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AIT AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

Heat pump installation and effects on surrounding environment

Acoustic Signatures of Heat Pumps
IEA HPT Annex 51

Webinar IEA HPT Annex 51

30.11.2020, 14:00 – 15:30

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IEA HPT

iea Energy Technology Network
Technology Collaboration Programmes

CONTENT

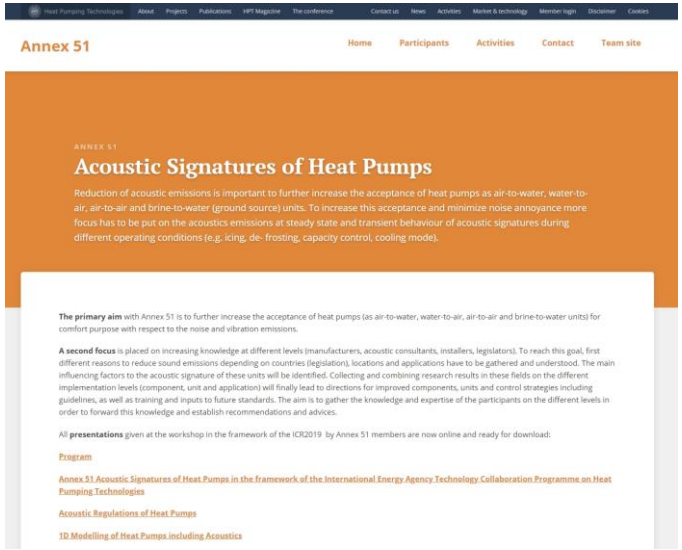
1 INTRODUCTION

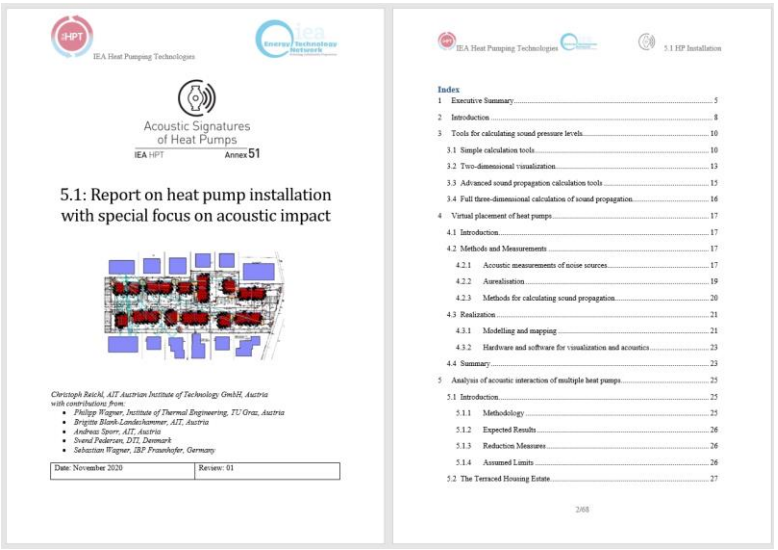
The Task 5 deliverable 5.1 „Heat pump placement and effect on surrounding environment“

INTRODUCTION

Deliverably 5.1 „Report on heat pump installation and effects on surrounding environment“ available for download in version V1 from

Home - Annex 51 (heatpumpingtechnologies.org)





2 TOOLS FOR CALCULATING SPL

Simple calculation tools, 2D visualization, advanced sound propagation and full 3D calculation

