iSERV Measured Data Analysis by HVAC Component and Activity - Austria

By

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Main website: http://www.iservcmb.info
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1 Introduction

This report presents the measured HVAC component and end use activity data obtained for Austria during the iSERV project. This particular report presents the recorded energy use information by floor area and HVAC components for each activity type within the iSERV system.

A separate report presents the energy use information by the floor area served only. The reports have been separated for reasons of size and clarity, as well as due to the more controversial nature of the initial benchmarks used for apportionment by activity, as reported in this document.

2 Overall HVAC Component and Activities Overview plus Data Summaries

This section covers the overall description of the HVAC components as given in the iSERV spreadsheets for Austria as well as summarising the measured data from the more detailed parts of this report.

2.1 Overall HVAC Components and Activities Summary

Table 1 and Table 2 summarise the data collected for the HVAC Components and the iSERV Activity types available in Austria. It can be seen that the HVAC components in this country service 34 total activity types with areas ranging in size from 15 to 104,176 m^2. There were averages of 18, 9, 8 or 2 meters available for each system analysed.
The most frequently encountered component type in this country was the Cold Generator.

Table 1 – Overall Systems Summary for Austria showing numbers of components and meters associated with each activity type

Activity type	Floor Area / m2	# of spaces	Air Handling Units	All-in-One Systems	Cold Generators	Heat Generators	Heat Recovery	Heat Rejection	Humidifiers	Pumps	Terminal Units
Bedroom	274.66	1			1						
Catering: Bars	434.39	3			2	3		1		2	
Catering: Eating/drinking area	2050.12	6	3		8	1	1	3		4	
Catering: Full Kitchen Preparing Hot Meals	1566.34	6	2		8	1		3		4	
Catering: Kitchenette (small appliances, fridge and sink)	73.56	3			1	4		1		10	120
Catering: Vending Machines	16.1	1	1		1						
Cellular Office Area	104175.91	20	10	3	29	5	2	6		22	120
Circulation area (corridors and stairways)	2032.76	3	3		1	2				2	
Consulting/treatment room	11802.73	3			5						
Exhibition rooms, museum	5600	2	1		2			1		6	
Generic Checkin areas	3723.33	8	1		7	1		2		7	
Generic Ward	912.88	5	2		3	4				1	
Hotel room	51889	2			17						
Hydrotherapy pool hall	170.81	1			2						
IT: High Density IT Suite	1322	2				2				2	
IT: LAN Rooms	114.35	3			2					1	1
IT: Server Room	348.22	7	2		9			2		8	120
Laboratory	892.11	6			7						
Lecture theatre	3559.5	6	3		4	1	1		1		1
Library - reading room	29.69	1			1						
Meeting Room	3773.61	13	5		8	4		2		16	120
Open Plan Office Area	2800	1	2			1	1		1		1
Reception	1094.18	1	2		1		1	2		4	
Recreational : Changing facilities with showers	789.75	1			4						
Recreational : Recreational Pool	641.71	1			2	1		1			
Retail Warehouse Sales area - electrical	330.56	1			1	2		1		8	120
Retail Warehouse Sales area -	39354.22	10			23						

Activity type	Floor Area / m2	# of spaces	Air Handling Units	All-in-One Systems	Cold Generators	Heat Generators	Heat Recovery	Heat Rejection	Humidifiers	Pumps	Terminal Units
general											
Stage (theatres and event buildings)	1170	1	1		2			1		6	
Storage Area/Cupboard	1229	1			3						
Teaching Areas	1559.05	1			4						
Toilet	527.13	2			3	2				2	
Unoccupied space	299.59	1			4						
Waiting Rooms	15.69	1			1						
Warehouse storage	569.85	1			4						

Table 2 – Number of meters serving each activity

Activity type	Coolth	Electricity	Heat	Heat & Coolth
Bedroom		1		
Catering: Bars	12	9	2	1
Catering: Eating/drinking area	11	12	1	1
Catering: Full Kitchen Preparing Hot Meals	40	17	16	1
Catering: Kitchenette (small appliances, fridge and sink)	1	5	1	
Catering: Vending Machines		1		
Cellular Office Area	52	49	20	3
Circulation area (corridors and stairways)		3		
Consulting/treatment room		9		2
Exhibition rooms, museum		1		
Generic Checkin areas	27	14	7	1
Generic Ward	1	7	2	2
Hotel room	34	21	21	
Hydrotherapy pool hall	16	6	6	
IT: High Density IT Suite	1	4	1	
IT: LAN Rooms		3		
IT: Server Room	16	14	12	
Laboratory		6		
Lecture theatre	15	6	10	
Library - reading room		1		
Meeting Room	3	13	1	

Activity type	Coolth	Electricity	Heat	Heat & Coolth
Open Plan Office Area		3	1	
Reception		3		
Recreational : Changing facilities with showers		8		2
Recreational : Recreational Pool	11	5	1	1
Retail Warehouse Sales area - electrical		1		
Retail Warehouse Sales area - general	23	35	20	
Stage (theatres and event buildings)		1		
Storage Area/Cupboard		15		
Teaching Areas		8		2
Toilet		15		
Unoccupied space		8		2
Waiting Rooms		1		
Warehouse storage		8		2

2.2 Summary by Activity type of measured Electrical Power Demands

This summary section contains 34 tables, one for each activity type for which we have data, summarising the range of electrical power demands found across all the HVAC sub-component types monitored in iSERV.

The main observations from all these tables are:

- 31 activities had measured data
- Of these activities 21 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from (at least 2 samples).
- The measured electrical power demand for Server Rooms is highest

A summary of the average **maximum** power demand benchmarks is shown in Table 3. Values in brackets indicate the standard deviation found from this average maximum. This data can be used to estimate the likely power demand to be to be incurred by the HVAC component while servicing this type of activity in this country. The more detailed tables also show the annual average and minimum power demands found for this equipment. Zero figures are excluded from the minima i.e. the minima show how little power might be drawn by energised equipment.

