15TH IEA HEAT PUMP CONFERENCE
MAY 26–29, 2026 | HOFBURG
VIENNA 2026
DECARBONISATION THROUGH INNOVATION

A Web-Based Tool for Visualizing Sound Propagation from Air-to-Water Heat Pumps Using a Map Interface

Michael Wernhart[a,*], Christoph Reichl[b], René Rieberer[a]

[a] Graz University of Technology, Institute of Thermal Engineering, 8010 Graz, Austria
[b] Austrian Institute of Technology GmbH, Center for Energy, 1210 Vienna, Austria

Abstract

Air-to-water heat pumps are a key technology in the transition to low-carbon heating systems, but their outdoor units can emit significant noise, raising concerns about acoustic comfort in residential areas.

To reduce residents' uncertainty and concern regarding noise and to enable sound propagation assessments for residential heat pump planning a web-based tool has been developed as part of IEA HPT TCP Annex 63: *"Placement Impact on Heat Pump Acoustics"* This tool builds upon a 2D version previously developed by the Danish partner DTI during IEA HPT TCP Annex 51, originally created for the Danish Energy Agency. The enhanced platform allows users to select different heat pump models, position them in real-world locations using geospatial data, and assess the resulting sound pressure levels and noise propagation in the surrounding environment through an interactive map interface.

This paper presents the design, functionality, and application of the tool, as well as its potential for improving acoustic planning in residential areas.

Keywords: Noise; Residential; Geodata; Environment

1. Introduction

Air-to-water heat pumps (A/W-HP) facilitate an efficient integration of renewable electrical energy for heating in order to replace fossil resources. Therefore, they became central to national strategies aimed at reducing greenhouse gas emissions in the building sector and are pivotal for energy transition [1][2]

However, despite the technological and ecological benefits of A/W-HP, their outdoor-units (esp. compressor and fan) generate noise which can propagate into the neighborhood. Therefore, they often raise concerns which can result in a delay or prevention of an otherwise retrofit project. One reason for this barrier is that the interpretation of manufacturer's sound power levels and understanding propagation effects, e.g. under real-world conditions (geometries, facades), can be challenging and might result in a mismatch of presumed and actual sound impact. [3]

To address these issues, an easily accessible web-based tool was developed within IEA HPT Annex 63 [4] which allows users to virtually place heat pumps in realistic neighborhood settings to visualize predicted sound pressure levels. The platform represents a modernized and enhanced version of a previous system created during IEA HPT Annex 51 [5]. It (now) supports multilingual interfaces (with the possibility for stakeholders to implement further languages), ensures global applicability using OpenStreetMap geospatial data and an extensive heat pump database.

The present paper provides a description of the modelling foundations, their implementation and practical application of the tool.

* Corresponding author. *E-mail address:* michael.wernhart@tugraz.at

2. Modelling approach

Noise from outdoor heat pump units is governed by source characteristics, installation configuration, and environmental propagation. Regulations typically limit allowable sound pressure levels depending on the installation site, especially during night-time operation.

The basic propagation model based on ISO 9613 [6] is shown in Eq. (1). Here, the A-weighted sound pressure level (L_p) at a distance (d) is derived from the A-weighted sound power level (L_w) taken from manufacturer data assuming a point source radiating above a reflecting ground plane ("-8 dB" conversion constant for a hemispheric propagation).

$$L_p(d)=L_w - 20\log_{10}(d) - 8 \qquad \text{Eq. (1)}$$

To consider effects of the surrounding environment on the sound pressure level, a calculation according to Eq. (2) is based on [7] applied. Here, L_w^{eff} denotes the effective sound power level of the heat pump (if an acoustic enclosure is applied, it is represented by a reduction of the sound power level according to Eq. (3)).

$$L_p(r,\varphi)=L_w^{eff} - [20\log_{10}(d)+8] - A_{barrier} + C_{refl} + C_{dir}(\varphi) + C_{surf} \qquad \text{Eq. (2)}$$

$$L_w^{eff} = L_w - A_{shield} \qquad \text{Eq. (3)}$$

The further individual terms in Eq. (2) are defined as follows:

- C_{refl} considers amplification due to nearby building surfaces: +3 dB for a single façade; +6 dB for a corner configuaration

- $C_{dir}(\varphi)$ accounts for the directional radiation pattern of the outdoor unit. Typical values are 0 dB in fan direction, −3 to −6 dB laterally, and −6 to −10 dB rearward. If no manufacturer directional data are available, an omnidirectional source is assumed.

