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Heat pumps for Spain: Reforming Spanish energy policy to support the transition to clean heating

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Introduction and overview

Heat pumps are a vital clean energy technology for Spain, and they need to grow rapidly in number over the coming decades for Spanish energy and climate goals to be met. The technology can deliver space and water heating, as well as space cooling, depending on configuration. All Spanish regions require domestic hot water, but space heating and cooling needs vary significantly by location. Large parts of Spain, such as those in the north or at high altitudes, have significant space heating demand; other regions have a sizeable need for cooling.

For Spain to meet its goal of a decarbonised energy system by 2050, space and hot water heating will need to be transitioned away from fossil fuels. Spain has the key ingredients to support a clean and electrified heating system: a significant renewable energy resource and a warm climate with short winters across many regions, meaning that its heating needs are typically small compared to many European countries and could be met relatively easily by heat pumps.

While heat pump sales in Spain are generally increasing year on year, this briefing[1] considers the future role of heat pumps in Spain's energy transition as well as the policy drivers needed to scale uptake to the levels implied by climate change and

[1] The authors would like to acknowledge and express their appreciation to the following people who provided helpful insights into early drafts: Francisco Zuloaga (ECODES), Marta San Román (Asociación de Fabricantes de Equipos de Climatización) and Monica Vidal (CAN Europe).

energy goals. The briefing is based on the principles from the Regulatory Assistance Project's (RAP) *Heat pump policy toolkit*.

Spain's demand for cooling is growing, driven in part by a changing climate which has doubled the frequency of heatwaves and increased the length of summer by 10 weeks.[2] This rise in the demand for cooling could support the growth of the use of heat pumps. Where already installed, cooling systems (themselves heat pumps) are often 'reversible' and able to provide space heating efficiently, potentially producing enough to cover the building's full heat demand. The ability of these systems to be used for heating is an important opportunity for Spain.

While reversible systems which provide heating and cooling might be an important driver of heat pump numbers in Spain, particularly in hotter areas, they are not a panacea and the high demand for heating relative to cooling in some areas will necessitate the need for standalone clean heating solutions. In addition, where air-to-air heat pumps are used for heating (and cooling), there will also be a need to consider what will be used to produce hot water.

We suggest that the following policy changes, expanded in the remainder of this briefing, would support the more rapid growth of heat pump deployment in Spain.

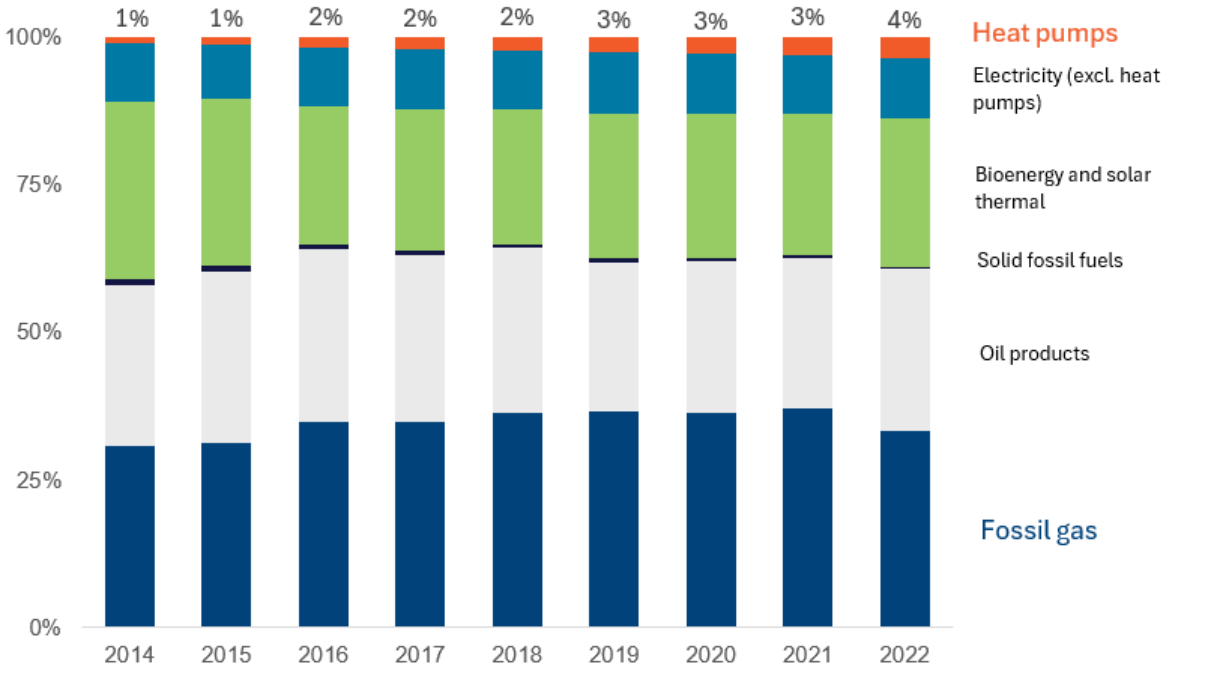
1. **Reform energy pricing** to reduce the relative cost of electricity compared to gas and lower heat pump running costs.
2. **Reform the grant system** to offer support for a wider range of heat pumps, including hot water heat pumps and air-to-air heat pumps.
3. **Allocate long-term funding** for the heat pump grant scheme to provide multi-year market certainty.
4. **Prioritise a comprehensive heating and cooling strategy** to provide direction to households, businesses and the heating market.
5. **Evaluate the role of reversible air-to-air heat pumps** as a full replacement for gas heating systems in Spain.
6. **Consider creating new or enhancing existing obligations** on energy suppliers to drive more rapid delivery of heat pumps.
7. **Roll out a communications plan and funding for installer training centres** to support an efficient rollout of heat pumps.
8. **Develop a simple loan programme** or guarantee funds to provide low-cost finance for households looking to switch to a heat pump, but which lack capital.