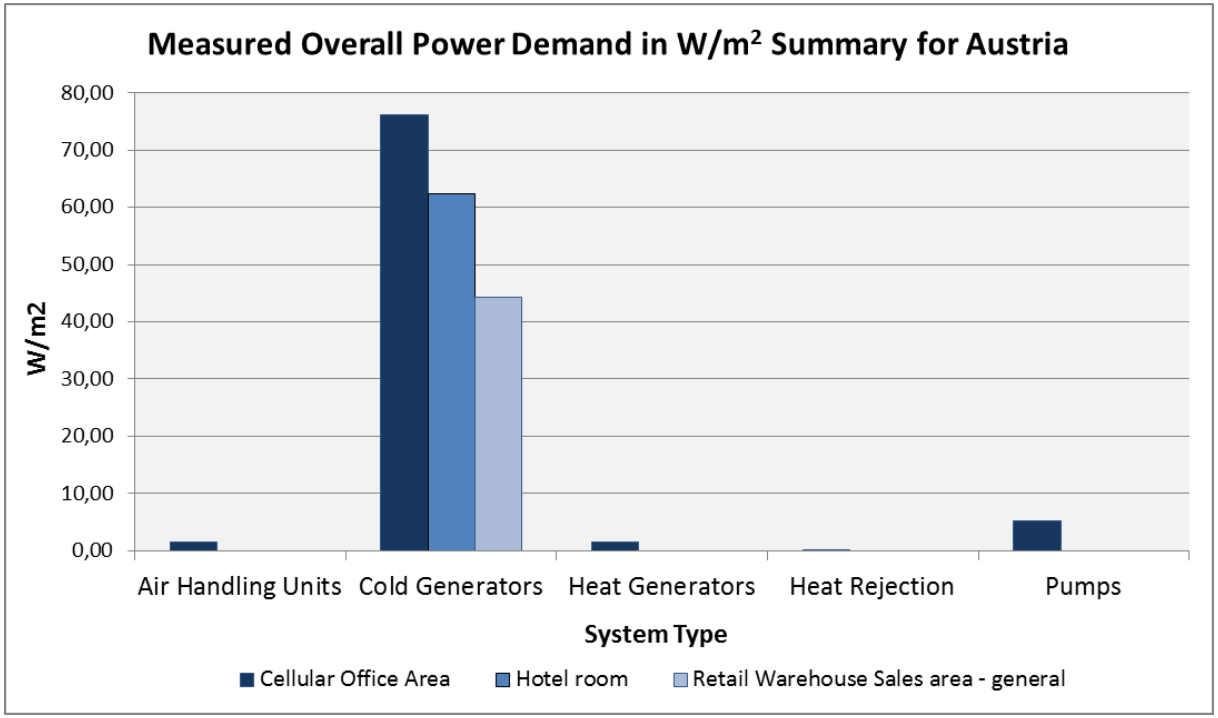
The first column shows the section number in which these benchmarks can be found. Benchmarks in red are considered to have too few samples or too short a measurement period to be reliable.

Table 3 – Benchmarks for measured Average and Standard Deviation Power Demands in W/m² Summary by HVAC Component and Activity Type for Austria

Activity type	Section reference	Sample Size	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection	Pumps
Bedroom	2.2.1	1	0.00 (0.00)	9.29 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Bars	2.2.2	2	0.00 (0.00)	0.66 (0.06)	1.56 (0.31)	0.50 (0.00)	141.30 (0.00)
Catering: Eating/drinking area	2.2.3	3	6.86 (3.86)	12.24 (12.68)	1.44 (0.00)	0.60 (0.00)	0.00 (0.00)
Catering: Full Kitchen Preparing Hot Meals	2.2.4	2	84.53 (69.51)	144.81 (205.57)	1.43 (0.00)	2.67 (0.00)	0.00 (0.00)
Catering: Kitchenette (small appliances, fridge and sink)	2.2.5	1	0.00 (0.00)	599.32 (0.00)	1.62 (0.41)	0.00 (0.00)	35.31 (0.00)
Catering: Vending Machines	2.2.6	1	3.11 (0.00)	0.49 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cellular Office Area	2.2.7	10	1.52 (1.75)	76.10 (325.78)	1.56 (0.31)	0.20 (0.25)	5.24 (13.27)
Circulation area (corridors and stairways)	2.2.8	3	0.70 (0.90)	2.93 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Consulting/treatment room	2.2.9	5	0.00 (0.00)	10.21 (2.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Exhibition rooms, museum	2.2.10	1	0.54 (0.00)	0.19 (0.00)	0.00 (0.00)	0.03 (0.00)	0.18 (0.22)
Generic Checkin areas	2.2.11	1	1.58 (0.00)	66.81 (106.69)	1.44 (0.00)	0.24 (0.31)	0.23 (0.19)
Generic Ward	0	2	7.05 (5.06)	8.85 (9.28)	2228.37 (3847.70)	0.00 (0.00)	35.32 (0.00)
Hotel room	2.2.13	17	0.00 (0.00)	62.33 (1.84)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: LAN Rooms	2.2.14	2	0.00 (0.00)	516.32 (507.93)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: Server Room	2.2.15	2	3.74 (2.69)	16296.07 (39437.91)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Laboratory	2.2.16	7	0.00 (0.00)	40.90 (43.94)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Lecture theatre	2.2.17	3	5.13 (7.03)	2.82 (0.00)	0.29 (0.00)	0.00 (0.00)	0.00 (0.00)
Library - reading room	2.2.18	1	0.00 (0.00)	14.53 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	2.2.19	5	3.56 (3.39)	234.13 (632.20)	1.62 (0.41)	0.03 (0.00)	5.24 (13.27)
Open Plan Office Area	2.2.20	2	0.42 (0.29)	0.00 (0.00)	0.29 (0.00)	0.00 (0.00)	0.00 (0.00)
Reception	2.2.21	2	2.14 (0.00)	5.38 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Recreational : Recreational Pool	2.2.22	1	0.00 (0.00)	0.00 (0.00)	29.53 (0.00)	0.00 (0.00)	0.00 (0.00)
Retail Warehouse Sales area - electrical	2.2.23	1	0.00 (0.00)	1649.90 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Retail Warehouse Sales area - general	0	23	0.00 (0.00)	44.20 (2.31)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Stage (theatres and event buildings)	2.2.25	1	0.05 (0.00)	1.24 (0.00)	0.00 (0.00)	0.02 (0.00)	0.23 (0.19)
Storage Area/Cupboard	2.2.26	3	0.00 (0.00)	4.59 (0.24)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Teaching Areas	2.2.27	4	0.00 (0.00)	1.84 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Toilet	0	3	0.00 (0.00)	6.88 (0.36)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Activity type	Section reference	Sample Size	Air Handling Units		Cold Generators		Heat Generators		Heat Rejection		Pumps	
Unoccupied space	2.2.29	4	0.00	(0.00)	0.92	(0.15)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Waiting Rooms	2.2.30	1	0.00	(0.00)	19.36	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Warehouse storage	2.2.31	4	0.00	(0.00)	0.92	(0.15)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)

