Extreme heat resilience: lessons from Spain for Australia

Report from Gill Owen Scholarship 2023

renew.

ENERGY CONSUMERS AUSTRALIA

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Cover image: Seville, taken by author 30 September 2023. Thermometer reading taken in sunlight; maximum in shade 38 degrees Celsius.

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About the project

This report outlines the findings of a research project conducted in September-October 2023 in Spain with the support of the Gill Owen Scholarship 2023 from Energy Consumers Australia. The core research focus was to gain an understanding of Spanish responses to heatwaves and extreme heat events in the context of critical challenges to energy systems. Research was conducted through interviews with stakeholders, site visits, and desk research. Primary locations were Madrid and Seville.

Key findings

Heatwaves are becoming more frequent and more severe. Spain's exposure to extreme heat is increasing due to climate change and cities are experiencing more frequent heatwaves.

Rising energy costs and challenges to the energy system have impacted resilience to heatwaves. Pressure on Spain's energy system following the 2022 energy crisis temporarily increased costs, while driving measures such as renewables investment and the 'Iberian Exception' that have reduced energy prices in 2023. Impacted reliability and demand reduction strategies reduced the salience of air conditioning as a response to extreme heat. Measures to reduce air conditioning use including a ban on air conditioning under 27 degrees were consistent with positive adaptation outcomes.

Spain has adapted to heatwaves, but further adaptation is required to avoid significant health impacts. The temperature at which heat results in more deaths is increasing in Spanish cities, reflecting an improved resilience to extreme heat. However, adaptation has to continue to keep pace with rising temperatures driven by climate change.

A wide range of responses and activities is needed to adapt to extreme heat events. Adaptation to extreme heat has not been the result of one single action but rather a broad range of developments across domains and locations. Key measures considered include retrofits of homes, reduction of urban heat island effects, improved infrastructure, improved health systems, public communications, and strategies for immediate heatwave responses.

Addressing energy poverty and vulnerability to extreme heat should be central to adaptation. Health impacts of heatwaves are disproportionately experienced by low-income communities, older people, people experiencing energy poverty or precarious conditions, and people with pre-existing health conditions. Responses to extreme heat should be understood and developed in a framework of energy poverty and social vulnerability.

Public awareness and communication are important. Ensuring public awareness of heatwave adaptation and education on steps available to reduce risks are critical to promote buy-in and active participation in a 'heat culture'.

Strategic governance, data and frameworks are important in Spain's response to heatwave risk. A national plan was introduced in 2004 and is updated annually. The national plan is complemented by local and regional plans. Data on health and mortality are available and updated to inform responses and research. Further opportunities exist to expand frameworks to measure and prioritise adaptation.

Social programs and responses can provide lessons for Australia. The prominence of heatwaves and extreme heat resilience in Spain has led to a wide range of programs and social movements. These experiences may inform the development of Australian programs seeking to build community resilience to extreme heat.

Recommendations and lessons for Australia

Australia's National Adaptation Plan must address the risk of increasingly extreme heat events. The Australian government is committed to developing a National Adaptation Plan in 2024. The Plan should be developed to include specific strategies for adaptation to heatwaves, including immediate responses and long-term adaptation.

Australia should adopt a system of naming heatwaves. Public communication and awareness of heatwave risk has been a critical element of Spain's response. Australia should adopt a framework for alerts and communications that builds on Seville's heatwave naming approach.

The needs of vulnerable communities and households should be at the centre of Australia's heatwave response. The health and social impacts of heatwaves reflect existing inequality and can exacerbate existing vulnerabilities. Australia's response should centre energy poverty and social exclusion. The lived experience of people with vulnerability to extreme heat events should inform Australian adaptation strategies.

Australia should extend policies to improve the resilience and energy efficiency of homes. Energy efficiency retrofits to existing homes and high thermal efficiency standards for newly built homes improve resilience to heatwaves. Australia should extend and deepen its policy response to residential thermal efficiency, including retrofit programs, finance, new home standards, energy ratings disclosure, and minimum energy efficiency standards for renters.

Australia's response should not depend solely on air conditioning. A dependence on air conditioning is not resilient to energy price increases, energy poverty, blackouts, or other external pressures on energy systems. Future temperature increases will put further pressure on energy systems where air conditioning is a primary response to heat. Other measures to improve resilience must form part of Australia's strategy.

Australia should measure and assess the resilience of cities and communities to extreme heat. This should include a clear framework for assessing urban resilience (such as the U-ADAPT framework under development in Spain), publishing of data such as mortality, and ongoing monitoring and evaluation of responses to extreme heat events.

Heatwaves in Spain

Extreme heat driven by climate change is a threat around the world, but Spain is particularly exposed. The country has experienced annual temperature increases in recent decades higher than elsewhere in Europe. Climate change is driving higher temperatures and drought conditions; future projections indicate climate change may lead to large-scale desertification and changed rainfall patterns.

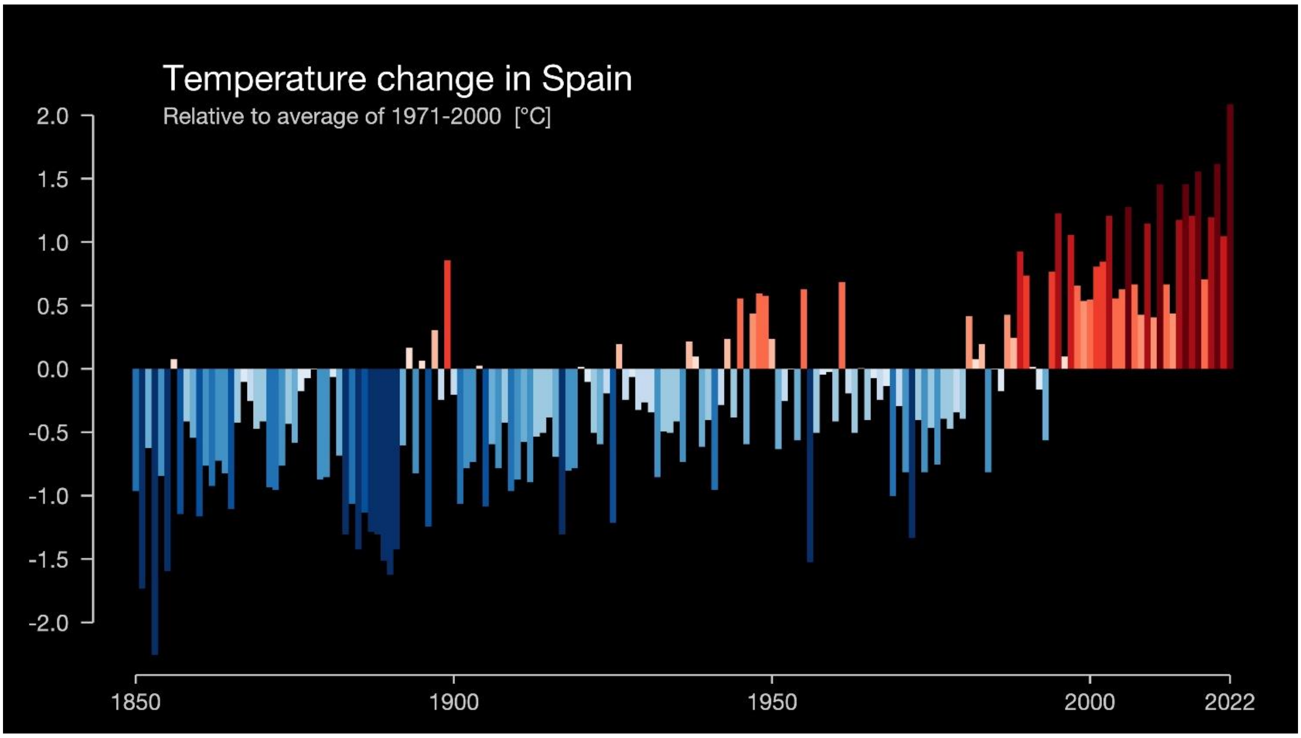

Figure 1: Temperature change in Spain. (Source: Berkeley Earth / showyourstripes.info)

2023 has been the hottest year recorded globally in human history. In Spain, the 2023 summer was the third hottest on record, behind 2022 and 2003. At a national level across peninsular Spain and the Balearic Islands, 4 official heatwaves were recorded in the 2023 summer, lasting a combined 24 days of heatwave conditions. At 23 weather stations the hottest ever summer mean temperature was recorded.[1]

Spain's meteorological agency (*Agencia Estatal de Meteorología* or AEMET) defines a heatwave as a period of at least 3 consecutive days in which 10% of considered weather stations register maximum temperatures of the 95th percentile or above of daily maximum temperatures in the months of July and August for the period of 1971-2000.[2] The approach means that the threshold for heatwave conditions varies across different regions: for example, temperatures exceeding the threshold in cooler Atlantic or alpine regions would not be considered a heatwave in warmer regions such as Andalucia, Extremadura or the Canary Islands.