TOOLS FOR CALCULATING SPL

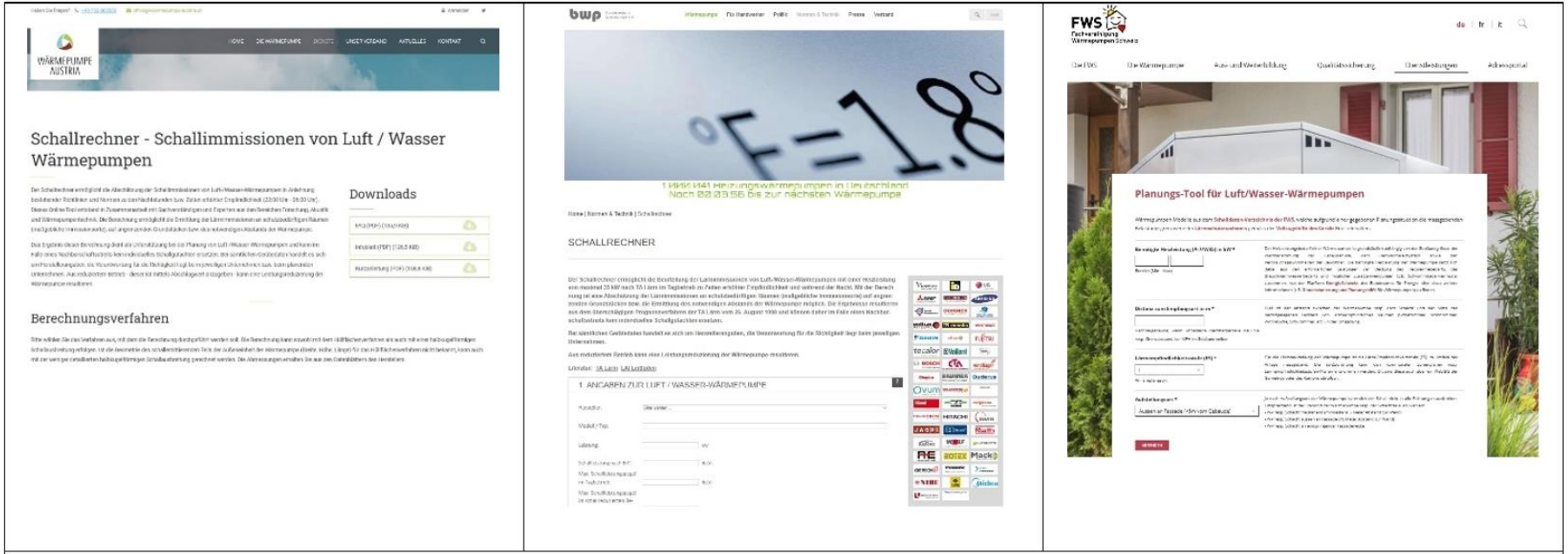
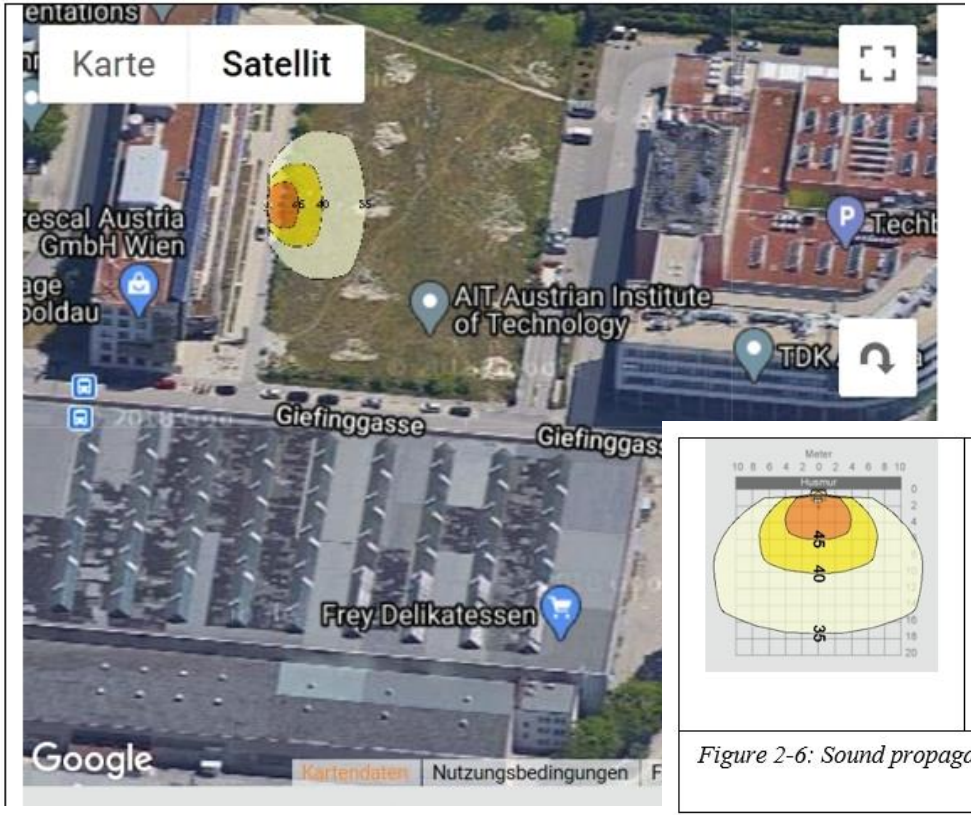