Figure 1: Measured Overall Power Demand in W/m2 by HVAC Component type for selected activity types. Summary for Austria (max SD: 325.78; min sample size: 10)



2.2.1 Bedroom - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 4 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Bedroom for Austria

Parameter	Cold Generators
Average (Standard Deviation)	9.29 (0.00)
Maximum (Standard Deviation)	42.70 (0.00)
Minimum (Standard Deviation)	0.08 (0.00)
Sample Size (number)	1

2.2.2 Catering: Bars - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 5 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Bars for Austria

Parameter	Cold Generators	Heat Generators	Heat Rejection	Pumps
Average (Standard Deviation)	0.66 (0.06)	1.56 (0.31)	0.50 (0.00)	141.30 (0.00)
Maximum (Standard Deviation)	124.24 (1.45)	19.16 (18.83)	327.78 (0.00)	1256.05 (0.00)
Minimum (Standard Deviation)	0.00 (0.00)	0.01 (0.01)	0.01 (0.00)	20.51 (0.00)
Sample Size (number)	2	3	1	1

2.2.3 Catering: Eating/drinking area - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 6 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Eating/drinking area for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection
Average (Standard Deviation)	6.86 (3.86)	12.24 (12.68)	1.44 (0.00)	0.60 (0.00)
Maximum (Standard Deviation)	3583.34 (3091.73)	105.23 (65.34)	6.77 (0.00)	395.99 (0.00)
Minimum (Standard Deviation)	0.02 (0.04)	0.01 (0.01)	0.00 (0.00)	0.01 (0.00)
Sample Size (number)	3	8	1	1

2.2.4 Catering: Full Kitchen Preparing Hot Meals - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 7 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Full Kitchen Preparing Hot Meals for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection
Average (Standard Deviation)	84.53 (69.51)	144.81 (205.57)	1.43 (0.00)	2.67 (0.00)
Maximum (Standard Deviation)	39571.33 (55685.28)	1197.21 (1321.50)	6.77 (0.00)	1762.11 (0.00)
Minimum (Standard Deviation)	0.54 (0.72)	0.11 (0.10)	0.00 (0.00)	0.07 (0.00)
Sample Size (number)	2	6	1	1

2.2.5 Catering: Kitchenette - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 8 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Kitchenette for Austria

Parameter	Cold Generators	Heat Generators	Pumps
Average (Standard Deviation)	599.32 (0.00)	1.62 (0.41)	35.31 (0.00)
Maximum (Standard Deviation)	3768.68 (0.00)	25.35 (21.89)	313.91 (0.00)
Minimum (Standard Deviation)	5.19 (0.00)	0.01 (0.01)	5.13 (0.00)
Sample Size (number)	1	2	1

2.2.6 Catering: Vending Machines - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 9 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Vending Machines for Austria

Parameter	Air Handling Units	Cold Generators
Average (Standard Deviation)	3.11 (0.00)	0.49 (0.00)
Maximum (Standard Deviation)	17.24 (0.00)	2.74 (0.00)
Minimum (Standard Deviation)	0.09 (0.00)	0.01 (0.00)
Sample Size (number)	1	1

2.2.7 Cellular Office Area - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 10 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Cellular Office Area by component for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection	Pumps
Average (Standard Deviation)	1.52 (1.75)	76.10 (325.78)	1.56 (0.31)	0.20 (0.25)	5.24 (13.27)
Maximum (Standard Deviation)	81.40 (123.24)	484.90 (2048.69)	19.16 (18.83)	123.67 (172.86)	60.73 (112.61)
Minimum (Standard Deviation)	0.02 (0.02)	1.18 (3.30)	0.01 (0.01)	0.00 (0.01)	0.73 (1.94)
Sample Size (number)	5	26	3	2	7

2.2.8 Circulation area - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 11 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for for Austria

Parameter	Air Handling Units	Cold Generators
Average (Standard Deviation)	0.70 (0.90)	2.93 (0.00)
Maximum (Standard Deviation)	44.93 (60.27)	7.48 (0.00)
Minimum (Standard Deviation)	0.01 (0.01)	0.03 (0.00)
Sample Size (number)	3	1

2.2.9 Consulting/treatment room - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 12 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Consulting/treatment room for Austria