Similarly, the formal definition of a heatwave does not necessarily include heat events outside of usual seasonal patterns. For example, in 2023 new records were set for the hottest temperatures ever recorded in Spain in April (reaching over 38 degrees Celsius in Córdoba), and unusually long hot conditions of consecutive days in the high 30s

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[1] Ministerio para la Transición ecológica y el Reto Demográfico. Media release: *El verano de 2023 fue el tercero más cálido desde que hay registros.* https://www.miteco.gob.es/content/dam/miteco/es/prensa/23_09_14_El_verano_de_2023_fue_el_tercero_m%C3%A1s_c%C3%A1lido_desde_que_hay.pdf

[2] AEMET (2019). *Olas de calor en España desde 1975.* *https://www.aemet.es/documentos/es/conocermas/recursos_en_linea/publicaciones_y_estudios/estudios/Olas_calor/Olas_Calor_Actualizacion_Junio_2019.pdf*

were experienced in southern Spain into October; while these events were major historical anomalies they were not formally recorded as heatwaves.

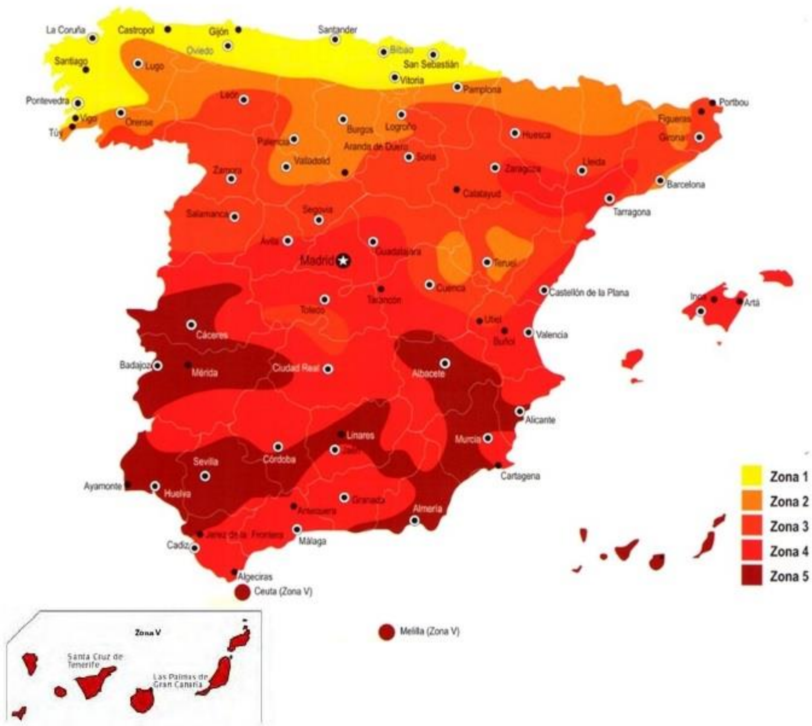

Image: Spain summer climate zones. Regions such as Andalucía, Extremadura and Canary Islands experience hottest summer temperatures.

At a regional level, AEMET data can be used to calculate the number of days under heatwave conditions experienced in locations annually from 1975 to the present. Selected locations using data drawn from analysis by RTVE[3] are as follows. A general trend of an additional three days under heatwave conditions per decade has been observed, alongside an increase in the surface areas affected by heatwaves. The extended heatwave periods experienced in 2022 represent a significant historical anomaly.

[3] RTVE. https://www.rtve.es/noticias/20230914/calculadora-olas-calor-espana/2446505.shtml