Figure 2-1: Simple web based calculation tools

TOOLS FOR CALCULATING SPL

Figure 2-2: Two-dimensional visualization of sound pressure levels

TOOLS FOR CALCULATING SPL



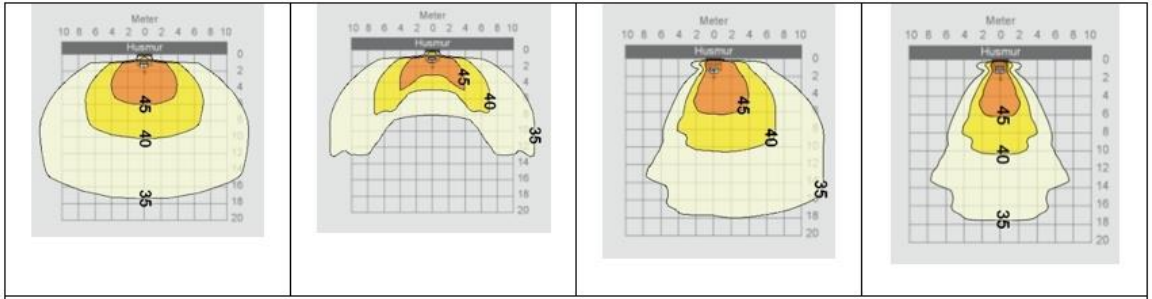


Figure 2-6: Sound propagation visualization depending on the nearby walls [Source: Danish Energy Agency, Denmark - http://stoejberegner.ens.dk]

TOOLS FOR CALCULATING SPL

All these tools neglect - apart from the corner- and wall-placement “penalties” - **absorbtion, reflection or frequency dependencies** in the calculation. The underlying formula is very ease and can be calculated by hand.

To include the effects of directivity and frequency behaviour as well as absorption and reflection a **much larger computational effort** would have to be made.

Advanced sound propagation calculation tools: CadnaA, SoundPlan, Noise3D, MITHRA-SIG, IMMI, Olive Tree Lab Suite, OpenPSTD

Full three-dimensional calculation of sound propagation: BEM, FEM

3 VIRTUAL PLACEMENT OF HEAT PUMPS

Acoustic measurements of noise sources, aurealisation, methods for calculating sound propagation, modeling and mapping and hardware and software for visualization

VIRTUAL PLACEMENT OF HEAT PUMPS

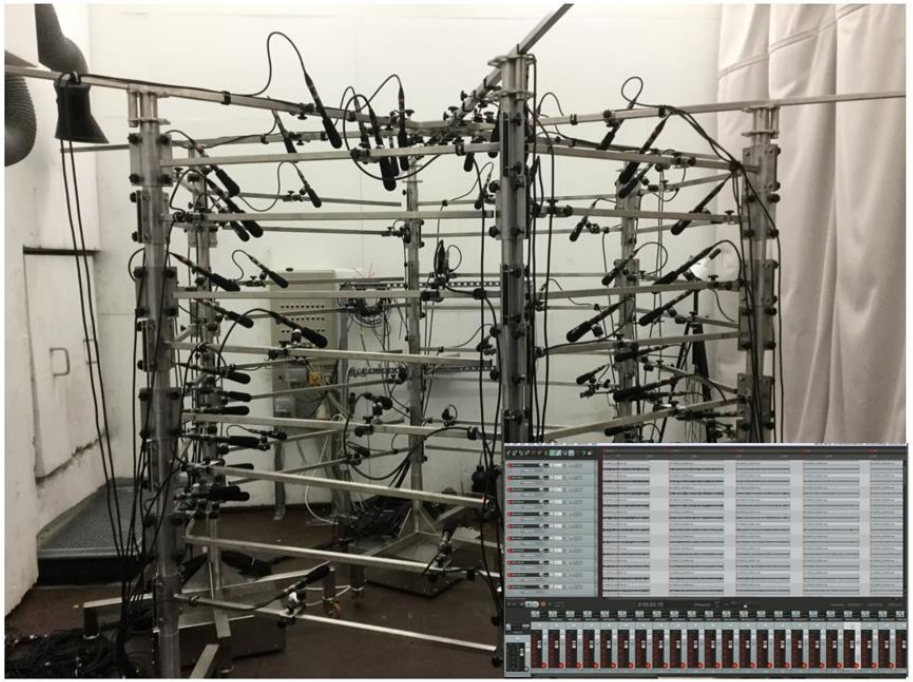


Figure 5-1: Up op 64 microphones are placed around a sound emitting object forming an acoustic "dome". In this case a six-fold symmetrical setup has been constructed. The right lower part of the image shows the some of the wave-signals recorded during a typical test.