Parameter	Cold Generators
Average (Standard Deviation)	10.21 (2.99)
Maximum (Standard Deviation)	44.45 (20.85)
Minimum (Standard Deviation)	0.68 (0.30)
Sample Size (number)	5

2.2.10 Exhibition rooms, museum - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 13 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Exhibition rooms, museum for Austria

Parameter	Air Handling Units	Cold Generators	Heat Rejection	Pumps
Average (Standard Deviation)	0.54 (0.00)	0.19 (0.00)	0.03 (0.00)	0.18 (0.22)
Maximum (Standard Deviation)	43.94 (0.00)	15.55 (0.00)	2.75 (0.00)	15.02 (18.22)
Minimum (Standard Deviation)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Sample Size (number)	1	2	1	6

2.2.11 Generic Check in areas - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 14 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Generic Check in areas for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection	Pumps
Average (Standard Deviation)	1.58 (0.00)	66.81 (106.69)	1.44 (0.00)	0.24 (0.31)	0.23 (0.19)
Maximum (Standard Deviation)	128.31 (0.00)	521.54 (713.84)	6.77 (0.00)	151.15 (211.27)	18.53 (15.76)
Minimum (Standard Deviation)	0.01 (0.00)	0.06 (0.07)	0.00 (0.00)	0.01 (0.01)	0.00 (0.00)
Sample Size (number)	1	7	1	2	6

2.2.12 Generic Ward - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 15 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Generic Ward for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Pumps
Average (Standard Deviation)	7.05 (5.06)	8.85 (9.28)	2228.37 (3847.70)	35.32 (0.00)
Maximum (Standard Deviation)	23.17 (5.63)	37.53 (44.58)	6322.11 (10763.07)	314.01 (0.00)
Minimum (Standard Deviation)	0.10 (0.00)	0.09 (0.07)	115.78 (200.44)	5.13 (0.00)
Sample Size (number)	2	2	3	1

2.2.13 Hotel room - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 16 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Hotel room for Austria

Parameter	Cold Generators
Average (Standard Deviation)	62.33 (1.84)
Maximum (Standard Deviation)	437.87 (15.59)
Minimum (Standard Deviation)	0.03 (0.00)
Sample Size (number)	2

2.2.14 IT: LAN Rooms - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 17 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for IT: LAN Rooms by component for Austria

Parameter	Cold Generators
Average (Standard Deviation)	516.32 (507.93)
Maximum (Standard Deviation)	2276.44 (2469.61)
Minimum (Standard Deviation)	8.56 (0.82)
Sample Size (number)	2

2.2.15 IT: Server Room - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 18 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for IT: Server Room for Austria

Parameter	Air Handling Units	Cold Generators
Average (Standard Deviation)	3.74 (2.69)	16296.07 (39437.91)
Maximum (Standard Deviation)	12.30 (2.98)	102038.26 (248207.74)
Minimum (Standard Deviation)	0.06 (0.00)	151.28 (336.86)
Sample Size (number)	2	6

2.2.16 Laboratory - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 19 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Laboratory for Austria

Parameter	Cold Generators
Average (Standard Deviation)	40.90 (43.94)
Maximum (Standard Deviation)	137.67 (87.34)
Minimum (Standard Deviation)	5.21 (8.54)
Sample Size (number)	6

2.2.17 Lecture theatre- power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 20 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Lecture theatre for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators
Average (Standard Deviation)	5.13 (7.03)	2.82 (0.00)	0.29 (0.00)
Maximum (Standard Deviation)	13.33 (17.75)	7.20 (0.00)	0.29 (0.00)
Minimum (Standard Deviation)	0.42 (0.25)	0.03 (0.00)	0.29 (0.00)
Sample Size (number)	3	1	1

2.2.18 Library – reading room - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 21 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Library – reading room for Austria

Parameter	Cold Generators
Average (Standard Deviation)	14.53 (0.00)
Maximum (Standard Deviation)	66.79 (0.00)
Minimum (Standard Deviation)	0.13 (0.00)
Sample Size (number)	1

2.2.19 Meeting Room – reading room - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 22 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Meeting Room for Austria

Parameter	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection	Pumps
Average (Standard Deviation)	3.56 (3.39)	234.13 (632.20)	1.62 (0.41)	0.03 (0.00)	5.24 (13.27)
Maximum (Standard Deviation)	34.96 (32.81)	1444.90 (3984.72)	25.36 (21.88)	2.32 (0.00)	60.74 (112.60)
Minimum (Standard Deviation)	0.05 (0.04)	5.38 (10.33)	0.01 (0.01)	0.00 (0.00)	0.73 (1.94)
Sample Size (number)	3	8	2	1	7

2.2.20 Open Plan Office Area - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 23 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Open Plan Office Area for Austria

Parameter	Air Handling Units	Heat Generators
Average (Standard Deviation)	0.42 (0.29)	0.29 (0.00)
Maximum (Standard Deviation)	1.19 (0.46)	0.29 (0.00)
Minimum (Standard Deviation)	0.22 (0.00)	0.29 (0.00)
Sample Size (number)	2	1

2.2.21 Reception - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 24 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for reception for Austria

Parameter	Air Handling Units	Cold Generators
Average (Standard Deviation)	2.14 (0.00)	5.38 (0.00)
Maximum (Standard Deviation)	1263.12 (0.00)	27.60 (0.00)
Minimum (Standard Deviation)	0.00 (0.00)	0.00 (0.00)
Sample Size (number)	2	1

2.2.22 Recreational: Recreational Pool - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 25 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Recreational: Recreational Pool for Austria

Parameter	Heat Generators
Average (Standard Deviation)	29.53 (0.00)
Maximum (Standard Deviation)	139.32 (0.00)
Minimum (Standard Deviation)	0.08 (0.00)
Sample Size (number)	1