[2] Ministry for Ecological Transition. (2024). *National Climate Change Adaptation Plan: 2021-2030*. https://www.miteco.gob.es/content/dam/miteco/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/pnacc-2021-2030-en_tcm30-530300.pdf

The Spanish heat mix

Currently, as shown in Figure 1, Spain is heavily reliant on fossil fuels to meet its space and water heating needs in residential buildings. What's more, fossil gas increased its share over the period 2014-2021, from 31% to 37%. In addition, oil products meet around 25% of heating needs. The fossil fuels used for heating in Spain are nearly entirely imported.[3,4] Bioenergy also accounted for a large share in 2021 at 24%, whereas direct electrical resistance heat made up about 10%. In 2021, heat pumps only accounted for 3% of energy used for space heating; as shown below, however, this had grown from around 1% in 2014.[5]

Figure 1. Energy used for space heating and hot water in homes in Spain, 2014-2021*



Source: Eurostat, nrg_d_hqq.

**District heating energy is absent from this graph.*

Currently, electricity and heat pumps together make up only 14% of heating in Spain. Heat pumps, which use a small amount of electricity relative to the heat they produce, are becoming increasingly clean as the dirtiest fossils fuels (i.e. coal) are retired from the electricity system, and increasingly homegrown as generation from wind and solar expands.[6] In 2023, wind and solar combined provided 40% of Spain's

[3] International Energy Agency. (2024). *Spain Oil Security Policy*. https://www.iea.org/articles/spain-oil-security-policy

[4] International Energy Agency. (2024). *Spain Natural Gas Security Policy*. https://www.iea.org/articles/spain-natural-gas-security-policy

[5] Eurostat. (2024). *Disaggregated final energy consumption in households – quantities (nrg_d_hqq).* https://ec.europa.eu/eurostat/databrowser/view/nrg_d_hhq/default/table?lang=en.

[6] Ember. (2024). *Spain*. https://ember-climate.org/countries-and-regions/countries/spain/

electricity,[7] and the share of renewable electricity is expected to increase to 81% by 2030 and 100% by 2050. Heat pumps are already an extremely clean option for providing heating in Spain, producing five times less emissions than gas boilers on today's grid.[8]

On average, Spain has significantly lower numbers of heating degree days (44%) and higher numbers of cooling degree days (146%) than the EU average.[9] The variability in Spanish heating and cooling needs can be quite stark, however. In higher altitude areas and areas in the north such as Soria, temperatures may reach freezing during winter with typical summer maximums of 30°C. By contrast, Almeria in the south on the Mediterranean coast rarely sees temperatures below 10°C and may experience summer temperatures above 40°C. There will, of course, be areas between these extremes – and heat pumps can play a role across them all.

The path towards clean energy

Recognising the importance of heat pumps, the draft Spanish National Energy and Climate Plan (NECP) suggests that the energy they produce will increase from 50.2 terajoules (TJ) in 2022 to 113 TJ in 2030, more than doubling in just eight years, with impacts for both new and existing buildings.[10] The 'Plataforma por la Descarbonización de la Calefacción y el Agua Caliente' has also recently recognised the central role of heat pumps for cleaning up heating in Spain.[11]

As shown below in Figure 2, the Spanish heat pump market is growing at a reasonable rate, but the requirements for the rapid expansion in heat pumps indicated by the NECP should not be underestimated. Specific and enhanced support will be necessary. The rapid and previously unprecedented growth achieved in recent years will need to be maintained, and homes currently utilising fossil fuels will need to be retrofitted with heat pumps.

[7] Ember, 2024.

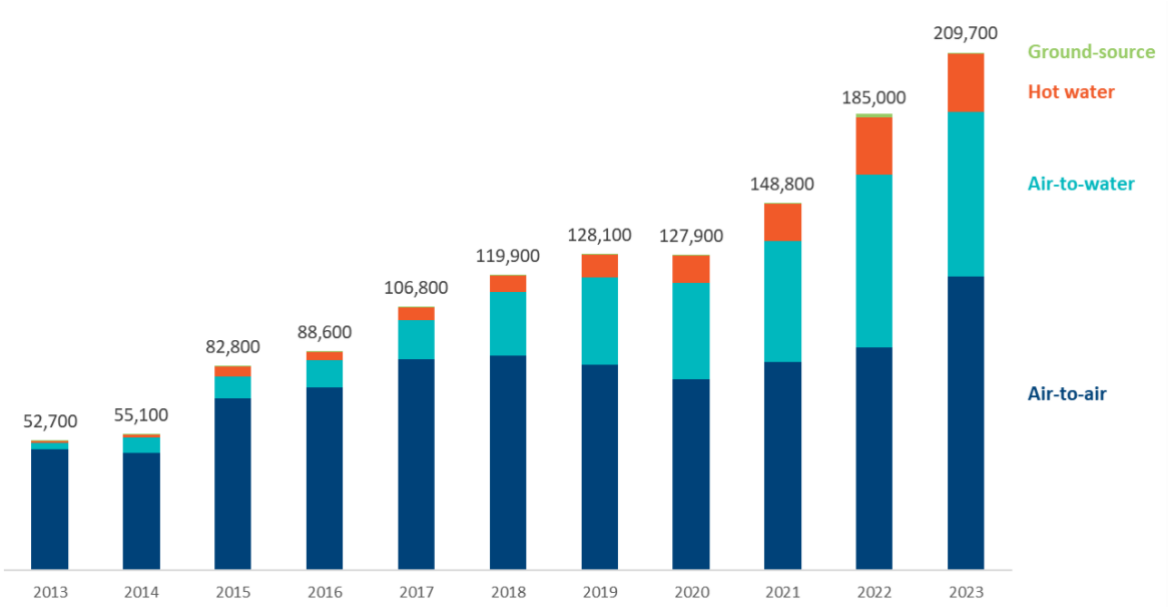
[8] Calculated by authors based on Ember, 2024.