VIRTUAL PLACEMENT OF HEAT PUMPS

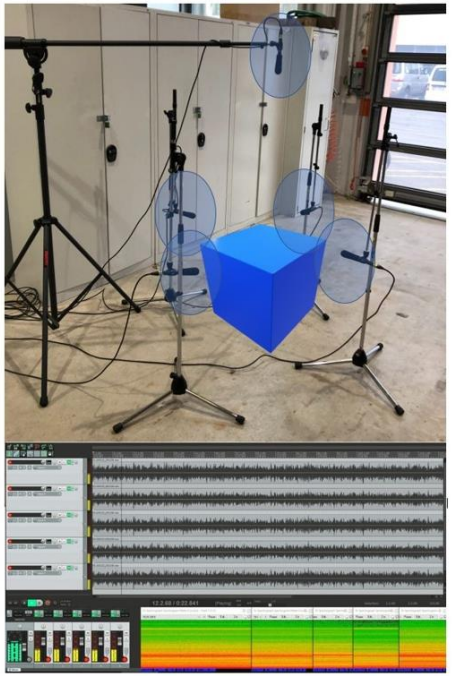


Figure 5-2: 5 microphones are placed around a sound emitting object, one at each side and one from the top. The lower part of the image shows the 5 five signals and their corresponding frequency content represented in waterfall images.

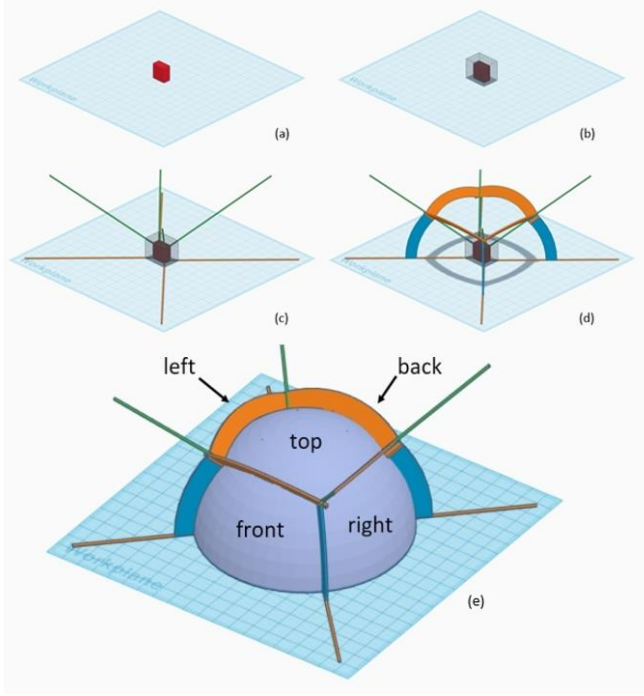


Figure 5-3: Visualization of the directivity aurealisation technique: (a) the red box represents the sound emitting HVAC component (e.g. heat pump); (b) the acoustic pressure is recorded in a specific distance to the emitting surfaces at 5 locations – a measurement surface is formed; (c) rays are generated connecting the emitter's corners with the corners of the measurement surface; (d) parts of the planes stretched by these rays intersected with a sphere; (e) final visualization of the 5 parts of the half-sphere attributed to the 5 microphone measurement positions.

VIRTUAL PLACEMENT OF HEAT PUMPS

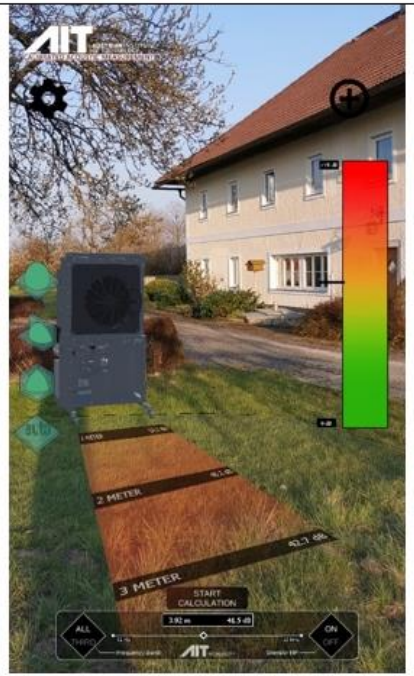


Figure 5-5: A laboratory heat pump (SilentAirHP) placed in a real environment using AR, with frequency-dependent sound propagation.