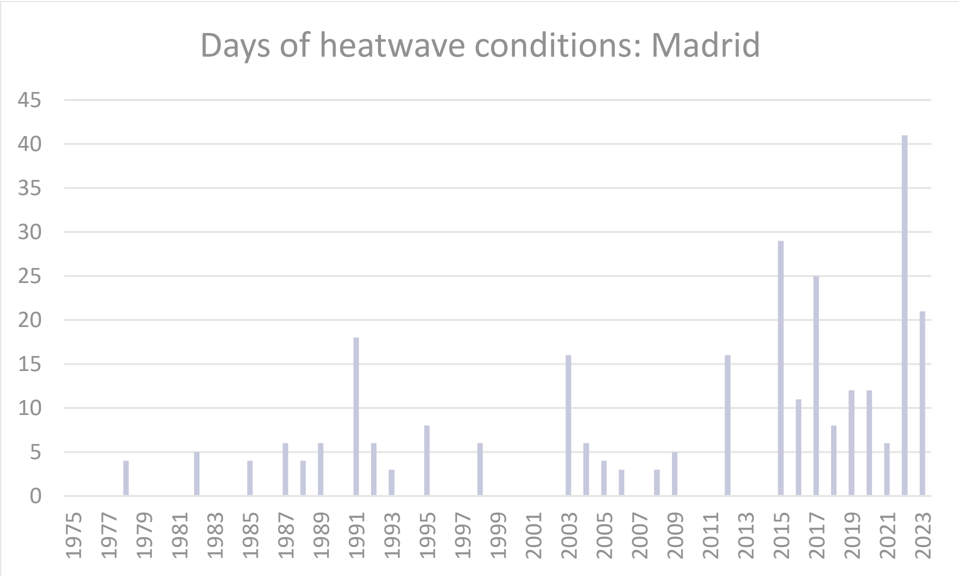

Figure 2: annual days of heatwave conditions in Madrid, 1975 - 2023

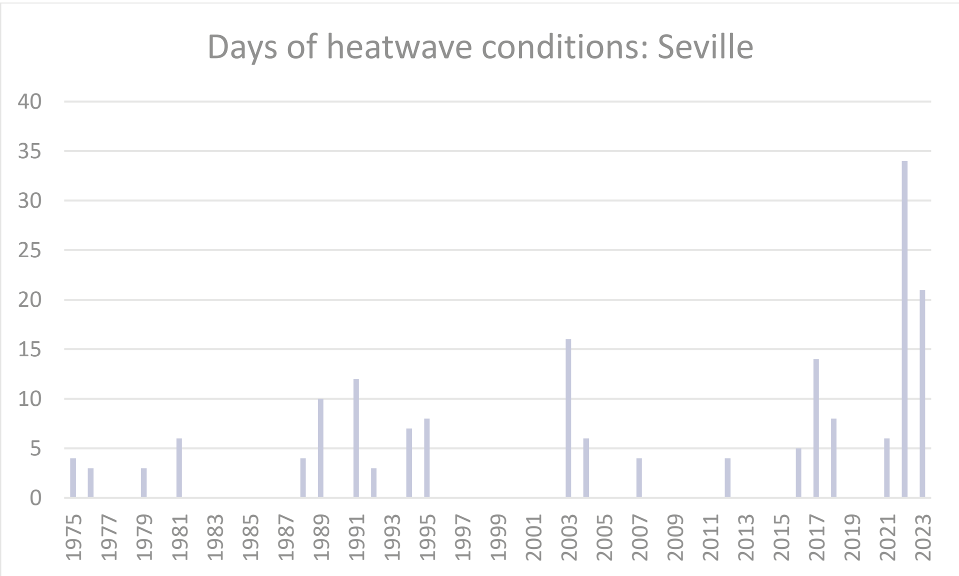

Figure 3: annual days of heatwave conditions in Seville, 1975 - 2023

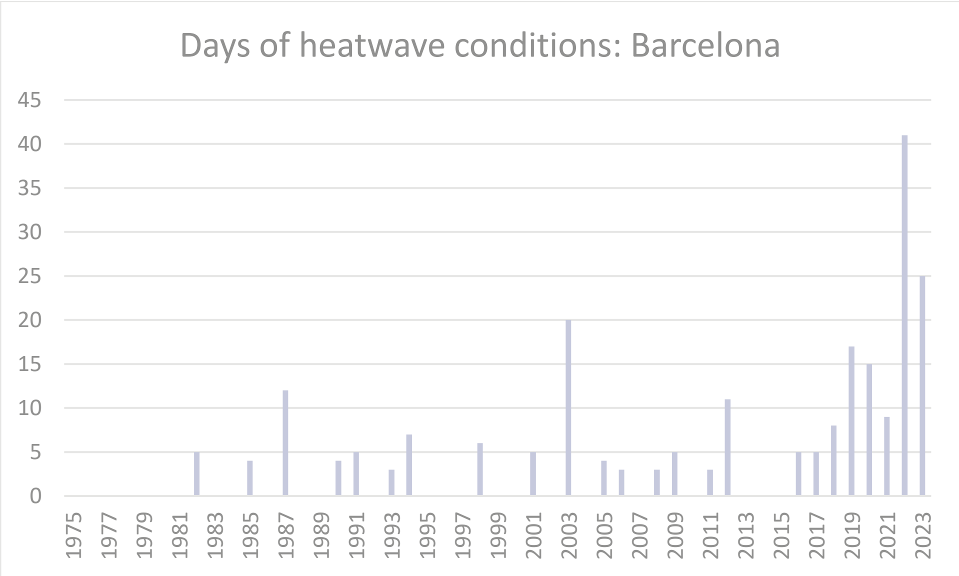

Figure 4: annual days of heatwave conditions in Barcelona, 1975 - 2023

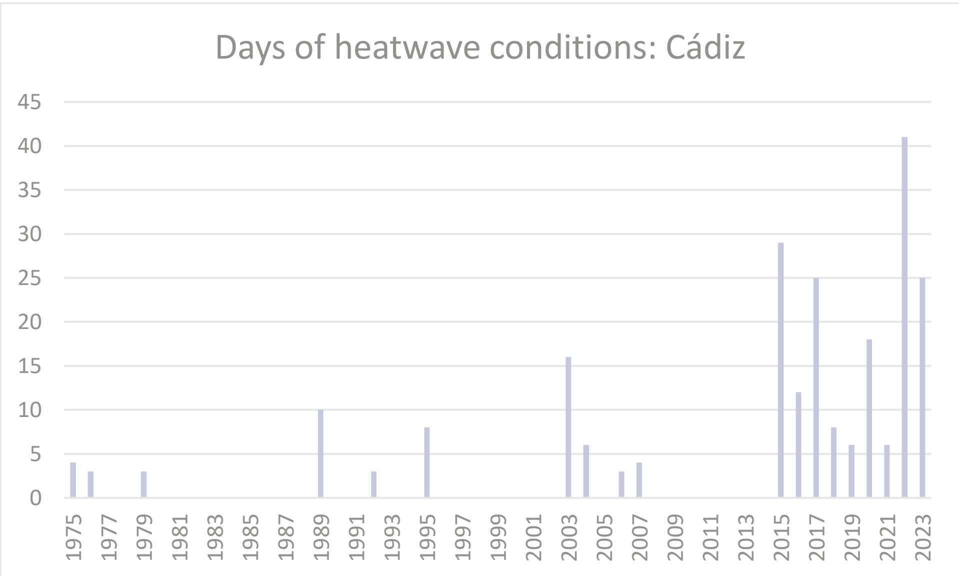

Figure 5: annual days of heatwave conditions in Cádiz, 1975 - 2023

Energy

Energy prices

The 2022 and 2023 heatwave events came in the context of critical challenges for Spain's energy systems.

Wholesale and consumer energy costs increased significantly in 2022. The primary driver was exposure to international gas prices, driving up the overall cost of electricity due to the use of fossil gas for peak electricity generation. Costs increased during 2021 and were exacerbated by the international energy crisis following the Russian invasion of Ukraine.

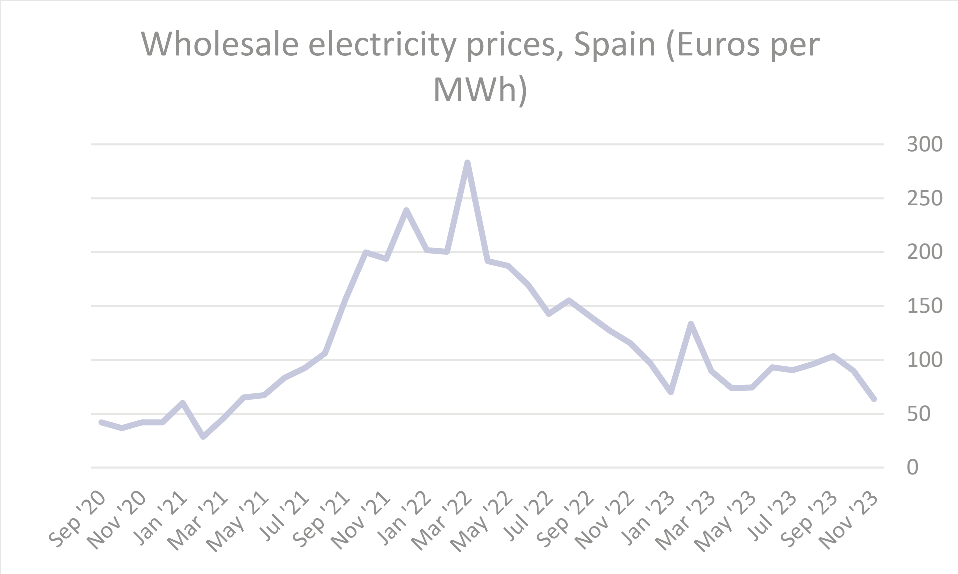

Figure 6: wholesale electricity prices, Spain 2020 - 2023

Highly successful measures were enacted to reduce costs and minimise impacts on households, including particular protections for households that are financially or socially vulnerable. An agreement known as the "Iberian Exception" was reached to temporarily remove Spain and Portugal from the common European energy market, allowing the government to introduce an effective cap on wholesale gas prices (comparable to the measure enacted by Australia in December 2022). Alongside the continued growth of the strong renewable energy sector, the intervention resulted in Spanish energy prices falling to rates well below other European countries by the second half of 2023.

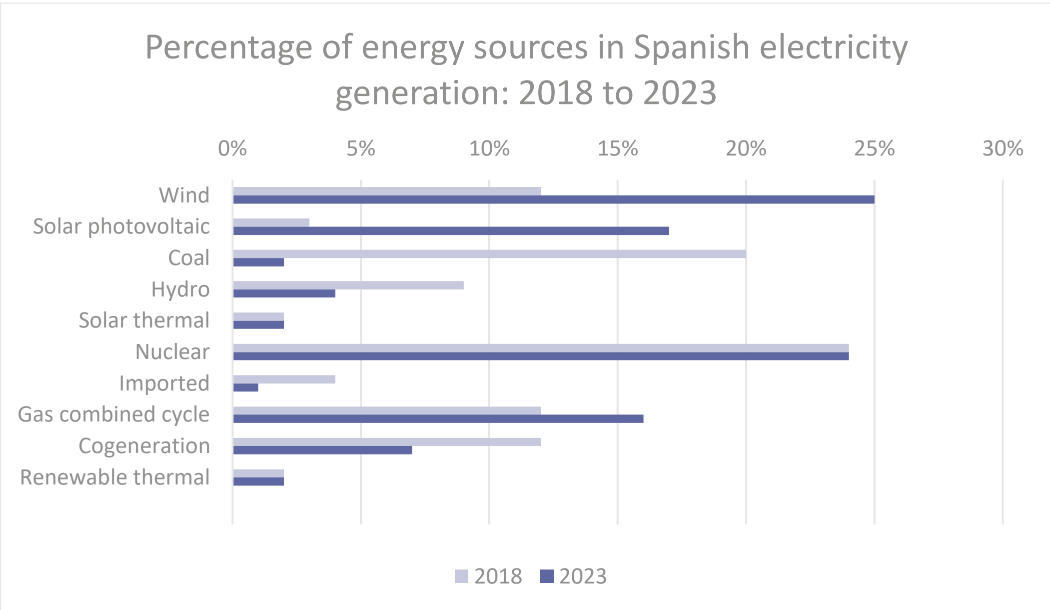

Figure 7: Sources of Spanish electricity generation 2018-2023.[4]

Further demand reduction measures were enacted. An agreement of European energy ministers was reached on 26 July 2022 for the voluntary reduction of fossil gas demand across the EU of 15% by March 2023. In Spain's case, this commitment resulted in an objective of a 7% reduction in gas demand. The major strategies to reach this goal were a

[4] Source: Ministry of Ecological Transition and Demographic Challenge.

mix of energy efficiency, energy savings through reduced usage, and electrification in alignment with the growth of renewables.

Energy and cooling

A law introduced in August 2022 (*Ley Real Decreto 14/2022*[5]) prohibited the use of air conditioning in public spaces and businesses (such as offices, restaurants, and shops) to a thermostat setting below 27 degrees in summer, and heating above 19 degrees in winter. Related communications measures included requirements for signage providing temperature and humidity settings and outlining any other energy savings taken by a business; and increased inspections and enforcement. The government assessed that for each degree Celsius thermostats were increased, energy demand was reduced by 7%. Interviewees indicated that limiting thermostat settings in public spaces has an additional benefit of limiting the 'thermal jump' experienced when moving between very hot and very cool spaces and is consistent with optimal health outcomes. The laws applied to public spaces and businesses only.

The author is not aware of data or research indicating changed household use of air conditioning in 2022-23 resulting from cost pressures or other factors. Data from real estate listings in 2022[6] found that 35% of listed homes across the country had air conditioning available. Rates were higher in warmer locations and major cities (Córdoba 73%, Seville 70%, Palma 61%, Valencia 58%, Madrid 58%, Barcelona 53%), whereas less than 2% of homes had air conditioning in many locations in colder northern regions. Rates of air conditioner availability were higher for homes listed for rent (49%) than in homes for sale (33%); air conditioner availability in rental homes listings reached 84% in Seville and Córdoba. In comparison, 70-80% of Australian homes are estimated to have air conditioning.