[9] Joint Research Council. (2024). *Heat Pump Market: Country Fiches*. https://publications.jrc.ec.europa.eu/repository/handle/JRC137131

[10] European Commission. (2023). *Spain – Draft Updated NECP 2021-2030*. https://commission.europa.eu/publications/spain-draft-updated-necp-2021-2030_en

[11] Platforma por Descarbonización de la Calefacción y el Agua Caliente. (2024). *Renewable Heating Roadmap*. https://www.descarbonizacalefaccion.es/hoja-de-ruta-calefaccion-renovable/

Figure 2. Annual sales of heat pumps for space and water heating in Spain



Source: European Heat Pump Association Market Statistics, https://stats.ehpa.org.

While heat pumps are growing in number, sales of air-to-air heat pumps intended primarily for cooling have been expanding at an even higher rate, with 276,585 installed in 2020.[12] There is a risk that, as the use of cooling systems grows, emissions increase while at the same time fossil fuel heating systems remain. Yet it may be possible to consider heating and cooling together, a point elaborated on later in this paper.

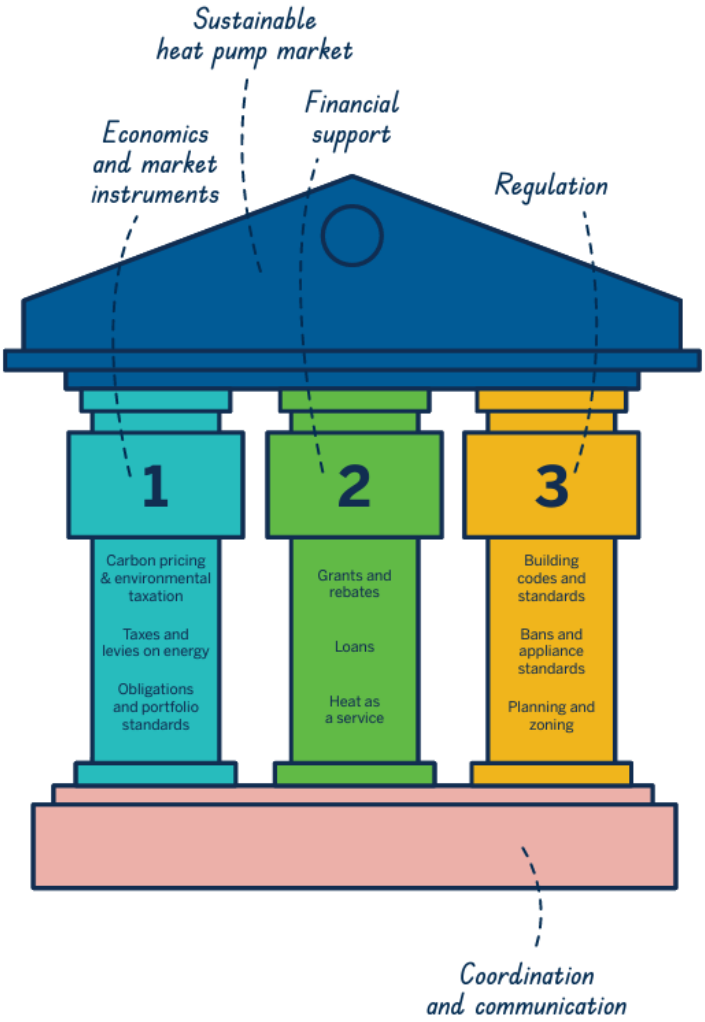
Applying the *Toolkit* to the Spanish heat pump market

This briefing utilises the structure of the *Heat pump policy toolkit*[13] (see Figure 3), published in 2022, in order to examine Spanish heat pump policy. The *Toolkit* highlights the importance of forming packages of policy measures to ensure wider economic rebalancing, the role of regulation and standards, financial support to manage building owner capital costs, and softer support to coordinate the transition.

[12] Joint Research Centre. (2024). *Heat Pump Market: Country Fiche: Spain*. https://publications.jrc.ec.europa.eu/repository/bitstream/JRC137131/JRC137131_010.pdf

[13] Regulatory Assistance Project. (2022). *A policy toolkit for global mass heat pump deployment*. https://www.raponline.org/knowledge-center/policy-toolkit-global-mass-heat-pump-deployment/

Figure 3. The *Heat pump policy toolkit* temple



Affordability of heat pumps in Spain

For heat pumps to be adopted at scale, a fundamental principle is that their total cost of ownership, comprised of upfront and running costs, should be lower than fossil fuel heating. Currently, this is often not the case for heat pumps in Spain.

Upfront costs

At the time of writing, the upfront cost of air-to-water heat pumps is significantly higher than that of gas boilers. Estimates provided by the Spanish Association of Air Conditioning Equipment Manufacturers (AFEC) indicate that an air-to-water heat pump which will provide heating and hot water costs roughly €9,000 for equipment and installation. An air-to-air heat pump is notably cheaper at €2,000 and will provide cooling; however, air-to-air heat pumps do not produce hot water.

Also costing €2,000, a gas boiler is cheaper than an air-to-water heat pump. It does not supply cooling, however, thus in many households extra devices are needed to manage the ever-increasing temperatures and lengthy hot periods.

To reduce the relative costs of heat pumps, Spain has been offering residential building owners a grant for air-to-water heat pumps of €500/kW up to €3,000 for a number of years.[14] This is included in the analysis below, which considers air source heat pumps, widely seen to be a key technology. Grants have also been available for ground source heat pumps, which we do not consider.

Funding can be challenging to access in practice and its outlook is uncertain.[15] Grant approval is strictly regulated by Spain's regional governments to ensure proper use, meaning that disbursement can be slow and not guaranteed for all households. No national subsidy or grant is offered for air-to-air heat pumps or gas boilers, though some Spanish regions (e.g. Castilla y León) do support the replacement of a gas boiler more than 10 years old with a new gas boiler.