2.2.23 Retail Warehouse Sales area - electrical - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 26 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Retail: Warehouse Sales area - electrical for Austria

Parameter	Cold Generators
Average (Standard Deviation)	1649.90 (0.00)
Maximum (Standard Deviation)	10374.97 (0.00)
Minimum (Standard Deviation)	14.28 (0.00)
Sample Size (number)	1

2.2.24 Retail Warehouse Sales area - general - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 27 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Retail: Warehouse Sales area – general for Austria

Parameter	Cold Generators
Average (Standard Deviation)	44.20 (2.31)
Maximum (Standard Deviation)	171.89 (16.77)
Minimum (Standard Deviation)	0.25 (0.03)
Sample Size (number)	3

2.2.25 Stage - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 28 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Stage for Austria

Parameter	Air Handling Units	Cold Generators	Heat Rejection	Pumps
Average (Standard Deviation)	0.05 (0.00)	1.24 (0.00)	0.02 (0.00)	0.23 (0.19)
Maximum (Standard Deviation)	4.28 (0.00)	100.51 (0.00)	1.28 (0.00)	18.53 (15.76)
Minimum (Standard Deviation)	0.00 (0.00)	0.01 (0.00)	0.00 (0.00)	0.00 (0.00)
Sample Size (number)	1	2	1	6

2.2.26 Storage Area/Cupboard - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 29 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Storage Area/Cupboard- Electricity Power Demand summary by component for Austria

Parameter	Cold Generators
Average (Standard Deviation)	4.59 (0.24)
Maximum (Standard Deviation)	17.84 (1.74)
Minimum (Standard Deviation)	0.03 (0.00)
Sample Size (number)	3

2.2.27 Teaching Areas - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 30 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Teaching Areas for Austria

Parameter	Cold Generators
Average (Standard Deviation)	1.84 (0.29)
Maximum (Standard Deviation)	7.84 (3.67)
Minimum (Standard Deviation)	0.17 (0.00)
Sample Size (number)	4

2.2.28 Toilet - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 31 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Toilet for Austria

Parameter	Cold Generators	
Average (Standard Deviation)	6.88	(0.36)
Maximum (Standard Deviation)	26.75	(2.61)
Minimum (Standard Deviation)	0.04	(0.01)
Sample Size (number)	3	

2.2.29 Unoccupied space – power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 32 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Unoccupied space for Austria

Parameter	Cold Generators	
Average (Standard Deviation)	0.92	(0.15)
Maximum (Standard Deviation)	3.92	(1.84)
Minimum (Standard Deviation)	0.08	(0.00)
Sample Size (number)	4	

2.2.30 Waiting Rooms – power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 33 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Waiting Rooms for Austria

Parameter	Cold Generators	
Average (Standard Deviation)	19.36	(0.00)
Maximum (Standard Deviation)	88.95	(0.00)
Minimum (Standard Deviation)	0.18	(0.00)
Sample Size (number)	1	

2.2.31 Warehouse storage - power demand summary by component

The table shows the average, maximum and minimum power demands found from the data for this activity type for the overall component type shown in each column.

Table 34 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Warehouse storage for Austria

Parameter	Cold Generators	
Average (Standard Deviation)	0.92	(0.15)
Maximum (Standard Deviation)	3.92	(1.84)
Minimum (Standard Deviation)	0.08	(0.00)
Sample Size (number)	4	

2.3 Summary of measured annual energy use by HVAC Component type servicing a given activity

This summary section contains 5 tables, one for each activity type for which we have data, summarising the range of electrical annual energy consumption per m^2 found across all the HVAC sub-component types monitored in iSERV.

The main observations from all these tables are:

- 16 activities had measured data
- Of these activities 11 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from (at least 2 samples)
- The measured annual energy use for Server Rooms is highest

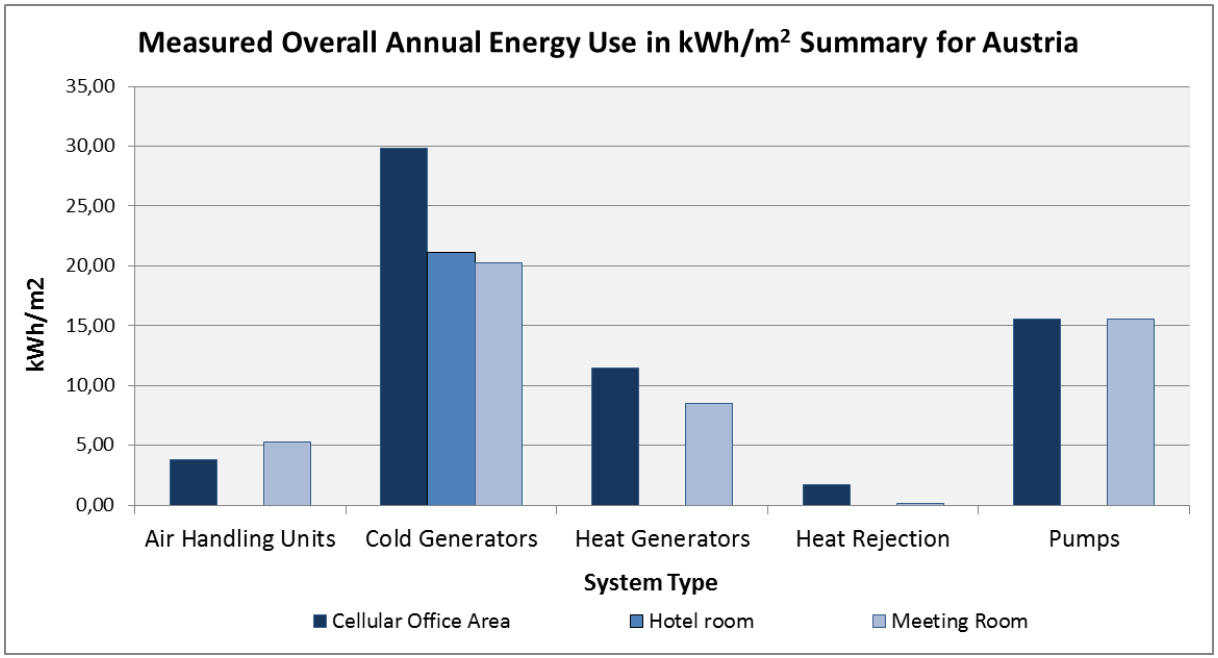
A summary of the measured average annual energy use benchmarks by activity type and HVAC component type is shown in Table 35. Values in brackets indicate the standard deviation found from this average. This data can be used to estimate the likely annual energy use range to be incurred by the HVAC component while servicing this type of activity in this Austria. The more detailed tables also show the annual maximum and minimum annual energy use ranges found for this equipment.