- C_{surf} is used to distinguish between predominantly hard (0 dB) and soft surfaces (−3 dB), considering differences in ground absorption (e.g. earth or grass are considered an acoustically soft surface)

- $A_{barrier}$ considers difraction of sound propagation due to single barriers (no free line of sight) and is calculated according to Eq. (4) at a given wavelength ($\lambda = \frac{c_s}{f}$).

$$A_{barrier} = 10 \cdot \log\left(3 + \frac{40}{\lambda} \cdot \delta\right) \qquad \text{Eq. (4)}$$

The path-length-difference (δ) is calculated as shown in Figure 1.

When $\frac{40}{\lambda}\delta < -2$ *or no frequency-data are given, the barrier is set to* $A_{barrier}$=0 dB. *The maximum barrier attenuation is limited to* $A_{barrier,max}$=25 dB.

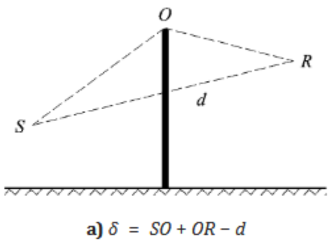

Figure 1: Path-length-difference at a single barrier (acc. to [8])

3. Web-Based Tool Architecture

The simple sound propagation platform is built on an ASP.NET backend and integrates the results of the acoustic model in a geospatical user interface using OpenStreetMap. The tool is available at https://heatpumpingtechnologies.org/project63/2dsp/ .

Users can:

- select a heat pump model from a database or enter custom sound power data (e.g. from the databases provided on the plattform),
- place the unit on the map,
- rotate the fan orientation,
- choose surface characteristics, and
- evaluate sound pressure levels at arbitrary (receiver) points.

Sound levels are computed on demand and visualised either as contour fields or as discrete receiver values. The expendable platform supports multilingual user interfaces and can be configured for different regulatory frameworks (e.g. highlighting an overshoot of thresholds at given locations), enabling international applicability.

The model itself is complete in terms of physics and methodology. The required inputs correspond to the standard information used in environmental noise assessments:

- sound power level (from a heat pump model database or user input)
- geometric description of the building
- ground properties and terrain profile

4. Example Application

To illustrate the application of the tool, a typical residential scenario is evaluated (see Figure 2). Therefore, an A/W-heat pump (L_w = 65 dB) is placed in the backyard of a house, with the fan oriented towards the garden and a ground surface consisting mainly of grass. For the consideration of sound diffraction frequency data (125 Hz) from [9] is used.

Figure 2: left: Input of heat pump data and definition of boundary conditions; right: Positioning and information on a map

In the first step (left), the user enters the heat pump's technical parameters and defines the boundary conditions of the installation. This includes the sound power level, the type of mounting position (e.g., free-standing, corner, or wall placement), the characteristics of the surrounding ground surface (hard or soft), and the presence or orientation of potential noise barriers. These inputs determine both the emission characteristics of the heat pump and the acoustic interaction with nearby surfaces.

In the second step (right), the outdoor unit is positioned in a map (incl. satellite view of the property). The user selects the (intended) installation point, and the tool generates a spatial sound propagation map based on the previously defined boundary conditions. The coloured contours represent the calculated sound pressure levels after diffraction, providing an intuitive visualization of how far and in which directions sound spreads in the specific environment. This spatial representation allows for a quick assessment of potential noise impacts on neighbouring properties.