Running costs

Under typical current energy prices in Spain,[16] a heat pump with a seasonal coefficient of performance of 3.65 costs less to operate per year than a gas boiler for heating.[17] Based on residential energy prices in the second half of 2023, an air-to-water heat pump costs around €610 to run per year for a typical household, compared to a gas boiler at €780.[18] This €170 difference means that a Spanish air-to-water heat pump's higher upfront cost will take more than 20 years to be paid off by operating cost savings. The air-to-water heat pump running costs are significantly inflated by elevated electricity prices resulting from taxes and levies which are not placed on fuel oil or fossil gas.[19] While taxes were reduced during the price crises, these have since been raised to their previous levels.[20]

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[14] The subsidy scheme will be providing financial support for some systems until the end of 2024 but there is considerable uncertainty over what recently announced proposals will mean for the market. AFEC, personal communication with RAP, 8 August 2024.

[15] AFEC, personal communication with RAP, 29 April 2024.

[16] Spanish households have the option to choose either a regulated or market tariff for electricity and gas. The regulated tariff, known as the Voluntary Price for the Small Consumer (PVPC), is based on real-time energy supply and demand levels. The market tariff is contracted with private firms, typically for a stable rate over a calendar year. A social tariff is available for low-income households, though owing to the complex application process this may be challenging to access. See https://www.endesa.com/en/the-e-face/energy-sector/free-market-regulated-market-pvpc and https://www.endesa.com/en/advice/ratesubsidy/rate-subsidy.

[17] The seasonal coefficient of performance of 3.65 is the average for residential homes according to IDAE, Síntesis del Estudio Parque de Bombas de Calor en España, p. 29, https://www.idae.es/uploads/documentos/documentos_Bombas-de-calor_FINAL_04ee7f42.pdf.

[18] Eurostat prices after all taxes and levies for electricity (€232.32/MWh) https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_204/default/table?lang=en and gas (€101.00/MWh) https://ec.europa.eu/eurostat/databrowser/view/NRG_PC_202/default/table?lang=en.

[19] RAP and 3E. (2022). *Levelling the playing field: Aligning heating energy taxes and levies in Europe with climate goals*. https://www.raponline.org/knowledge-center/aligning-heating-energy-taxes-levies-europe-climate-goals/

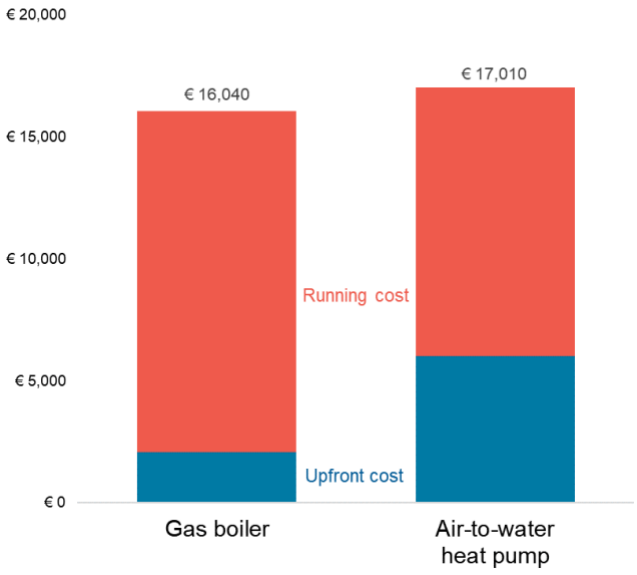
[20] Sur in English. (2024). *Tax increases make gas and electricity prices more expensive in Spain as of today, 1 April*. https://www.surinenglish.com/spain/tax-hike-makes-gas-and-electricity-bills-20240401114212-nt.html

Air-to-air heat pumps will typically have similar costs as air-to-water heat pumps for heating at around 20% less than gas, but using an additional electric hot water heater can lead to higher running costs compared to a gas boiler. The use of a hot water heat pump alongside an air-to-air heat pump will typically result in lower bills than a gas boiler.

Total cost of ownership of heat pump options

Figure 4 below, based on RAP analysis, shows how the typical total ownership costs of air-to-water heat pumps are higher than for gas heating in Spain, even taking into account the existing grant. Likewise, Spanish heating oil prices, roughly €1.06/L in April 2024, mean that heating with oil boilers is more cost-efficient than heat pumps at current electricity prices.[21] The upfront cost of an oil boiler is likely to be similar to a gas boiler, or perhaps a little more, meaning that there are unlikely to be major savings from switching from oil to a heat pump under current electricity prices, even with the current grant.

Figure 4: Total cost of ownership for space and water heating with a gas boiler and air-to-water heat pump in Spain, including the €3,000 subsidy for air-to-water heat pumps



Source: RAP analysis. Please see Annex for a full list of data sources.

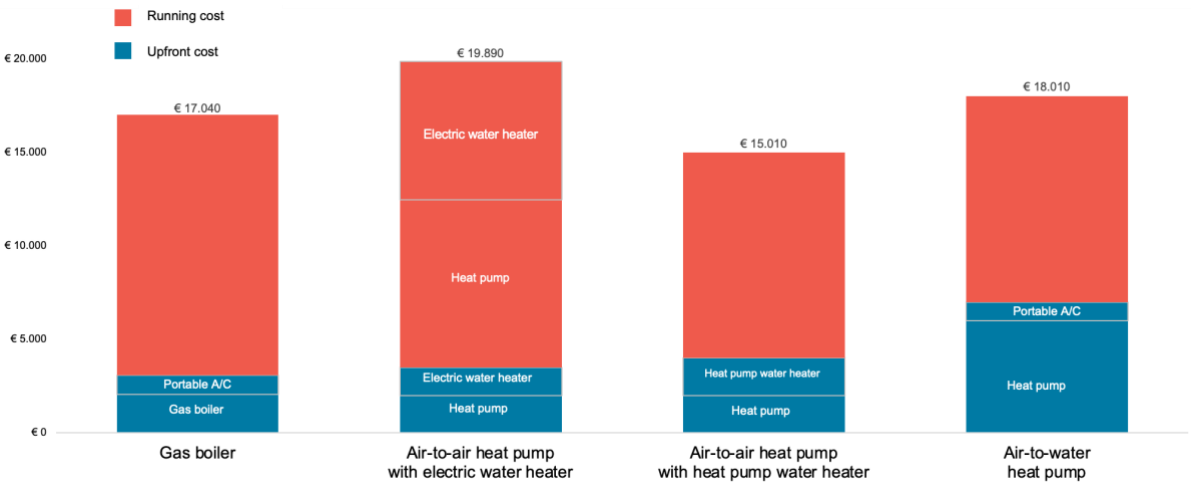
Figure 5 offers a cost comparison between options which include cooling.[22] This complicates the picture slightly because air-to-air heat pumps typically provide cooling and heating but not hot water, and air-to-water heat pumps and gas boilers

[21] Heating oil prices of €1.06/L translate to €106/MWh which, given average Spanish household space and water heating demand, equals around €630/year, lower than heat pump running costs shown in Figure 4.