HVAC POSITIONER APP ON THE WEB

AUSTRIAN INSTITUTE OF TECHNOLOGY

APP for optical and acoustic positioning of heating and cooling devices

Heat pumps are the first choice, if it concerns to bring heating cost saving and environmental-careful heat production together. However their acquisition is a long-term decision and requires exact planning. The HVAC Positioner is the first and only App that uses augmented reality to place a heat pump in a real environment. The implemented real-time sound propagation calculation allows to position the system (heat pump or refrigeration system) perfectly according to current regulations and personal preferences. The AIT Austrian Institute of Technology has developed a method to minimize noise emissions of the population in urban areas. These methods allow a simple, intuitive and at the same time precise handling of noise emissions and are used in the APP of the HVAC Positioner.

The advantages of the HVAC Positioner at a glance:

- Integration of the heat pump / cooling unit in any environment
- The noise development can be displayed visually
- Ongoing development of the application
- Continuous updating of the database and device types
- Available in iOS and Playstore - but the end device (tablet, cell phone) must support augmented reality

APP in Playstore: HVAC Positioner
APP in iOS store: iOS HVAC Positioner

Available on the iPhone App Store

GET IT ON Google Play

4 ANALYSIS OF MULTIPLE HEAT PUMPS

The terraced housing estate, simulation of maximum sound propagation using IMMI, noise barriers influence, time dependent sound propagation