Benchmarks in red are considered to have too few samples or too short a measurement period to be reliable.

Table 35 – Benchmarks for measured Average and Standard Deviation Annual Energy Use in kWh/m2 Summary by HVAC Component and Activity Type for Austria

Activity type	Sample Size	Air Handling Units	Cold Generators	Heat Generators	Heat Rejection	Pumps
Catering: Bars	2	0.00 (0.00)	6.07 (0.15)	11.46 (4.20)	4.53 (0.00)	402.44 (0.00)
Catering: Eating/drinking area	3	0.00 (0.00)	6.71 (0.16)	14.44 (0.00)	5.47 (0.00)	0.00 (0.00)
Catering: Full Kitchen Preparing Hot Meals	2	0.00 (0.00)	84.10 (63.18)	14.44 (0.00)	24.36 (0.00)	0.00 (0.00)
Catering: Kitchenette (small appliances, fridge and sink)	1	0.00 (0.00)	0.00 (0.00)	8.49 (0.00)	0.00 (0.00)	100.60 (0.00)
Cellular Office Area	10	3.78 (1.58)	29.85 (19.33)	11.47 (4.20)	1.75 (2.33)	15.52 (37.53)
Circulation area (corridors and stairways)	3	1.54 (0.82)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Exhibition rooms, museum	1	3.18 (0.00)	1.13 (0.00)	0.00 (0.00)	0.20 (0.00)	1.09 (1.32)
Generic Checkin areas	1	9.29 (0.00)	29.10 (35.94)	14.44 (0.00)	2.14 (2.85)	1.34 (1.14)
Generic Ward	2	0.00 (0.00)	0.00 (0.00)	36.23 (0.00)	0.00 (0.00)	100.61 (0.00)
Hotel room	17	0.00 (0.00)	21.12 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: Server Room	2	0.00 (0.00)	2119.02 (1131.95)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Lecture theatre	3	4.94 (5.93)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	5	5.27 (0.00)	20.24 (29.43)	8.49 (0.00)	0.17 (0.00)	15.52 (37.53)
Open Plan Office Area	2	1.90 (2.28)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Recreational : Recreational Pool	1	0.00 (0.00)	0.00 (0.00)	297.07 (0.00)	0.00 (0.00)	0.00 (0.00)
Stage (theatres and event buildings)	1	0.31 (0.00)	7.28 (0.00)	0.00 (0.00)	0.09 (0.00)	1.34 (1.14)

Figure 2: Measured Overall Annual Energy Use in kWh/m2 by HVAC Component type for selected activity types. Summary for Austria (max SD: 37.53; min sample size: 5)



2.3.1 Activity types – annual energy use/m² summary by Air Handling Unit sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Air Handling Unit sub-component type shown in each column.

These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 36 – Overall Data Summary by Air Handling Unit sub-component types. Average and Standard Deviation Annual kWh/m² in Austria

Activity type	Supply and extract with heating and cooling variants, etc	Supply only
Cellular Office Area	2.89 (0.52)	5.55 (0.00)
Circulation area (corridors and stairways)	0.96 (0.00)	2.12 (0.00)
Exhibition rooms, museum	3.18 (0.00)	0.00 (0.00)
Generic Checkin areas	9.29 (0.00)	0.00 (0.00)
Lecture theatre	4.94 (5.93)	0.00 (0.00)
Meeting Room	5.27 (0.00)	0.00 (0.00)
Open Plan Office Area	1.90 (2.28)	0.00 (0.00)
Stage (theatres and event buildings)	0.31 (0.00)	0.00 (0.00)

Table 36 provides the range of annual energy consumptions found in different Air Handling Unit Component sub-types servicing the activities shown in buildings across Austria. Having reference to the activities serviced enables estimation of the likely range of annual energy consumptions to be found in buildings composed of multiple activities.

2.3.2 Activity types – annual energy use/m² summary by Cold Generator sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Cold Generator sub-component type shown in each column.

These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 37 – Overall Data Summary by Cold Generator sub-component types. Average and Standard Deviation Annual kWh/m² in Austria

Activity Name	Direct evaporative cooler	Reciprocating Liquid Chillers	Screw Liquid Chillers
Catering: Bars	0.00 (0.00)	0.00 (0.00)	6.07 (0.15)
Catering: Eating/drinking area	0.00 (0.00)	0.00 (0.00)	6.71 (0.16)
Catering: Full Kitchen Preparing Hot Meals	0.00 (0.00)	0.00 (0.00)	84.10 (63.18)
Cellular Office Area	41.15 (13.81)	3.02 (0.00)	17.82 (13.39)
Exhibition rooms, museum	0.00 (0.00)	1.13 (0.00)	0.00 (0.00)
Generic Checkin areas	0.00 (0.00)	3.87 (0.00)	41.71 (38.95)
Hotel room	0.00 (0.00)	0.00 (0.00)	21.12 (0.00)
IT: Server Room	2119.02 (1131.95)	0.00 (0.00)	0.00 (0.00)
Meeting Room	54.23 (0.00)	3.25 (0.00)	0.00 (0.00)
Stage (theatres and event buildings)	0.00 (0.00)	7.28 (0.00)	0.00 (0.00)

Table 37 provides the range of annual energy consumptions found in different Cold Generator Component sub-types servicing the activities shown in buildings across Austria. Having reference to the activities serviced enables estimation of the likely range of annual energy consumptions to be found in buildings composed of multiple activities.