While not common across the country as a whole, repeated blackouts have been a serious issue in particular areas – notably low-income neighbourhoods on the outskirts of Seville, where major blackouts have coincided with heatwaves. For example, in June 2023 neighbourhoods faced 16 hours without power on a day when temperatures rose to around 42 degrees. Electricity networks have blamed illegal connections to the grid. Europe's largest informal settlement, Cañada Real on the outskirts of Madrid, has endured an extended lack of connection to the network leaving households without electricity for over 2 years.

Paula Rivas of the Green Building Council España noted in an interview with the author that these reliability risks and assurance of access to electricity (potentially exacerbated by climate conditions such as drought) are a key reason that dependence on air conditioning alone should not be a strategy for heatwave resilience. In particular, in the event of supply outages it is likely to be households or smaller users that face unreliable supply. Rather, measures such as thermal shell efficiency in homes and neighbourhood- or city-scale approaches to reducing urban heat island effects are critical. These include a broader focus on nature-based solutions and biodiversity protection in the built environment.

Summer energy poverty

Energy poverty may limit the capacity of households and communities to respond to extreme heat. Issues include lack of access to cooling, lower dwelling energy efficiency, lower access to green spaces or cooler public spaces, lower access to private spaces (such as cooled shops or hospitality venues), vulnerable living conditions, health conditions related to precarity or poverty, gendered implications of heatwave resilience such as impacts on women-led households, and a range of other factors.

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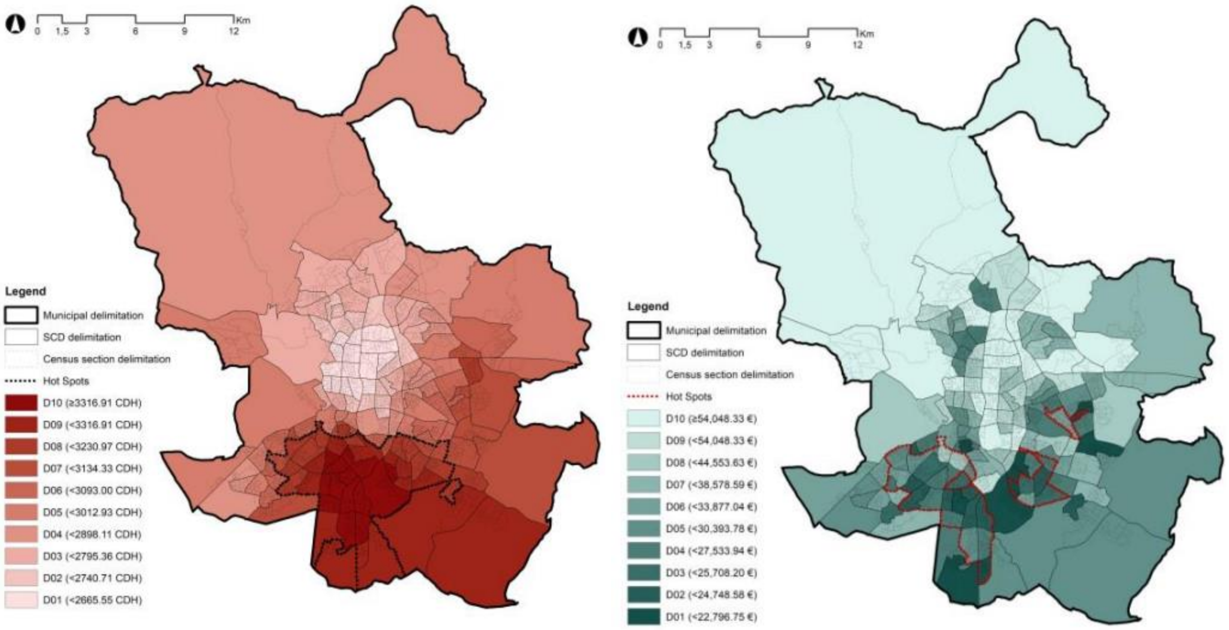
[5] Real Decreto Ley 14/2022. https://www.boe.es/eli/es/rdl/2022/08/01/14/con

[6] Idealista. https://www.idealista.com/news/inmobiliario/vivienda/2022/07/29/798109-solo-una-de-cada-tres-casas-en-espana-tiene-aire-acondicionado

An analysis conducted by researchers at Universidad Politécnica de Madrid and the COOLTORISE program has found that lower income neighbourhoods in Madrid are more exposed to urban heat island effects, with a broad correlation between higher temperatures (due to lower tree cover, geography or other urban design issues) and lower-income areas.[7] It should be noted that research has similarly found a relationship between urban heat island exposure and lower socio-economic status in Melbourne and Sydney.[8]



Images: Madrid urban heat island exposure (left, darker red more exposed); and household income (right, darker green lower income).[9]

European energy poverty programs and research typically focus on winter heating needs, and no formal framework for understanding summer energy poverty has been implemented at the European level. The COOLTORISE program aims to develop a clear framework for understanding and responding to summer energy poverty (see summary in Programs section). A policy brief[10] from the program argues that drivers of summer energy poverty are rooted in cross-cutting structural factors and that it is:

"crucial to enforce the comprehensive monitoring of housing conditions, health policies, urban space, energy access, employment and income, as well as climate change. The latter should be considered as a factor that informs present and future summer energy poverty. To effectively approach the significant issue of summer energy poverty, it would be advisable to implement its direct measurement by means of new primary indicators rather than relying solely on secondary ones. It would be essential to characterise summer energy poverty based on lived experiences and ensure

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[7] Sánchez-Guevara, C., Núñez Peiró, M., Taylor, J., Mavrogianni, A., & Neila González, J. (2019). Assessing population vulnerability towards summer energy poverty: Case studies of Madrid and London. *Energy and Buildings*, 190, 132-143.
[8] Sun, Q. (C.)., Das, S., Wang, K., Tao, Y., Amati, M., Hurley, J., Choy, S., and Duckham, M.: iHVI: AN OPEN-SOURCE TOOLKIT FOR CONSTRUCTING INTEGRATED HEAT VULNERABILITY INDEX IN AUSTRALIA, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVIII-4/W5-2022, 175–182, https://doi.org/10.5194/isprs-archives-XLVIII-4-W5-2022-175-2022, 2022.
[9] Image from Sánchez-Guevara et al (2019).
[10] Gayoso Heredia, Marta; San Nicolás Vargas, Patricia; Torrego Gómez, Daniel; Núñez Peiró, Miguel; Gómez Muñoz, Gloria; Román López, Emilia; Avanzini, Marcello; Ferrer Gabarró, Clara; García París, Marta; Kampouridou, Anneta; Kyrkou, Danai; Sánchez-Guevara Sánchez, Carmen. (2023) How to address summer energy poverty in public policies. Cooltorise project. Universidad Politécnica de Madrid. Available at: https://cooltorise.eu/cooltorise-policy-brief-how-to-address-summer-energy-poverty-in-public-policies/

that it ceases to be overlooked in Europe. Policy design should actively consider these nuances and incorporate targeted measures to address the unique challenges faced during the summer months."

Health impacts

Extreme heat events lead to an increase in mortality, as well as other health impacts. Dr Julio Díaz, Codirector of the Climate Change, Health and Urban Environment Reference Unit at *Instituto de Salud Carlos III*, when interviewed for this project highlighted increased health impacts from extreme heat for particularly vulnerable groups: older people (disproportionately women); people with pre-existing conditions such as cardiovascular disease, respiratory diseases, kidney disease, metabolic diseases, Alzheimer's disease, dementia, Parkinson's disease; pregnancy; and increased incidence of premature birth, emergency admissions and family violence.

The *Mortalidad Atribuible al Calor en España* (MACE) project uses daily government mortality data and weather readings to provide an updating analysis of deaths attributable to heat during summer months, published online.[11] The project analyses increased mortality from moderate heat (temperatures between the *minimum mortality temperature* and the 95th percentile) and extreme heat (temperatures above the 95th percentile). Alongside comparisons with the minimum mortality temperature, an estimate of excessive heat deaths is obtained by comparing extreme heat deaths to a hypothetical baseline of mortality at 95th percentile temperatures. The project finds that over 11,000 deaths in 2023 and over 15,000 deaths in 2022 were attributable to heat; of these, 2,155 deaths in 2023 and 3,012 deaths in 2022 were considered excessive heat deaths.