5. Conclusion

A web-based tool for predicting outdoor heat pump sound propagation has been developed using a simplified ISO 9613 acoustic model. The simplified ISO-based model captures the dominant propagation mechanisms relevant for short-range residential environments while avoiding the computational complexity of full ISO 9613-2 implementations.

Although the model does not resolve complex diffraction geometries, it provides an accessible means e.g., for homeowners and planners to assess noise impacts in residential settings and is sufficiently accurate for preliminary planning and public communication.

The application of the tool was demonstrated using an exemplary installation of a heat pump in a backyard. Placing the unit adjacent to a single façade and utilizing existing garden structures, such as a hedge, can further support compliance with noise-emission regulations.

The open system design of the tool allows text modules to be loaded, extended, or replaced as needed.

A first version of the tool will be showcased at the conference HPC (2026) and will later be available at the IEA HPT Annex 63 website [4].

Acknowledgements

This work has been funded by the FFG (Austrian Research Promotion Agency) within the Austrian participation in the “IEA HPT TCP Annex 63 “Placement Impact on Heat Pump Acoustics” (FFG-No.: FO999898198).

The authors acknowledge the support of tools based on OpenAI for assistance with coding and text preparation.

Nomenclature

Symbol	Description
$A_{barrier}$	Sound attenuation due to barrier (dB)
A_{shield}	Sound attenuation due to acoustic enclosure or shielding (dB)
$C_{dir}(\varphi)$	Directivity correction term depending on angle φ (dB)
C_{refl}	Correction due to reflections from building surfaces (dB)
C_{surf}	Correction due to ground surface type (hard/soft) (dB)
c_s	Speed of sound (m/s)
d	Distance between source and receiver (m)
δ	Path-length difference caused by a barrier (m)
f	Frequency (Hz)
$L_p(d)$	A-weighted sound pressure level at distance d (dB(A))
$L_p(d, \varphi)$	A-weighted sound pressure level considering directivity (dB(A))
L_w	A-weighted sound power level of the heat pump unit (dB(A))
L_w^{eff}	Effective sound power level considering shielding (dB(A))
λ	Acoustic wavelength (m)

References

[1] European Commission, Directorate-General for Energy. “Heat pumps.” 2023. Available at: https://energy.ec.europa.eu/topics/energy-efficiency/heat-pumps_en

[2] Żelazna, A., & Pawłowski, A. “Review of the Role of Heat Pumps in Decarbonization of the Building Sector.” Energies, 18(13), 3255, 2025. https://doi.org/10.3390/en18133255

[3] Department for Energy Security and Net Zero (UK). Review of Air Source Heat Pump Noise Emissions, Permitted Development Guidance and Regulations. UK Government report, 2023.

[4] IEA TCP HPT Annex 63 “Placement Impact on Heat Pump Acoustics” (2023-2026): https://heatpumpingtechnologies.org/project63/

[5] IEA TCP HPT Annex 51 “Placement Impact on Heat Pump Acoustics” (2017-2020): https://heatpumpingtechnologies.org/project51/

[6] ISO 9613-1: Acoustics — Attenuation of sound during propagation outdoors — Part 1: Calculation of the absorption of sound by the atmosphere.

[7] ISO 9613-2: Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation.

[8] Österreichischer Arbeitsring für Lärmbekämpfung, 2021, ÖAL-Richtlinie Nr. 28: Berechnung der Schallausbreitung im Freien und Zuweisung von Lärmpegeln und Bewohnern zu Gebäuden, Wien; accessed on 2025/11/17: https://www.oal.at/images/rl_downloads/RL28_2021-10-01.pdf

[9] Reichl, C., Bessac, F., Klein, G., Stöckl, L., Czuka, M., 2025, Improve Heat Pump Placement Concidering Frequency Resolved Acoustic Directivity Data: Creation of an Open Database, Forum Acusticum Euronoise 2025, 11th Convention of the European Acoustics Association, Malaga, Spain

.

.