2.3.3 Activity types – annual energy use/m² summary by Heat Generator sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Heat Generator sub-component type shown in each column.

These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 38 – Overall Data Summary by Heat Generator sub-component types. Average and Standard Deviation Annual kWh/m² in Austria

Activity Name	Ground Source Heat Pump (GSHP)	Water Source Heat Pump (WSHP)
Catering: Bars	14.44 (0.00)	8.49 (0.00)
Catering: Eating/drinking area	14.44 (0.00)	0.00 (0.00)
Catering: Full Kitchen Preparing Hot Meals	14.44 (0.00)	0.00 (0.00)
Catering: Kitchenette (small appliances, fridge and sink)	0.00 (0.00)	8.49 (0.00)
Cellular Office Area	14.44 (0.00)	8.49 (0.00)
Generic Checkin areas	14.44 (0.00)	0.00 (0.00)
Generic Ward	0.00 (0.00)	36.23 (0.00)
Meeting Room	0.00 (0.00)	8.49 (0.00)
Recreational : Recreational Pool	297.07 (0.00)	0.00 (0.00)

Table 38 provides the range of annual energy consumptions found in different Heat Generator Component sub-types servicing the activities shown in buildings across Austria. Having reference to the activities serviced enables estimation of the likely range of annual energy consumptions to be found in buildings composed of multiple activities.

2.3.4 Activity types – annual energy use/m² summary by Heat Rejection sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Heat Rejection sub-component type shown in each column.

These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 39 – Overall Data Summary by Heat Rejection sub-component types. Average and Standard Deviation Annual kWh/m² in Austria

Activity Name	Forced air condensers	Open Circuit Cooling Towers
Catering: Bars	0.00 (0.00)	4.53 (0.00)
Catering: Eating/drinking area	0.00 (0.00)	5.47 (0.00)
Catering: Full Kitchen Preparing Hot Meals	0.00 (0.00)	24.36 (0.00)
Cellular Office Area	0.10 (0.00)	3.40 (0.00)
Exhibition rooms, museum	0.20 (0.00)	0.00 (0.00)
Generic Checkin areas	0.13 (0.00)	4.15 (0.00)
Meeting Room	0.17 (0.00)	0.00 (0.00)
Stage (theatres and event buildings)	0.09 (0.00)	0.00 (0.00)

Table 39 provides the range of annual energy consumptions found in different Heat Rejection Component sub-types servicing the activities shown in buildings across Austria. Having reference to the activities serviced enables estimation of the likely range of annual energy consumptions to be found in buildings composed of multiple activities.

2.3.5 Activity types – annual energy use/m² summary by Pump sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Pump sub-component type shown in each column.

These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 40 – Overall Data Summary by Pump sub-component types. Average and Standard Deviation Annual kWh/m² in Austria

Activity Name	Chilled water primary pumps	Chilled water secondary pumps	Condenser water pumps
Catering: Bars	402.44 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Kitchenette (small appliances, fridge and sink)	100.60 (0.00)	0.00 (0.00)	0.00 (0.00)
Cellular Office Area	33.78 (57.87)	0.87 (0.00)	2.79 (0.00)
Exhibition rooms, museum	0.14 (0.00)	0.33 (0.00)	2.79 (0.00)
Generic Checkin areas	0.37 (0.00)	0.87 (0.00)	2.79 (0.00)
Generic Ward	100.61 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	33.78 (57.87)	0.87 (0.00)	2.79 (0.00)
Stage (theatres and event buildings)	0.37 (0.00)	0.87 (0.00)	2.79 (0.00)

Table 40 provides the range of annual energy consumptions found in different Pump Component sub-types servicing the activities shown in buildings across Austria. Having reference to the activities serviced enables estimation of the likely range of annual energy consumptions to be found in buildings composed of multiple activities.

2.4 Summary of measured monthly energy use by HVAC Sub-component type servicing a given activity

The tables in this section provide the ranges of average and standard deviation monthly energy consumptions found in different HVAC sub-component types servicing the noted end use activity across Austria.

Whilst this data has the same caveats as for the annual data in section 2.3, what it does illustrate is how the consumption of each sub-component varies with the month of the year. From this information it can be seen that the energy consumption of the Cold Generators rise up to the summer and falls then down again. The most intensive consumption occurs in the months May to July. For Heat Generators it can be seen that the energy consumption rise up to the winter. The most intensive consumption occurs in the months December to February.