[22] Data from AFEC, personal communication, and Eurostat, 2021.

produce heating and hot water but not cooling. As such, portable air conditioning is added to the gas boiler and air-to-water heat pump scenario, while hot water is produced by an electric water heater and a separate hot water heat pump in the two air-to-air situations. The hot water heat pump produces hot water much more efficiently than the electric heater, leading to much lower running costs.

Figure 5. Total cost of ownership of a gas boiler, an air-to-water heat pump, and an air-to-air heat pump (with electric water heater and heat pump water heater)



Source: RAP analysis. Please see Annex for full list of data sources.

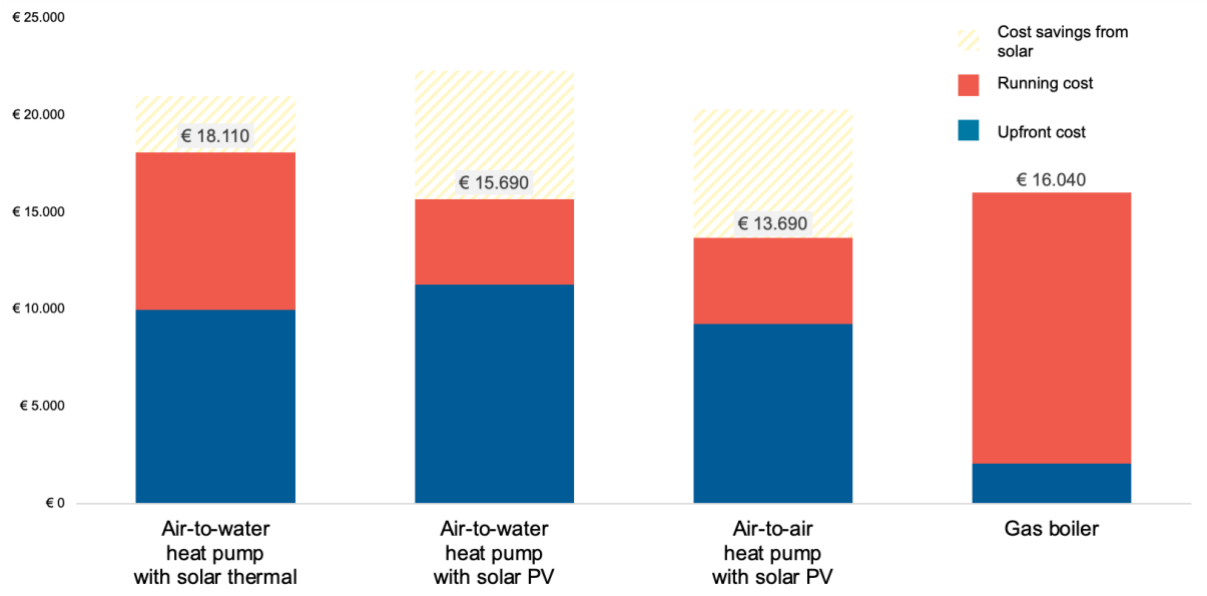
The upfront costs include a €3,000 subsidy for air-to-water heat pumps. The running cost of cooling is not considered and would be uniform across systems where cooling is possible.

Where cooling is required, analysis suggests that for the typical dwelling, the lowest total cost of ownership results from an air-to-air heat pump alongside a hot water heat pump, even without any subsidy. It's also noteworthy that this set-up typically costs less than the gas boiler without cooling.

The clear value of solar

The installation of a solar hot water or solar photovoltaic (PV) system integrated with the heating system could, despite the capital costs, significantly reduce the total cost of ownership. This dynamic is shown in Figure 6. Adding a solar thermal (hot water) system to the air-to-water heat pump could reduce hot water demand by about 80%, saving €2,900 over the lifetime of the system. Adding solar PV could cover 60% of the heat pump's electricity demand, providing €6,600 in savings. The inclusion of a solar PV system could mean that an air-to-water heat pump has a lower total cost of ownership than a gas boiler, at around €15,700 and €16,000 respectively. The lowest total cost of ownership scenario includes an air-to-air heat pump for heating, a hot water heat pump and solar PV. This combination is significantly cheaper over its lifetime than gas heating – and it provides cooling too.

Figure 6. Total cost of ownership of an air-to-water heat pump with solar thermal and with solar PV, an air-to-air heat pump with solar PV, and a gas boiler



Source: RAP analysis. Please see Annex for a full list of data sources.

Note: The air-to-air heat pump also includes a heat pump water heater. The air-to-air heat pump also provides cooling, a significant value which is not represented here.

The added value of reversible systems

Air-to-air heat pumps are reversible and can be used for cooling, offering them an advantage over air-to-water heat pumps which require significant modifications to be used for cooling, or gas boilers which provide no cooling at all. This additional value is too complex to be considered in the analysis (owing to the varying cost of cooling systems and the difficulty in understanding their usage patterns), but should very much be taken into account by policymakers. In hotter regions where cooling is a more significant energy use, air-to-air systems are likely to have particular value.

If a building already contains a reversible heat pump (primarily for cooling), it's possible that significant emissions reductions and growth in renewable energy could be achieved if households use this system for heating rather than a gas or oil boiler. Additional air-to-air systems could be installed to fulfil the remaining need for space heating, and then the only remaining fossil fuel use would be for hot water production. Hot water can often be electrified, can be driven by solar PV or solar thermal, or can even be provided by a separate hot water heat pump.