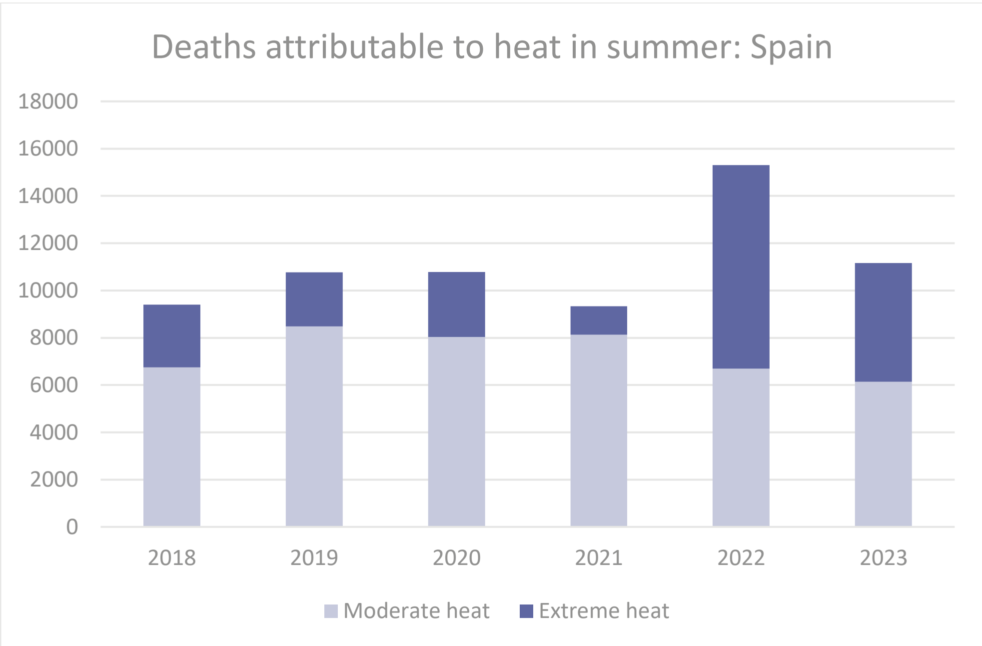

Figure 8: deaths attributable to heat in Summer across Spain.[12]

[11] Mortalidad Atribuible al Calor en España. https://ficlima.shinyapps.io/mace/. See also: Tobías, Aurelio; Royé, Dominic; Iñiguez, Carmen. Heat-attributable Mortality in the Summer of 2022 in Spain. Epidemiology 34(2):p e5-e6, March 2023.
[12] *Data source: MACE project.* Mortalidad Atribuible al Calor en España. https://ficlima.shinyapps.io/mace/.

Measuring Adaptation

Mortality and adaptation

A key indicator in research on heat-related deaths and adaptation is *minimum mortality temperature*. Typically, mortality rates across a population tend to increase with cold or hot temperatures (such as winter cold or summer extreme heat); the minimum mortality temperature is the optimal temperature at which mortality is lowest. This temperature varies across geographical locations and reflects adaptation to local climate conditions: for example, minimum mortality temperatures are typically higher in hotter climates.

In an interview provided to the author, Julio Díaz of Instituto de Salud Carlos III outlined research he and colleagues have conducted on changes to heatwave thresholds and minimum mortality temperatures, which form the basis of this summary.

Minimum mortality temperatures have increased over time in Spanish cities.[13] From 1983-2018, minimum mortality temperatures have increased by an average of 0.64 degrees Celsius per decade; that is, the temperature at which deaths begin to increase is rising. Data provided by Díaz for Madrid is as follows. Increases in minimum mortality temperatures are likewise observed in most other locations considered.

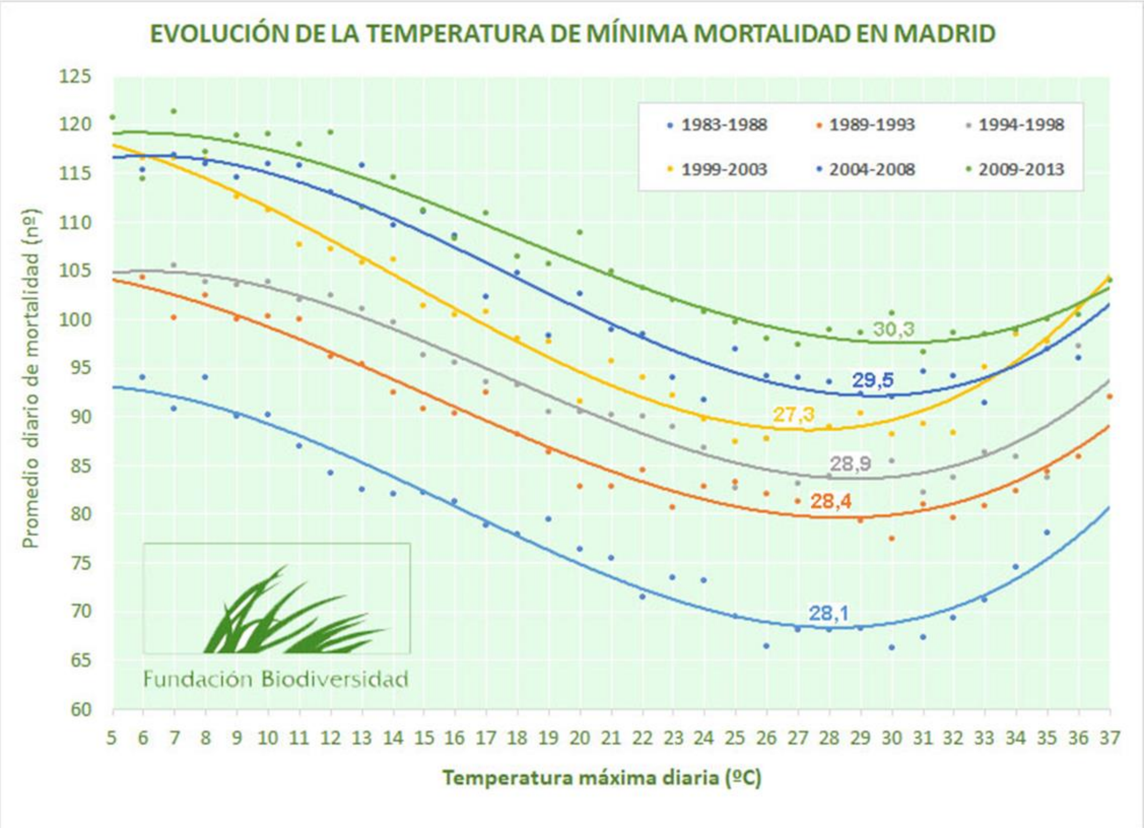

Figure 9: evolution of minimum mortality temperature in Madrid.[14]

[13] López-Bueno, J.A., Díaz, J., Follos, F. *et al.* Evolution of the threshold temperature definition of a heat wave vs. evolution of the minimum mortality temperature: a case study in Spain during the 1983–2018 period. *Environ Sci Eur* **33**, 101 (2021). https://doi.org/10.1186/s12302-021-00542-7

[14] Chart provided to author by Julio Díaz, ISCIII.

However, while minimum mortality temperatures are rising, climate change means that so too are average daily temperatures. While adaptation means that deaths only increase at a higher temperature, those higher temperatures are more likely to occur. This means that adaptation is a continuous process that must keep up with rising temperatures.

Comparing the rate of increased mean temperatures – 0.41 degrees Celsius per decade from 1983-2018 across Spain as a whole, but with regional variation – to the rate of increase in minimum mortality temperatures allows for an analysis of how well locations are adapting to climate change. Díaz finds that adaptation has been faster than temperature increases in most cities considered.

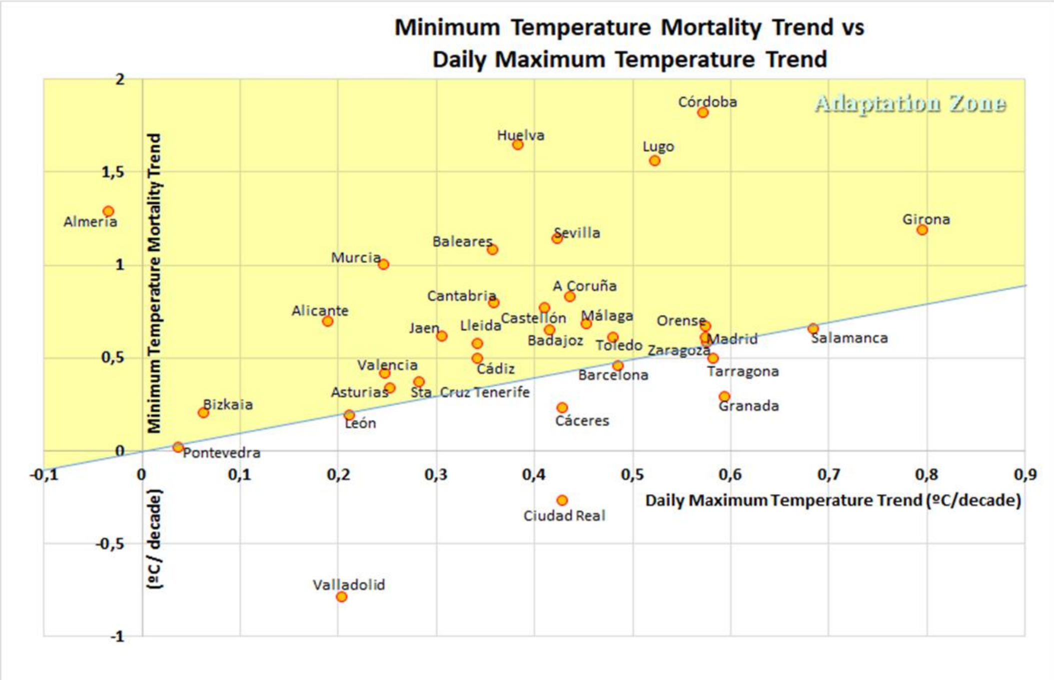

Figure 10: comparison of minimum mortality temperature increases with temperature increases, by location; 1983-2018.[15]

This analysis finds that extreme heat mortality rates are not increasing due to adaptation. However, ongoing projected increases in temperatures driven by climate change mean that processes of adaptation must continue in order to avoid significant increases in mortality: Díaz finds that on an RCP8.5 climate change scenario, mortality rates from extreme heat events would increase in 2051-2100 by 884% without further adaptation processes, but decrease by 30.5% with adaptation.[16] In this sense, adaptation is a continuous challenge and process, rather than a single action.