ANALYSIS OF MULTIPLE HEAT PUMPS

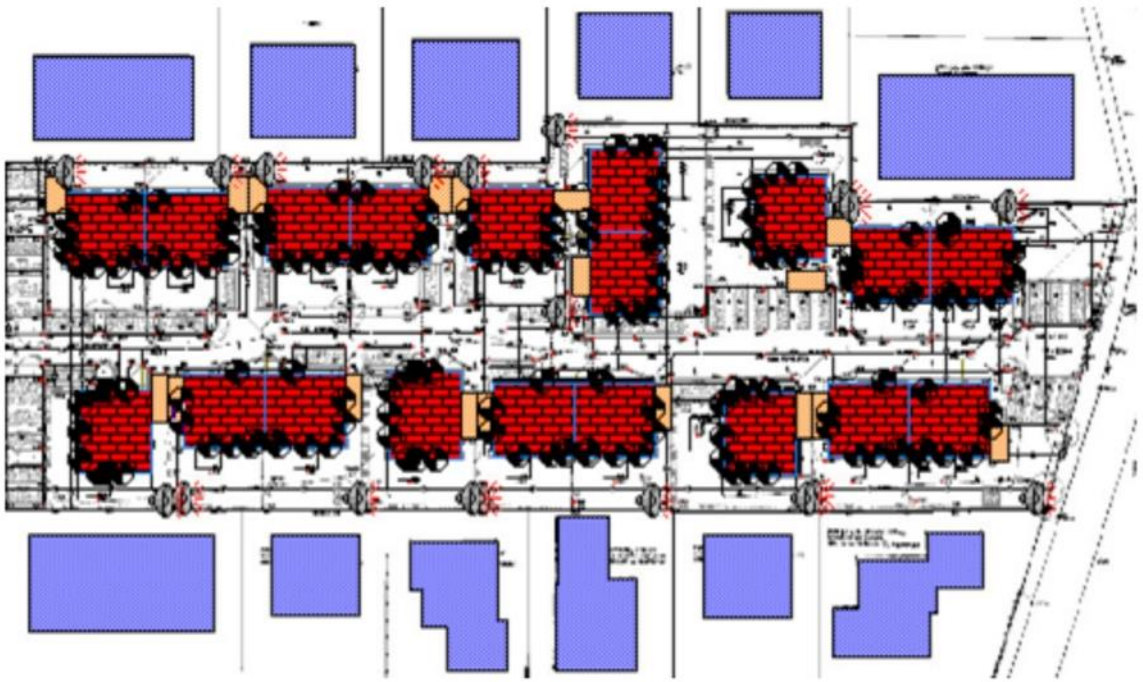


Figure 5-3: Placement of heat pumps in scenario A, variant 1A

ANALYSIS OF MULTIPLE HEAT PUMPS

Nr.	Immissionsort	Nr.	Immissionsort	Nr.	Immissionsort	Nr.	Immissionsort
1	T1 Kinderzimmer 1 DF Nord	42	T6 Schlafzimmer DF Ost	83	T11 Kinderzimmer 1 DF Nord	124	T16 KEW EG Nord
2	T1 Kinderzimmer 2 DF Süd	43	T6 Kinderzimmer 1 DG Nord	84	T11 Kinderzimmer 2 DF Süd	125	T16 Garderobe EG Nord
3	T1 Schlafzimmer DG West	44	T6 Kinderzimmer 2 DG Nord	85	T11 Schlafzimmer DG Ost	126	T16 KEW EG Süd
4	T1 KEW EG Süd 1	45	T6 KEW EG Nord	86	T11 Garderobe EG Ost	127	T16 KEW EG West 1
5	T1 KEW EG Süd 2	46	T6 KEW EG Ost 1	87	T11 KEW E		
6	T1 KEW EG Süd 3	47	T6 KEW EG Ost 2	88	T11 KEW E		
7	T1 KEW EG West	48	T6 KEW EG Ost 3	89	T11 KEW E		
8	T1 Garderobe EG West	49	T6 Garderobe EG West	90	T12 Schlafz		
9	T2 Kinderzimmer 1 DF Nord	50	T7 Schlafzimmer DF Ost	91	T12 Kinderz		
10	T2 Kinderzimmer 2 DF Süd	51	T7 Kinderzimmer 2 DG Süd	92	T12 Kinderz		
11	T2 Schlafzimmer DG Ost	52	T7 Kinderzimmer 1 DG Süd	93	T12 Garder		
12	T2 Garderobe EG Ost	53	T7 KEW EG Ost 1	94	T12 KEW E		
13	T2 KEW EG Ost	54	T7 KEW EG Ost 2	95	T12 KEW E		
14	T2 KEW EG Süd 1	55	T7 KEW EG Ost 3	96	T12 KEW E		
15	T2 KEW EG Süd 2	56	T7 KEW EG Süd	97	T13 Schlafz		
16	T2 KEW EG Süd 3	57	T7 Garderobe EG West	98	T13 Kinderz		
17	T3 Kinderzimmer 1 DF Nord	58	T8 Kinderzimmer 2 DG Nord	99	T13 Kinderz		
18	T3 Kinderzimmer 2 DF Süd	59	T8 Kinderzimmer 1 DG Nord	100	T13 KEW E		
19	T3 Garderobe EG West	60	T8 Schlafzimmer DG Süd	101	T13 Garder		
20	T3 Schlafzimmer DG West	61	T8 Garderobe EG Süd	102	T13 KEW E		
21	T3 KEW EG West	62	T8 KEW EG Süd	103	T13 KEW E		
22	T3 KEW EG Süd 1	63	T8 KEW EG West 1	104	T13 KEW E		
23	T3 KEW EG Süd 2	64	T8 KEW EG West 2	105	T13 KEW E		
24	T3 KEW EG Süd 3	65	T8 KEW EG West 3	106	T13 KEW E		
25	T4 Kinderzimmer 1 DF Nord	66	T9 Kinderzimmer 1 DF Nord	107	T14 Schlafz		
26	T4 Kinderzimmer 2 DF Süd	67	T9 Kinderzimmer 2 DF Süd	108	T14 Kinderz		
27	T4 Schlafzimmer DG Ost	68	T9 Schlafzimmer DG West	109	T14 Kinderz		
28	T4 Garderobe EG Ost	69	T9 KEW EG Süd 1	110	T14 Garder		
29	T4 KEW EG Ost	70	T9 KEW EG Süd 2	111	T14 KEW E		
30	T4 KEW EG Süd 1	71	T9 KEW EG Süd 3	112	T14 KEW E		
31	T4 KEW EG Süd 2	72	T9 KEW EG West	113	T14 KEW E		
32	T4 KEW EG Süd 3	73	T9 Garderobe EG West	114	T15 Schlafz		
33	T5 Kinderzimmer 1 DG Ost	74	T10 Kinderzimmer 1 DF Nord	115	T15 Kinderz		
34	T5 Kinderzimmer 2 DG Ost	75	T10 Kinderzimmer 2 DF Süd	116	T15 Kinderz		
35	T5 Schlafzimmer DG West	76	T10 Schlafzimmer DG Ost	117	T15 Garder		
36	T5 KEW EG Ost	77	T10 KEW EG Nord	118	T15 KEW E		
37	T5 KEW EG Süd 1	78	T10 Garderobe EG Ost	119	T15 KEW EG Süd 2	160	max. Wert Grundgr. Attrappe 7
38	T5 KEW EG Süd 2	79	T10 KEW EG Ost	120	T15 KEW EG Süd 3	161	max. Wert Grundgr. Nachbar 2
39	T5 KEW EG Süd 3	80	T10 KEW EG Süd 1	121	T16 Schlafzimmer DG Nord	162	max. Wert Grundgr. Nachbar 3
40	T5 KEW EG West	81	T10 KEW EG Süd 2	122	T16 Kinderzimmer 1 DG Süd	163	max. Wert Grundgr. Attrappe 8
41	T5 Garderobe EG West	82	T10 KEW EG Süd 3	123	T16 Kinderzimmer 2 DG Süd	164	max. Wert Grundgr. Attrappe 9