Spanish policy support for heat pumps

The following sections consider if or how the elements of the *Heat pump policy toolkit* (shown above in Figure 3) are present in Spanish energy policy, and whether the elements apply to both air-to-air and air-to-water heat pumps.

Economic and market-based instruments can reduce the relative running costs of heat pumps[23] and support their deployment by placing obligations on companies to deliver them.[24]

- **Carbon pricing and environmental taxation** on heating fuels can reduce the relative running costs of heat pumps but there is no sign of Spanish government plans to deliver this. The EU emissions trading system (ETS2) may deliver some element of a carbon price later this decade.

- **Taxes and levies on energy** also affect running costs, but there are no current plans in Spain to modify or move taxes and levies which add around €150 to the running costs of an air-to-water heat pump each year. The 'Iberian Exception,' introduced with the intention of limiting the impact of the most severe gas price rises on the wholesale electricity price, may have reduced the cost of electricity relative to gas. In any case, this mechanism has now come to an end. The value-added tax (VAT) rate on electricity (currently 10%) is set to increase at the end of the year to 21%; the special tax on electricity (IEE) is expected to reach 3.8%;[25] and the electricity production tax (IVPEE) increased in June from 5.25% to 7%.[26] Overall, taxes on electricity are discouraging the use of heat pumps in Spain.

- **Obligations and portfolio standards** can be placed on companies in the energy market, such as suppliers or appliance manufacturers, to mandate them to deploy heat pumps.[27] Currently no specific heat pump standard exists or is planned in Spain. The Spanish energy efficiency white certificate scheme 'Sistema de CAE' does, however, allow heat pumps as an energy saving measure. While precise information on what has been deployed by the scheme is not currently available,[28] we are aware that some deployment of air-source heat pumps has been encouraged.[29]

23 RAP and 3E, 2022.

24 Regulatory Assistance Project. (2023). *Clean heat standards: New tools for the fossil fuel phaseout in Europe.* https://www.raponline.org/knowledge-center/clean-heat-standards-new-tools-for-fossil-fuel-phaseout-in-europe/

25 KPMG. (2024). *Spain: Tax measures in new laws approved at end of 2023*. https://kpmg.com/us/en/home/insights/2024/01/tnf-spain-tax-measures-new-laws-approved.html#:~:text=Increase%20in%20rate%20of%20the,applicable%20until%2031%20December%202023)

26 Sur in English, 2024.

27 Regulatory Assistance Project. (2024). *Clean Heat Standards Handbook*. https://www.raponline.org/knowledge-center/clean-heat-standards-handbook/

28 Year 1 data for the scheme was not available at the time of writing.

29 Personal communication with the Ministry for the Ecological Transition and the Demographic Challenge.

Financial support helps building owners manage the potential additional upfront cost of heat pumps compared to alternatives.

- **Grants and rebates** are one such measure, and since 2021 the Spanish government has provided grants for households installing heat pumps.[30] Spain has provided €500/kW of subsidy for air-to-water heat pumps, up to a maximum of €3,000 per unit. Ground or water-source heat pumps have received €1,600 to €2,250/kW, up to €9,000 or €13,500 per home. Air-to-air systems and hot water heat pumps have not received a subsidy. Grants have been administered at the regional level, and we are not aware of any difference in policy support between regions or any specific additional support for low-income households. The programme will be providing funding until the end of 2024 but there are now limits regarding who can apply and uncertainty over the impact of proposed measures introduced at the beginning of August 2024.[31] The short-term nature of this funding outlook is a known industry concern, and is understood to be limiting investment.

- **Loans** can allow households access to capital to support heat pump retrofits. We are not aware of any government-supported loans for heat pumps in Spain.

- **Heat-as-a-service** schemes, like loans, allow costs associated with heat pump retrofits to be paid for over time, and sometimes include running and maintenance costs as part of a package.[32] We are unaware of any such schemes in Spain.

Regulatory policies can phase out fossil fuel heating technologies and encourage heat pumps in certain building types by limiting what products are on the market, and by setting geographical limits to what can be sold where.

30 IDAE. (2024). *For Renewable Energies in self-consumption, storage, and thermal residential sector (RD 477/2021. PRTR)*. https://www.idae.es/ayudas-y-financiacion/para-energias-renovables-en-autoconsumo-almacenamiento-y-termicas-sector

31 AFEC, personal communication with RAP, 8 August 2024.

32 IEA HPT. (2021). *Heat as a service proposition.* https://heatpumpingtechnologies.org/heat-as-a-service-proposition-one-of-the-keys-to-unlocking-the-residential-retrofit-market-for-heat-pumps/

- **Building codes and standards** currently in existence in Spain mean that new buildings must be 'nearly zero energy buildings' under the quite loose EU definition. This lack of specificity has led to fossil fuels still being used in new buildings,[33] although building codes reduce the likelihood of fossil fuel heating being installed.[34] The recently revised Energy Performance of Buildings Directive requires that new buildings not have any on-site emissions as of 2030, and requires planning for an emissions-free building stock by 2040.[35]

- **Bans and appliance standards** to limit the availability of fossil fuel heating systems for existing buildings have been introduced in several EU Member States. They are not yet being discussed in Spain.[36]

- **Planning and zoning** of clean heating in Spain is not widely discussed,[37] but the national energy and climate plan (NECP) sees an important role for heat networks. At the time of writing, the current 'heat map' of Spain was not operational.[38] The recast Energy Efficiency Directive introduces a requirement for larger municipalities to develop heating and cooling plans and will likely spur some action in this area.[39]

Coordinated policy efforts are needed to deploy heat pumps at the scale and pace required to meet clean energy and decarbonisation targets. Currently, heat pumps do not appear to be strategically incorporated into Spanish energy policy.

- **Communication** can help build consumer confidence and drive consumer demand. We are not aware of any Spanish government communications programmes to drive consumer confidence in heat pump technologies.