Critically, physiological adaptation is a part of this trend, however is not on its own sufficient. Explanatory factors for increased adaptation include improvements to infrastructure such as green and blue spaces; social changes, economic development and improvements to homes such as air conditioning and retrofits; improvements to hospitals and health systems; prevention strategies; and 'heat culture' and growing awareness.

[15] Chart provided to author by Julio Díaz, ISCIII.
[16] J. Díaz, M. Sáez, R. Carmona, I.J. Mirón, M.A. Barceló, M.Y. Luna, C. Linares, Mortality attributable to high temperatures over the 2021–2050 and 2051–2100 time horizons in Spain: Adaptation and economic estimate, *Environmental Research*, Volume 172, 2019, Pages 475-485, ISSN 0013-9351, https://doi.org/10.1016/j.envres.2019.02.041.

U-ADAPT

While adaptation is a well-understood and supported concept, there has been an identified lack of frameworks or concrete norms and indicators to assess the implementation of heatwave adaptation measures in cities. A new project, *U-ADAPT!: Urban Adaptation to Extreme Heat Events*, seeks to conceptualise a framework for urban adaptation and to develop a novel composite indicator allowing the measurement and comparison of urban adaptation to extreme heat events across EU cities and over time. This summary is based on stakeholder consultation information provided to the author by project Principal Investigator Yago Martín; further details of findings are to be published.[17]

The draft framework is developed around five adaptation domains (urban heat island effect; extreme heat event exposure; extreme heat event sensitivity; extreme heat event coping capacity; and extreme heat event adaptive capacity). The framework identifies 22 extreme heat event adaptation objectives, including a range of physical and social objectives to reduce heat exposure (for example, reduce urban active and passive heating; reinforcing urban cooling effects; reducing overheating in private and public buildings and transportation) and heat sensitivity and to improve coping capacity (for example, improving population awareness, reducing risk for vulnerable populations, enhancing monitoring and assessment). 125 adaptation measures and strategies are identified to achieve these adaptation objectives.

The detailed and specific measures are intended to allow for the assessment and comparison of adaptation measures undertaken by cities, and may provide an opportunity to assess progress and guide actions. A comparative analysis of European cities using the U-ADAPT framework is underway; this framework may be appropriate in an Australian context.

Governance

National Plan for prevention of health effects of excess temperatures

The *National Plan for prevention of health effects of excess temperatures* was first developed in 2004, in response to the impacts of major 2003 European heatwaves.[18] The Plan is updated each year and is activated from 16 May to 30 September each year, with flexibility for extension where required.

Primary measures include developing warning systems and public information; community advice on safety measures; information systems for health professionals; management of mortality data; coordination with social services targeting vulnerable groups; and administrative coordination across agencies and governments. The Plan includes a framework for identifying the risk level of extreme heat events, based on length, severity and location of heatwaves; ratings range from Level 0 (no risk) to Level 3 (high risk). Each level triggers specific actions on behalf of relevant government agencies. The National Plan plays a coordinating role across actors with direct responsibility, such as Autonomous Community health services; the Plan coordinates rather than overrides local and regional plans where these exist.

The Plan furthermore provides a framework for collection and publishing of weather and mortality data; data is available with short delays and has allowed for researchers to conduct consistent analysis of heatwave mortality.

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[17] Martin, Yago and Paneque, Pilar, A Roadmap for European Union's Urban Adaptation to Extreme Heat Events: The U-Adapt! Framework. Available at SSRN: https://ssrn.com/abstract=4183581. Further unpublished stakeholder information provided by author.

[18] Ministerio de Sanidad (2023). *Plan Nacional de actuaciones preventivas de los efectos del exceso de temperatura sobre la salud.* https://www.sanidad.gob.es/ciudadanos/saludAmbLaboral/planAltasTemp/2023/docs/Plan__Excesos_Temperaturas_2023_.pdf

A standing interministerial commission was created to oversee and apply the Plan, managed by the Ministry for Health and incorporating representatives from the Interior Ministry (responsible for emergencies); Ministry for the Ecological Transition and Demographic Challenge (responsible for energy and meteorological agency AEMET); the Social Rights Ministry; and the Ministry of Territorial Policy (managing coordination with Autonomous Communities).

National ministries are responsible for policy areas relevant to heatwave resilience beyond the National Plan; for example, the Ministry for the Ecological Transition and Demographic Challenge is responsible for energy, the expansion of renewables, and urban issues related to internal migration. The Ministry of Housing and Urban Agenda is responsible for the coordination of Recuperation, Transformation and Resilience Plan funding distribution for residential and local retrofits.

Other levels of government

Spain's decentralised political system means that programs or functions such as health and social services are delivered at the Autonomous Community (state), regional or municipal level.

Local and municipal governments have a key role in urban planning and local responses. Municipalities are typically responsible for urban design and local public spaces, and a primary actor in relation to measures to reduce urban heat island effects such as green spaces. Municipalities of over 50,000 residents are required to enact a 2021 law for 'low emissions zones', restricting vehicle access to city centres; the devolution of responsibility has seen a variety of levels of ambition, and in some cases local partisan political contestation following local elections in early 2023.

Some cities have adopted local and regional heatwave protocols, activated at a certain threshold. For example, Madrid has an annually updated action plan that is activated according to different thresholds (moderate risk at up to 3 days above 36.5 degrees; high risk for 38.5 degrees or extended periods of high temperatures beyond 3 days). The plan allows for changes to school hours, public space uses, specific actions for vulnerable groups, and public transport systems.[19] Barcelona's climate plan includes an emergency plan activated at a similar threshold, and longer-term adaptation measures including climate refuges, drinking and play fountains, energy advice services, shaded spaces, and specific measures for vulnerable groups.

Adoption of such policies varies significantly, including many cities with no similar formal processes or protocols. Córdoba, one of the hottest cities in Spain, has no protocol for immediate heatwave responses; this is a subject of policy advocacy in the city. While municipal governments have responsibility for many public cooler spaces such as libraries or similar facilities, concerns were raised to the author that a lack of municipal coordination can limit their effectiveness as heat refuges. In Seville, libraries adopt reduced summer hours and are often closed at the hottest time of day during summer months. Cost or other barriers may in many locations reduce access to other cooler places or facilities such as swimming pools. In some locations the only cooler spaces available are commercial, which in practice is a serious barrier to access.

Interventions and social responses

This section provides summaries of specific social, community, government and organisational responses to the threat of extreme heat events.

[19] Comunidad de Madrid (2023). *Plan de actuación ante episodios de altas temperaturas 2023.* https://www.comunidad.madrid/sites/default/files/plan-contra-calor.pdf

Home retrofits

Home retrofit programs are a critical focus of adaptation to increasing extreme heat events, alongside a focus on mitigation of emissions from residential energy use through energy efficiency, electrification, and distributed renewables.

60% of Spanish homes were built before the introduction of minimum energy efficiency standards, and around 80% of Spanish homes have a low energy efficiency rating (E, F or G on the European Energy Performance Certificate scheme). A new analysis by energy not-for-profit *Fundación Renovables*[20] finds that energy retrofits including heat pumps, solar where feasible, and a range of passive energy efficiency measures such as shading and thermal shell improvements can reduce energy use and emissions; installing heat pumps and addressing thermal bridging were found to be the most cost-effective measure across various Spanish climate zones.

The European Union-funded *Recuperation, Transformation and Resilience Plan* is targeting retrofits of 160,000 homes by the end of 2023 and 510,000 homes by 2026 in Spain as part of a broader European 'renovation wave'. Grants of up to 21,400 Euros are available to cover 40-80% of the cost of retrofits, and up to 100% for socially and financially vulnerable households.[21]

With a decentralised political and administrative system, funding and programs are managed at a regional or municipal level with funding distributed by the national government to Autonomous Community governments. Exact approaches and funding models vary significantly. Environmental NGO ECODES has conducted a comparative analysis of progress across different Autonomous Communities (roughly equivalent to Australia's states). Findings include that the upfront loan amount and resident out of pocket expenses vary significantly, with an average of 36% of costs provided prior to retrofits; only some Autonomous Communities provide all funding upfront. 81% of retrofits funded in major cities were found to correspond to areas of social disadvantage. However, not all regions specifically prioritised or set aside funds for retrofits in socially vulnerable communities.[22]

Direct funding sits alongside other regulations aimed at promoting home energy retrofits, including the mandatory disclosure of energy ratings when homes are advertised for sale or lease.