ANALYSIS OF MULTIPLE HEAT PUMPS

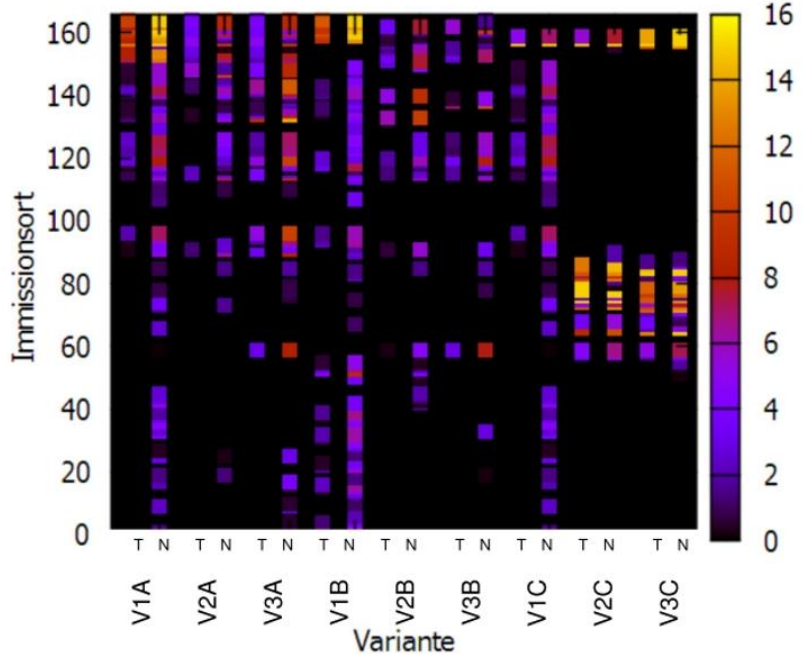


Figure 5-12: Penalty points at the points of immission ("Immissionsort") for different variants and scenarios

Scenario A	Variant 1A		Variant 2A		Variant 3A	
	Day	Night	Day	Night	Day	Night
Sum penalty points	119,71	346,64	33,41	153,08	76,46	239,72
Sum penalty points	**466,35**		**186,49**		**316,18**	
Max. penalty points	12,56	17,56	5,52	10,52	8,93	13,93
Min. penalty points	0,13	0,06	0,37	0,18	0,01	0,15
Mean penalty points	4,13	5,59	2,78	3,93	3,19	4,99
Scenario B	**Variant 1B**		**Variant 2B**		**Variant 3B**	
	Day	Night	Day	Night	Day	Night
Sum penalty points	98,73	341,81	36,89	133,71	30,59	108,86
Sum penalty points	**440,54**		**170,60**		**139,44**	
Max. penalty points	11,32	16,30	5,95	9,95	6,78	11,23
Min. penalty points	0,29	0,40	0,17	0,11	0,53	0,15
Mean penalty points	3,40	4,81	2,46	4,05	2,78	4,19
Scenario C	**Variant 1C**		**Variant 2C**		**Variant 3C**	
	Day	Night	Day	Night	Day	Night
Sum penalty points	57,28	230,82	160,62	198,64	167,65	215,25
Sum penalty points	**288,10**		**359,26**		**382,90**	
Max. penalty points	11,87	13,87	22,44	24,44	22,13	24,13
Min. penalty points	0,13	0,06	1,82	0,04	1,07	0,12
Mean penalty points	2,86	4,44	10,04	9,03	8,38	7,97

Table 5-4: Distribution of penalty points to the nine variants (green shows the best value in a row, red the worst number in a row)

