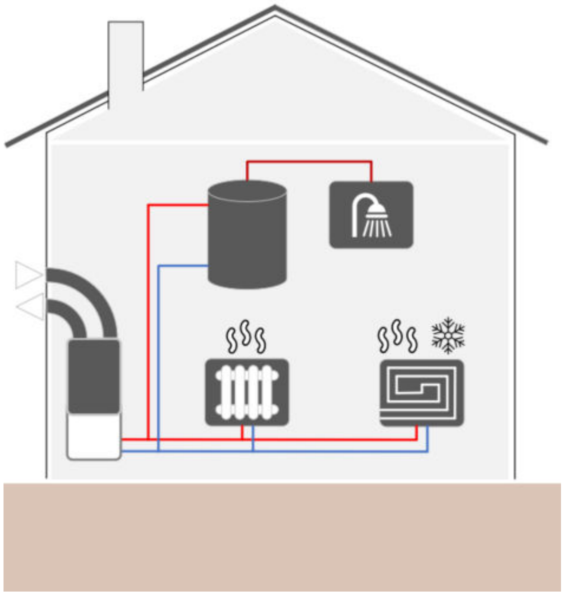
### Outcome

A list of options (heat pump systems) that are investigated to the same degree and can serve as alternatives for making the final decision on which system to adopt.



**Ground Source Heat Pumps (GSHP)**
▶ Use underground pipes to extract heat from the ground.
▶ Can be vertical (deep boreholes) or horizontal (shallow loops in a large trench).
▶ Provide stable efficiency since underground temperatures are relatively constant year-round.





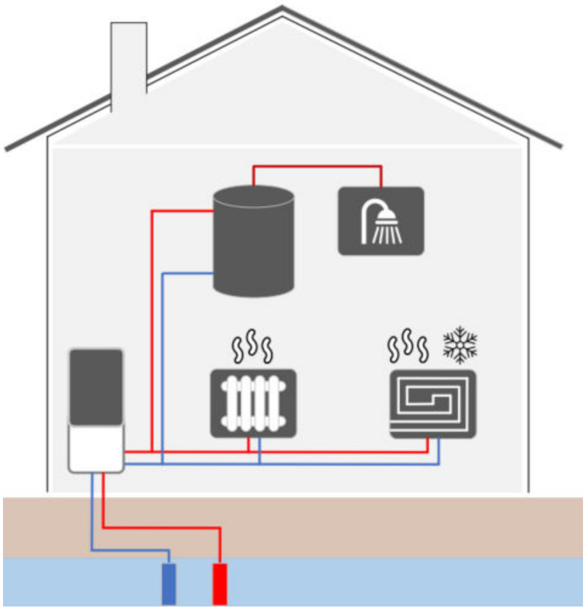
**Air Source Heat Pumps (ASHP)**

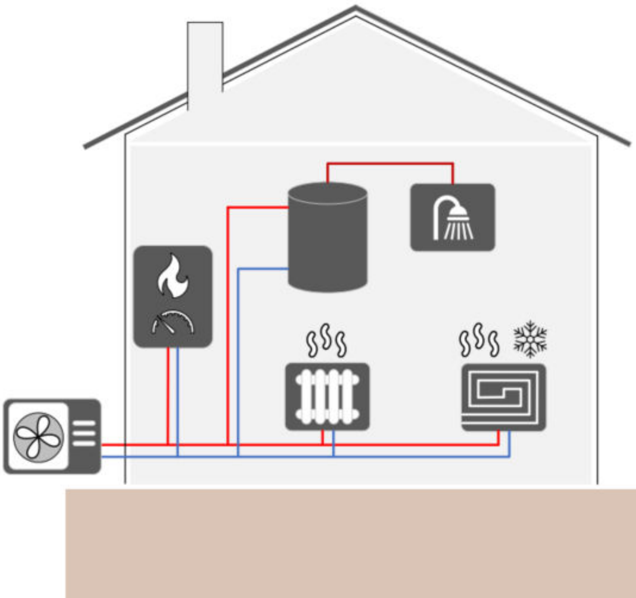
▶ Air-to-Air: Transfer heat from outdoor air directly to indoor air via fans. Common in homes without water-based heating. Larger buildings usually require multiple units.