The challenges for renovations are somewhat different to those faced in Australia. Over 80% of homes in cities are apartments, limiting the scale of rooftop solar PV; while there is a growth in community energy models, Spain's significant renewable energy generation is primarily in larger-scale solar and wind farms. The apartment-dominated housing stock also requires building-scale retrofits, neighbourhood-scale initiatives led by councils, coordination and a focus on the surrounds of buildings. When compared to detached house retrofits, this can result in greater benefits and inclusion, but also deeper coordination problems, requirements for public funding, and social licence issues related to addressing shared spaces or streetscapes or achieving buy-in for building-wide retrofits.

Heat culture

A concept that was emphasised by multiple interview participants was that of *heat culture* (*cultura de calor*). This encompasses the shared understandings and practices of communities on resilience to heat, and the active participation by communities and individuals (alongside the passive infrastructure that is often considered as the primary focus of adaptation). Elements may include actions within the home – using shade, choosing an appropriate

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[20] Fundación Renovables (2023). *Hogares sostenibles, soluciones asequibles. Costo eficiencia en la rehabilitación energética*. https://fundacionrenovables.org/wp-content/uploads/2023/12/20231130-Hogares-sostenibles-soluciones-asequibles_DEF-1.pdf

[21] Ministerio de Vivienda y Agenda Urbana. *Programa de ayudas para la rehabilitación integral de edificios residenciales y viviendas*. https://www.mitma.gob.es/ministerio/proyectos-singulares/prtr/vivienda-y-agenda-urbana/programa-de-ayudas-para-la-rehabilitacion-integral-de-edificios-residenciales-y-viviendas

[22] ECODES 2022. *Rehabilitar nuestras viviendas sin dejar a nadie atrás. Análisis comparativo de las convocatorias autonómicas de ayudas a la rehabilitación residencial del Plan de Recuperación en cuanto atención a la vulnerabilidad.* https://ecodes.org/images/que-hacemos/03.Energia_y_personas/pdf/ECODES_-_Informe_planes_rehabilitacion.pdf

time to open windows, taking possible steps prior to dependence on air conditioning – as well as shared community use of spaces around homes, public spaces, or broad social practices and attitudes.

Measures available to reinforce and strengthen heat cultures include public education and information, building awareness of heatwave risks and responses, and ensuring laws, workplaces and public spaces are consistent with best possible resilience. A specific focus on education on heat resilience for migrants was identified: for example, migrants from more humid climates may emphasise air conditioning rather than more adaptive strategies to heat in a Spanish climate context.

Climate zones and building codes

Climate zones vary across Spain, including Mediterranean, Atlantic, continental and alpine climates. In general, the south and some other smaller regions experience a relatively hot and dry climate, with hottest summertime temperatures occurring in regions such as the Guadalquivir valley in Andalucía (the location of cities such as Seville and Córdoba) and areas of the central plateau. Mediterranean climates on the east coast (Valencia, Barcelona) are more moderate, while northern regions (Galicia, Aragon, País Vasco) are significantly cooler and wetter.

The national building code uses a model of climate zones that takes into account the severity of both summer and winter temperatures. Winter temperatures (exposure to cold) are rated on a scale from Zone A to Zone E, with Zone A being the most mild and Zone E the coldest. Summer temperatures (exposure to heat) are rated on a numerical scale from 1 to 4, with 1 being mildest and 4 being hottest. Each location is allocated a combination of the two ratings: e.g. Madrid is classified as D3 (reflecting relatively high summer temperatures and low winter temperatures); cooler Burgos is E1; the mild winters and relatively hot summers of Cádiz result in a classification of A3; and the slightly cooler winter temperatures and extreme summer temperatures of Seville are classified as B4. The Code determines minimum energy efficiency requirements for thermal shell based on climate zones with conditions for heating and cooling loads. It furthermore sets requirements for a range of other energy features such as installed appliance efficiency, renewable energy sources for hot water, and electric vehicle charging.

Low emissions zones

A 2021 law (the *Climate Change and Energy Transition Law)* requires that all Spanish municipalities with population over 50,000 implement a 'low emissions zone' by the end of 2023 with a goal of mitigating emissions and improving urban air quality; reducing urban heat island effects is a secondary objective. Poor air quality compounds health impacts of heatwaves and measures to reduce air pollution improve health outcomes during extreme heat events. The low emissions zones are based on examples of central Madrid and Barcelona. The primary mechanism is curbing private vehicle use, barring vehicles that do not comply with emissions standards, creating pedestrian spaces, and favouring public transport and active transport. Municipalities are responsible for implementation of the national law and have a degree of autonomy in design.

Workplace responses

In hotter regions legal minimum requirements are in place limiting outdoor work under hot conditions. In Andalucía and Extremadura these include a limit of outdoor work to set hours during summer: from June to August outdoor agricultural work is limited to a maximum of 6 hours and 10 minutes of consecutive work, commencing at 7am and concluding before 2pm. Outdoor construction work is similarly limited to 7 hours concluding at 2pm. In practice enforcement of these rules has not always been achieved. Disturbing cases of workplace deaths related to heat stress have received significant media attention.

The union movement (as represented by the Workers Commissions or CCOO) has a range of industry and regional responses and campaigns for workplace safety under heat conditions, including union climate representatives.

Urban interventions

A wide range of urban interventions are visible in response to urban heat islands. Interventions vary widely across different municipalities and locations; this report does not seek to provide an exhaustive or comparative list. Measures include greening of public squares and spaces; reduction of vehicular traffic; outdoor cooling devices; shading; or cooler public spaces.

Image: street shading, central Madrid

Local decisions have been the subject of controversy and partisan political conflict, including in the context of local elections held in early 2023. A prominent controversy was the redevelopment of Madrid's central *Puerta del Sol*, with a design dominated by impermeable surfaces and no shading or trees. A range of other Madrid squares have been redeveloped to increase tree cover; the major *Plaza de España* was similarly redeveloped with limited tree cover. Other local disputes include removal of trees for projects (such as Madrid metro expansions); or council failure to plant new trees where opportunities or commitments exist, such as in Seville where tree planting takes place on an annual seasonal basis but concerns exist that plantings do not fully compensate for lost trees due to projects.

Image: redeveloped central square Puerta del Sol, Madrid.