- **Installer communication, training and certification/verification** can bolster market development and help supply chains. For example, France recently announced the creation of a centre for heat pump expertise to assist installers and the general public.[40] We are not aware of any government support for such programmes in Spain.

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33 BPIE. (2021). *NEARLY ZERO: A REVIEW OF EU MEMBER STATE IMPLEMENTATION OF NEW BUILD REQUIREMENTS*. https://www.bpie.eu/wp-content/uploads/2021/06/Nearly-zero_EU-Member-State-Review-062021_Final.pdf.pdf

34 Luis M. López-Ochoa, Jesús Las-Heras-Casas, Juan M. González-Caballín, Manuel Carpio. (2023). Towards nearly zero-energy residential buildings in Mediterranean countries: The implementation of the Energy Performance of Buildings Directive 2018 in Spain. *Energy* 276, 127539.

https://doi.org/10.1016/j.energy.2023.127539.

35 European Commission. (2024). *Questions and Answers on the revised Energy Performance of Buildings Directive (EPBD).* https://ec.europa.eu/commission/presscorner/detail/en/qanda_24_1966

36 EHPA. (2024). *Which countries are scrapping fossil fuel heaters? Update.* https://www.ehpa.org/news-and-resources/news/which-countries-are-ending-fossil-fuel-heaters/

37 Energy Cities. (2024). *EU Tracker – Local heating and cooling plans in Spain.* https://energy-cities.eu/countries/spain/

38 IDEA. (2020). *Heatmap of Spain*. https://www.idae.es/en/technologies/energy-efficiency/conversion-energy/heatmap-spain

39 European Commission. (2023). *New energy efficiency directive published*. https://energy.ec.europa.eu/news/new-energy-efficiency-directive-published-2023-09-20_en

40 French Ministry of Ecological Transition and Territorial Cohesion. (2024). *Heat pumps*. https://www.ecologie.gouv.fr/pompes-chaleur

- **Utility integration** means efficiently integrating heat pumps into energy systems through efficient operation and 'smart' use, making the most of variable output renewables and lower grid costs. Variable time-of-use tariffs are generally available in Spain, enabled by a widespread rollout of smart meters.[41] Hourly pricing is possible for domestic energy users, but less flexible and fixed price offerings are available too.

Discussion

Heat pumps are vital for a clean Spanish energy system. Average warm temperatures in the country where heating is needed will generally lead to excellent air-source heat pump performance. However, this review has highlighted that there are potentially different heat pump needs in Spain compared to much of the rest of cooler, continental Europe.

First, the variable climate of Spain, which includes climate zones from 'cool temperature wet' to 'tropical dry', means that some parts of the country may primarily demand cooling, whereas others may only need heating.[42] Large swathes of Spain use some heating and some cooling, and therefore for much of Spain reversible air-to-air heat pumps – which offer both efficient heating and cooling – will have value. Indeed, consumer desire for cooling could provide a strong incentive towards heat pumps, allowing households to meet their space heating needs with the same device. If only one heating appliance is needed (rather than a gas boiler plus a cooling system) this could lead to reduced costs. Air-to-air systems currently receive no policy support, however.

In order to fully decarbonise properties where air-to-air heat pumps provide heating and cooling, a solution to produce hot water must be found. Hot water could potentially be produced using solar thermal, a standalone hot water heat pump, or direct electric immersion heating. Hot water storage will allow the use of cheaper electricity for hot water production and pairs well with solar PV systems. All-in-one systems which provide heating, cooling and hot water from one external unit are not yet widely used but may become increasingly popular. RAP analysis suggests that, currently, combinations of reversible air-to-air heat pumps and hot water heat pumps could be a very cost-effective and clean option for Spanish properties.

In any case, roof-based solar is likely to have extremely high value for Spanish buildings, as its output will be high in Spain's sunny climate and is likely to coincide with electricity demands for cooling. Such solar PV, solar thermal or combined solar and PV systems could also contribute to heating and hot water generation, and could provide major running cost benefits for heat pumps. While solar thermal may not be used for cooling, it can produce large quantities of hot water per unit of area

[41] Florence School of Regulation. (2020). *The Spanish experience with dynamic tariffs.* https://fsr.eui.eu/the-spanish-experience-with-dynamic-tariffs/#:~:text=ToU%20energy%20charges%20under%2Dregulated,0.5%20c%E2%82%AC%2FkWh

[42] Spain Climate Zones. (2024). Forest – JRC. https://forest.jrc.ec.europa.eu/media/filer_public/a3/e8/a3e85e9c-b856-49f9-9d23-8ef09023c8d9/esp_climate.pdf

compared to PV. The analysis suggests that heat pump technology combinations which include solar PV can, across their lifetime, be significantly cheaper than gas boilers. Lowest lifetime costs come from combinations of air-to-air heat pumps, hot water heat pumps and solar PV.

One complexity for Spain is the high proportion of the population who live in apartments (over 60%).[43] While heat pumps, in particular air-to-air, are used successfully as standalone systems in apartments around the world, space constraints may mean that building-scale heat pump systems are more appropriate if hot water storage is needed, particularly when there is shared solar on the building. Multiple heat pump units on the outside of buildings could also cause visual amenity concerns.[44] The delivery of building-wide clean heating systems needs to be considered carefully by Spanish policymakers.

Conclusions and policy recommendations

Spain has great potential to rapidly accelerate its heat pump deployment to support its journey to a clean energy system and to build on the ever-greening electricity sector. Good heat pump performance is likely due to Spain's generally warm climate. This good performance, alongside the potential to use building-scale solar PV to run heat pumps, could lead to excellent running costs for building owners so that heat pump and solar combinations actually have lower lifetime costs than gas systems, even with extremely high taxes on electricity.

Currently, however, with the primary fiscal driver being the air-to-water heat pump grant, the policy and market framework does not provide the amount of support for heat pumps that is needed. This framework also leads to the possibility that, in Spain, using heat pumps for heating will cost more than fossil fuels. We make the following specific recommendations for Spanish energy policy reform to support the more rapid deployment of heat pumps.