▶ Air-to-Water: Transfer heat from outdoor air to a water-based heating system, such as radiators, underfloor heating, or domestic hot water.

▶ ASHPs can have either an outdoor or indoor unit. Outdoor units have a greater visual impact on the facade, while indoor units require more internal space and may be limited by ducting needs.

▶ Exhaust Air Heat Pumps reuse heat from indoor exhaust air, typically in combination with mechanical ventilation systems.





**Water Source Heat Pumps (WSHP)**

▶ Extract heat from a nearby water body (lake, river, well, or aquifer).

▶ Highly efficient but requires access to a suitable water source.

**Hybrid Heat Pumps**

▶ Combine a heat pump with another heating system (e.g., gas boiler or solar thermal) to optimize performance and reduce reliance on electricity during peak demand.

# 5 Evaluate synergies

This step explores how heat pumps can work alongside other systems to help reduce running costs further. The synergies listed are examples only and will vary from project to project.

**Renewables:**
For historic buildings aiming to maximise sustainability, integrating renewable energy sources with the heat pump system is worthy of consideration. The use of renewables can lead to lower emissions, and/or lower operational costs of the heat pump system. This might involve the use of:

*Solar Panels:* Supplementing the energy demand of the heat pump system with eg. photovoltaic (PV) panels can reduce reliance on grid supplied electricity and lead to lower operational costs.

*Wind Energy:* If the site is suitable, small wind turbines may help offset electricity consumption. By using renewable energy options, the overall environmental impact of the building's energy system can be minimised, particularly where the grid supplied electricity is from fossil-fuelled sources. However, these solutions are not without visual and other impacts and may only be acceptable to stakeholders if the installation is designed in a way that avoids harm to the heritage significance of the building e.g. By installing the PV panels on an outbuilding, or in the garden etc.

**Energy storage:**
Assess the potential benefit associated with the installation of electric and/or thermal storage.

**Smart energy solutions:**
Consider whether smart solutions and automation could enable your system to intelligently and automatically take advantage of energy tariffs that vary during the day.

**District heating:**
Consider if it is possible to supplement the overall energy system of the building with district heating, especially if the project goals emphasise LCA indicators and cost.

### Outcome

After this step, it should be clear what measures and options can enhance the operation and feasibility of the heat pump system.

# 6 Perform an economic analysis

**After establishing that a heat pump system is theoretically feasible (at this conceptual stage) based on the previous steps, check if it is viable from an economic perspective.**

Take into account that the upfront cost of heat pump installation in a historic building can vary based on complexity and the type of system chosen. Therefore, consider:

**Cost Savings:** Estimate the reduction in running costs (heating, cooling, maintenance) over time to determine the Return On Investment (ROI), factoring in that fossil energy prices may fluctuate.

**Upfront Capital Investment:** Calculate the initial costs for equipment, installation, and any necessary modifications to the building.

**Available Incentives:** Explore financial incentives, rebates, or tax credits for retrofitting historic buildings with energy-efficient systems.

### Outcome

Initial assessment of the economic viability of using the solutions identified in the previous steps.

# 7 Make your decision

Guided by the initial objectives set out in step 1, determine if any of the potential solutions identified in the previous steps are suitable and rank them. If not, go back to step 1 and revise your objectives. Document the planning process so far and, after having consulted the necessary specialists, share your results with the client and stakeholders.

### Outcome

You should now be able to make an informed initial decision on whether to adopt a heat pump system in your project, and if so, then what type and what other supporting systems might be suitable to install.

# Tailored intervention solutions for futureproofing historic buildings

**FuturHist aims to develop replicable retrofit solutions for historic buildings of the future. The project ambition is to shift the focus from individual buildings to building typologies and future-proof them for clean energy transition. It will help create a more sustainable and energy-efficient built environment while preserving historic structures.**

**MORE INFORMATION**
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