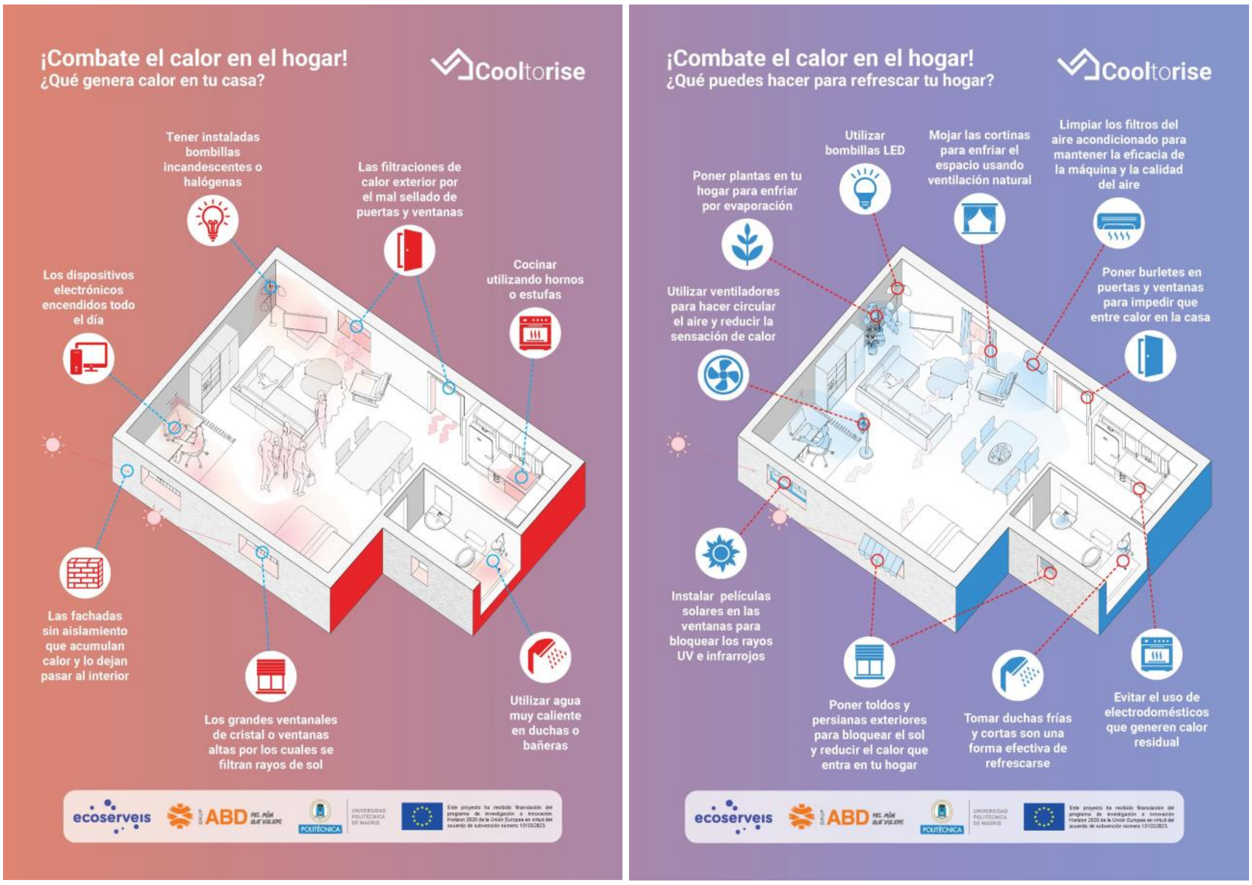
Programs, movements and initiatives

COOLTORISE

COOLTORISE is an EU-funded program working across four southern European countries engaging with summer energy poverty. It engages directly with households experiencing summer energy poverty as well as coordinating research and advocacy for awareness of summer energy poverty. This summary is primarily informed by an interview provided to the author by Miguel Núñez of the Universidad Politécnica de Madrid, a core participating organisation in the program.

European understandings and frameworks on energy poverty typically implicitly centre on winter heating needs in colder climates. For regions in southern Europe, a focus is required on summer energy poverty and its impacts on heat resilience. The COOLTORISE project includes an objective to set a common framework on summer energy poverty and to define solutions that can inform actions.

The program delivers workshops on heat resilience, household interventions and heat culture, with a primary focus on communities vulnerable to energy poverty. Communication and education resources specific to heat resilience and summer energy poverty have been developed by UPM researchers and distributed through the COOLTORISE program.



Images: communications materials on heat developed by UPM and COOLTORISE. Translation: Fight heat in the home! Left: what generates heat in your home? Right: What can you do to cool down your home?

Gender equity and addressing common barriers that impede the participation of women in programs is considered in program design; Miguel Núñez of UPM notes in an interview the gendered impacts of heatwaves and energy poverty, and the specific impacts on households led by women. The COOLTORISE program and associated work of UPM researchers includes family workshops at times and locations suitable for families with children, and child-focused educational activities on heat resilience; age-appropriate activities include measuring draughts with hand-held paper windmills.

The program furthermore includes heat alerts to participants and subscribers, in the form of SMS alerts with information and advice. Alerts are sent on an opt-in basis only to program participants as an initiative in place of government alerts; they may form a model for expansion including to community-wide alerts from official government agencies.

EPIU Getafe / Hogares Saludables

EPIU Getafe and *Hogares Saludables* (Healthy Homes) are an EU-funded program hosted by the council of Getafe, a suburban municipality south of Madrid, with an objective of identifying and addressing energy poverty.

The Healthy Homes program provides a one-stop shop for home upgrades addressing energy poverty, including advice, assessments, funding, and delivery. Advice includes understanding energy bills, reducing energy use, accessing concessions, consumer rights, and energy efficiency upgrades. The program has a permanent public desk at the Getafe council office as well as regular stalls and ‘mobile offices’ in public locations. Advertising is prominently visible encouraging residents to access the program.

Image: public advertisement for Getafe's Healthy Homes program. Translated text: "1300 families in Getafe have saved close to 400,000 Euros from their energy bills thanks to advice from Healthy Homes Getafe. You can benefit too. Visit us or call us."

Other elements of the program include public education and communications campaigns, workshops, and research coordination. The program furthermore targets interventions at the building, location and neighbourhood scale. A prominent example is the demonstration of upgrades to public squares and areas near buildings that are vulnerable to extreme heat with techniques such as vegetation, permeable surfaces, and shading.

Image: unrenovated public square, Las Margaritas, Getafe

Image: Renovated cooler space and heat refuge, featuring permeable surfaces, vegetation and shading. Las Margaritas, Getafe

Image: signage for upgraded "healthy space" in Las Margaritas, Getafe.

ProMETEO Sevilla

ProMETEO Sevilla is a pilot project led by the US-based Adrienne Arsht-Rockefeller Foundation Resilience Centre of the Atlantic Council, with collaboration from the Seville council, Spanish meteorological agency AEMET, universities and NGOs. The primary focus of the project is the world-first categorisation and naming of heatwaves in a model based on international practices towards other weather events such as cyclones or hurricanes. Officially named heatwaves affecting Seville between June and August in 2023 were Yago, Xenia, Wenceslao, and Vera. The naming strategy aims to build public awareness of the impacts of heatwaves on health, and to advocate for measures to reduce their impact. Alongside naming heatwaves, the project has developed a framework to classify potential impacts of heatwaves (from no impact to very high risk), comparable to Australian bushfire risk rating levels; education and public communications on measures to reduce impacts; and issuing heatwave alerts.

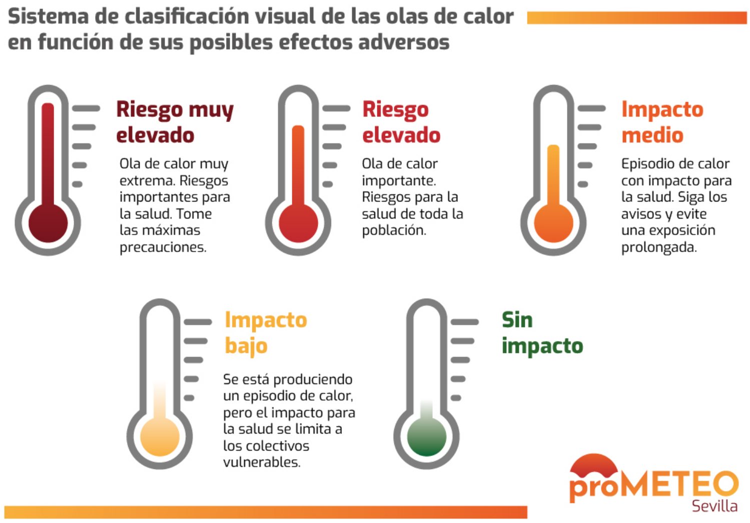


Image: heatwave alert levels as communicated by proMETEO Sevilla; ranging from very high risk to no impact.

Image: heatwave alert as issued by proMETEO Sevilla.

Escuelas de Calor

Escuelas de Calor (literally “Schools of Heat”, a play on a song title) is a community campaign that pushed for cooling or rehabilitation to reduce temperatures in school classrooms in Sevilla. The campaign successfully secured a government commitment and law passed unanimously by the Andalucían parliament in 2020 to guarantee thermal comfort in schools. However, implementation of retrofits or the installation of air conditioning was delayed in many schools, becoming a public focus ahead of elections held during summer in 2023 (campaigners leafleted at school voting booths). A principal slogan is “Classrooms, Not Saunas”. In some cases, local associations or parents’ groups have funded the installation of air conditioners where government installations have been delayed, raising concerns about social equality as community funding is less accessible for schools in lower-income areas.

Image: Escuelas de Calor protest, Seville. (Image source: La Voz del Sur)

Barrios Hartos

Barrios Hartos (“fed up neighbourhoods”) is a network of community organisations and residents’ groups representing suburbs around Seville. The network has campaigned actively for a response to the problem of blackouts affecting specific neighbourhoods, primarily low-income neighbourhoods to the south of Seville, including during times of extreme heat. A protest was held by the network outside the offices of energy distributor Endesa following a 16-hour blackout affecting working class neighbourhoods during a June 2023 heatwave. Endesa has argued that the blackouts are a result of illegal energy use (related to indoor marijuana crops), and that they have installed capacity that should be sufficient for legal demand. Alongside campaigning on the blackouts issue, Barrios Hartos provides a platform for community organising and a range of campaigns on issues affecting residents.

Image: protest outside office of electricity distributor Endesa by Barrios Hartos. Translation: "Sick of blackouts. Generators now! Endesa is responsible". (Image source: tercerainformacion.es)

Alliance for retrofits with nobody left behind

An alliance of 25 NGO, university and civil society groups is advocating for retrofit programs at the EU, national and regional levels that centre a social focus and guarantee access to energy and accessibility retrofits for people in socially and economically vulnerable positions. Activities include campaigns, research, and coordination across projects.

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Ángela Lara García, Universidad de Sevilla

Juan Fernando Martín, Fundación Renovables

Yago Martín, Universidad Pablo de Olavide

Miguel Núñez Peiró, Universidad Politécnica de Madrid

Paula Rivas, Green Building Council España

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