1. **Reform energy pricing** to reduce the relative costs of electricity compared to gas and thus to lower running costs. Such reform can be achieved by reducing taxes on electricity, by applying carbon taxes to fossil fuels, or by removing the burden of levies from electricity bills. Such an approach would also increase government tax revenue.
2. **Reform the grant system** to offer support for a wider range of heat pumps, including hot water heat pumps and air-to-air heat pumps. In both cases, grants may need to be smaller than for air-to-water systems, and careful targeting would

[43] Eurostat. (2021). *House or Flat: where do you live?* https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210521-1

[44] MSN. (2024). *Hot headed villagers battle over illegal air-conditioner units in Italy's iconic Portofino*. https://www.msn.com/en-gb/news/world/hot-headed-villagers-battle-over-illegal-air-conditioner-units-in-italy-s-iconic-portofino/ar-AA1oIUQ6?apiversion=v2&noservercache=1&domshim=1&renderwebcomponents=1&wcseo=1&batchservertelemetry=1&noservertelemetry=1

be needed. Air-to-water grants could be increased, and enhanced support could be offered for lower-income households. Targeted support could also be provided to multi-family buildings. The scheme can be simplified to reduce bureaucracy.

3. **Allocate long-term funding** for the grant scheme to provide multi-year market certainty.
4. **Prioritise a comprehensive heating and cooling strategy** to provide direction to households, managers and owners of multi-apartment buildings, businesses and the heating market.
5. **Evaluate the role of reversible air-to-air heat pumps** as a full replacement for gas heating systems in Spain. Further research may be useful into how policy can support such systems and how innovative technologies can replace fossil fuel-based hot water production.
6. **Consider creating new or enhancing existing obligations** on energy suppliers or building owners to drive more rapid delivery of heat pumps.
7. **Roll out a communications plan and funding for installer training centres** to support an efficient rollout of heat pumps.
8. **Develop a simple loan programme** or guarantee fund to provide low-cost finance for households looking to switch to heat pumps and solar but which lack capital.

Annex: Total cost of ownership methodology

Estimates of total cost of ownership for an air-to-air heat pump, air-to-water heat pump, gas boiler and oil boiler in Spain are presented in this paper. The model used by RAP calculates the total cost of ownership per year for each technology in 2023/2024. Parameters used in the model are discussed in the following paragraphs.

Residential space and water heating demand in 2021 was taken from the Eurostat database *Household final energy consumption disaggregated*.[64] The average space heating demand per country was divided by the number of households to reach an average space and water heating demand per household.[65]

Average seasonal conversion efficiencies are assumed for an air-to-water heat pump with a seasonal coefficient of performance (SCOP) of 3.65 and a condensing gas boiler with an efficiency of 95%. The efficiency of the electric water heater included with the air-to-air heat pump is 100%. These efficiencies are largely accepted as industry standards and may even downplay the performance of heat pumps in Spain, where average external air temperatures are higher. For example, the Sustainable Energy Authority of Ireland reported a median SCOP of 3.95 in 2020, and Denmark and the Netherlands have seen SCOPs reach above 4.[45] These countries are all significantly colder than Spain.

The median SCOP was taken from an IDAE study, *Síntesis del Estudio Parque de Bombas de Calor en España*.[46] The efficiency value used in this study may also be generous towards gas boilers, considering it corresponds to the minimum as defined by Appendix X in the European Commission's Energy Efficiency Directive guidance note.[47] The existing fleet of boilers in Spain is not comprised exclusively of the most energy-efficient options, and would therefore likely operate at a fleet efficiency much lower than 95%.

For each technology, the calculation consists of a capital cost component and an operating cost component. For upfront costs, these values were supplied by AFEC. Spain has provided grants of up to €3,000 for air-to-water heat pumps in single-family homes; these grants were considered in the calculation, even though they may currently be challenging to access in practice. A lifetime of 18 years for each technology was used. The upfront costs used in the model are as follows:

- Air-to-water heat pump: €9,000

[45] International Renewable Energy Agency (IRENA). (2022). *Renewable Solutions in End-Uses: Heat Pump Costs and Markets*. https://www.irena.org/Publications/2022/Nov/Renewable-solutions-in-end-uses-Heat-pump-costs-and-markets

[46] IDAE, Síntesis del Estudio Parque de Bombas de Calor en España, p. 29. https://www.idae.es/uploads/documentos/documentos_Bombas-de-calor_FINAL_04ee7f42.pdf

[47] European Commission. (2019). Annex to the European Commission Recommendation (EU) 2019/1658 of 25 September 2019 on transposing the energy savings obligations under the Energy Efficiency Directive. https://eur-lex.europa.eu/eli/reco/2019/1658

- Air-to-air heat pump: €3,060
- Gas boiler: €2,070

For the scenarios including cooling, an upfront cost of €1,000 for portable air conditioners is included for the air-to-water heat pump and gas boiler cases. An upfront cost of €1,500 for an electric water heater or €2,000 for a hot water heat pump are included for the air-to-air heat pump. We estimate that the upfront costs of a solar thermal system and solar PV system (3 kilowatts-peak) are €4,000 and €5,280 respectively.[48]

In terms of operating costs, current electricity and fossil gas were taken from Eurostat. These prices are shown in the table below.

Table 1. Gas and electricity retail prices used for analysis

	Fuel price (ct/kWh)
Electricity after taxes, rates in second half of 2023	23.23
Fossil gas	10.10

Source: Eurostat.

Maintenance costs were confirmed by AFEC and assumed for the heat pump at €180/year and gas boiler at €190/year. Standing charges for electricity and gas networks are assumed to be €90/year and €115/year respectively.

[48] Estimates for solar power prices are €1,600/kWp with 10% VAT and are from Solarpower Europe, *Solar Powers Heat 2023*, https://api.solarpowereurope.org/uploads/0523_SPE_Solar_Heating_report_09_mr_98b11ef7ab.pdf?updated_at=2023-03-09T06:13:41.408Z, and estimates for solar thermal costs are from market research.

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