ANALYSIS OF MULTIPLE HEAT PUMPS

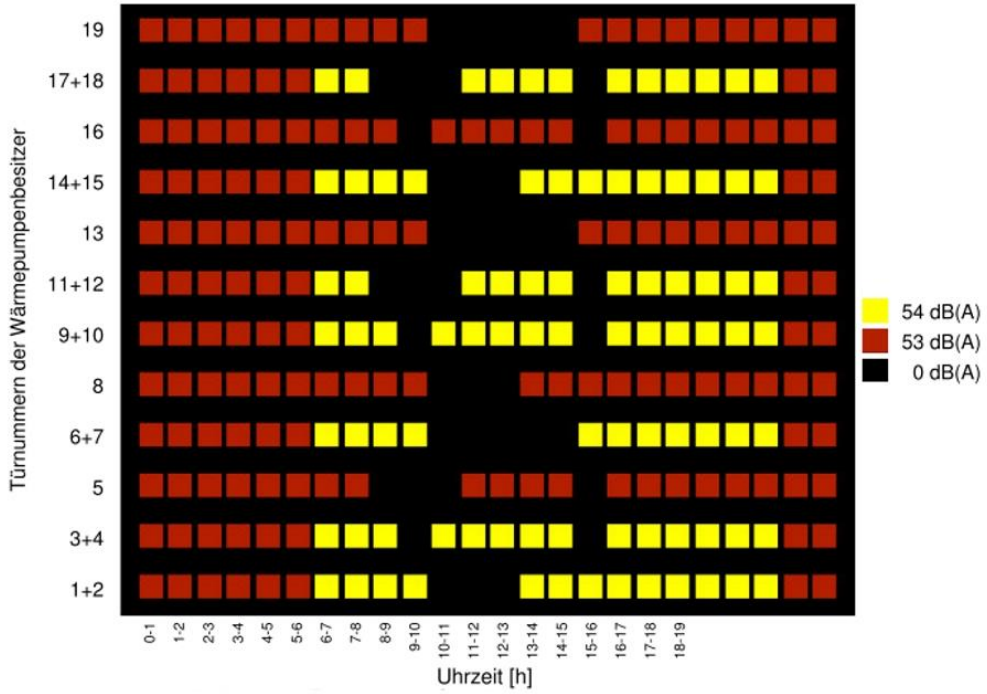


Figure 5-16: Time dependent sound power level of heat pumps (the x-axis shows time of day, y-axis the different door numbers of the considered houses)

5 ADDITIONAL TOPICS

Analysis of unit placement, indoor & outdoor sound propagation, potential of sound absorption at nearby surfaces and common „unclever“ decisions in heat pump placement

ADDITIONAL TOPICS

- Analysis of unit placement, indoor & outdoor sound propagatin
- Potential of sound absorption at nearby surfaces
- Common „unclever“ decisions in heat pump placement
- Further reading

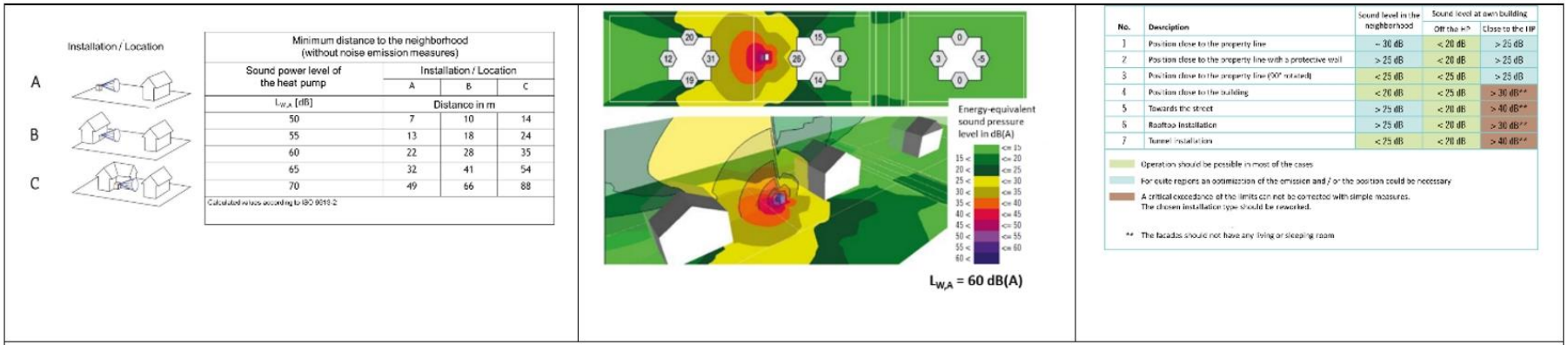


Figure 2-5: Analysis of unit placement, indoor & outdoor sound propagation

6 SUMMARY

Topics discussed, document for download

SUMMARY

- Task 5 deliverable 5.1 „Report on heat pump installation with special focus on acoustic impact“ available for download in verison V1 from the Annex 51 website
- Simple webbased calculation tools are available
- 2D visualization for horizontal sound pressure maps
- 3D visualization using augmented reality is in development and current versions are available in Google Play and iOS Store for test
- Investigation of the placement of multiple heat pumps using IMMI
- Additional topics have covered in the document

ACKNOWLEDGEMENTS

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IEA RESEARCH COOPERATION

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THANK YOU!

Christoph Reichl for the Annex 51 team

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