2.4.1 Activity types – monthly energy use/m² summary by Air Handling Units – Extract only

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 41 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Air Handling Units - Extract only servicing the given activity for Austria

Activity Name	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	4.93 (0.00)	4.37 (0.00)	5.05 (0.00)	8.30 (0.00)	8.81 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	9.26 (0.00)	7.17 (0.00)	7.91 (0.00)	3.76 (0.00)
Reception	1.16 (0.00)	1.03 (0.00)	1.19 (0.00)	1.95 (0.00)	2.07 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.18 (0.00)	1.69 (0.00)	1.86 (0.00)	0.88 (0.00)

2.4.2 Activity types – monthly energy use/m² summary by Air Handling Units – Supply and extract with heating and cooling variants

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 42 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Air Handling Units - Supply and extract with heating and cooling variants servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.28 (0.00)	2.32 (0.00)	2.06 (0.00)	1.09 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Full Kitchen Preparing Hot Meals	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	4.07 (0.00)	34.11 (0.00)	30.36 (0.00)	16.01 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Vending Machines	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.36 (0.00)	3.00 (0.00)	2.67 (0.00)	1.41 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cellular Office Area	3.13 (0.57)	0.19 (0.15)	0.15 (0.11)	0.15 (0.09)	0.25 (0.11)	0.68 (0.85)	0.44 (0.50)	0.94 (0.90)	0.74 (0.85)	0.47 (0.27)	0.14 (0.06)	0.15 (0.11)	0.15 (0.16)
Circulation area (corridors and stairways)	1.01 (0.03)	0.11 (0.00)	0.09 (0.01)	0.09 (0.01)	0.08 (0.02)	0.08 (0.01)	0.10 (0.02)	0.45 (0.59)	0.42 (0.47)	0.20 (0.17)	0.08 (0.00)	0.09 (0.00)	0.10 (0.00)
Exhibition rooms, museum	3.34 (0.54)	0.08 (0.00)	0.05 (0.02)	0.07 (0.02)	0.28 (0.18)	1.12 (1.11)	0.82 (0.86)	0.44 (0.01)	0.10 (0.03)	0.33 (0.00)	0.11 (0.03)	0.07 (0.00)	0.03 (0.00)
Generic Checkin areas	9.76 (1.57)	0.22 (0.00)	0.16 (0.07)	0.21 (0.05)	0.81 (0.52)	3.27 (3.25)	2.39 (2.51)	1.29 (0.01)	0.30 (0.09)	0.95 (0.01)	0.31 (0.08)	0.21 (0.00)	0.09 (0.00)
Generic Ward	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.56 (0.23)	4.31 (1.37)	3.79 (1.15)	1.76 (0.27)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: Server Room	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.30 (0.12)	2.29 (0.73)	2.01 (0.61)	0.93 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Lecture theatre	4.69 (4.60)	0.54 (0.67)	0.26 (0.46)	0.48 (0.60)	0.35 (0.41)	0.36 (0.42)	0.52 (0.43)	2.39 (3.63)	2.16 (3.11)	1.00 (1.25)	0.39 (0.47)	0.52 (0.65)	0.50 (0.61)
Meeting Room	5.53 (0.89)	0.13 (0.00)	0.09 (0.04)	0.12 (0.03)	0.46 (0.29)	1.85 (1.84)	0.87 (1.00)	1.86 (1.41)	1.40 (1.49)	0.88 (0.41)	0.18 (0.04)	0.12 (0.00)	0.05 (0.00)
Open Plan Office Area	1.81 (1.77)	0.21 (0.26)	0.10 (0.18)	0.19 (0.23)	0.13 (0.16)	0.14 (0.16)	0.12 (0.14)	0.12 (0.13)	0.14 (0.17)	0.11 (0.12)	0.15 (0.18)	0.20 (0.25)	0.19 (0.24)
Stage (theatres and event buildings)	0.33 (0.05)	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)	0.03 (0.02)	0.11 (0.11)	0.08 (0.08)	0.04 (0.00)	0.01 (0.00)	0.03 (0.00)	0.01 (0.00)	0.01 (0.00)	0.00 (0.00)

2.4.3 Activity types – monthly energy use/m² summary by Air Handling Units – Supply only

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 43 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Air Handling Units - Supply only servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	0.00 (0.00)	4.93 (0.00)	4.37 (0.00)	5.05 (0.00)	8.30 (0.00)	8.81 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	9.26 (0.00)	7.17 (0.00)	7.91 (0.00)	3.76 (0.00)
Catering: Full Kitchen Preparing Hot Meals	0.00 (0.00)	72.48 (0.00)	64.29 (0.00)	74.20 (0.00)	122.06 (0.00)	129.56 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	136.14 (0.00)	105.45 (0.00)	116.38 (0.00)	55.30 (0.00)
Cellular Office Area	5.71 (0.09)	0.60 (0.00)	0.47 (0.03)	0.45 (0.01)	0.43 (0.04)	0.41 (0.02)	0.48 (0.11)	0.78 (0.00)	0.46 (0.00)	0.42 (0.00)	0.33 (0.00)	0.35 (0.00)	0.51 (0.00)
Circulation area (corridors and stairways)	2.17 (0.03)	0.23 (0.00)	0.18 (0.01)	0.17 (0.00)	0.16 (0.02)	0.16 (0.01)	0.18 (0.04)	0.30 (0.00)	0.17 (0.00)	0.16 (0.00)	0.13 (0.00)	0.13 (0.00)	0.19 (0.00)
Reception	0.00 (0.00)	1.16 (0.00)	1.03 (0.00)	1.19 (0.00)	1.95 (0.00)	2.07 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.18 (0.00)	1.69 (0.00)	1.86 (0.00)	0.88 (0.00)

2.4.4 Activity types – monthly energy use/m² summary by Cold Generators – Direct evaporative cooler

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 44 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Cold Generators – Direct evaporative servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	60.72 (26.41)	1.38 (0.75)	1.93 (0.89)	5.21 (2.92)	6.53 (3.22)	7.74 (4.22)	7.96 (3.65)	7.96 (3.79)	9.55 (4.39)	5.45 (2.69)	3.23 (1.74)	1.18 (0.55)	0.63 (0.29)
Cellular Office Area	36.53 (14.44)	4.31 (1.72)	4.41 (1.95)	5.42 (2.55)	5.74 (2.86)	6.39 (3.43)	2.09 (4.62)	1.22 (0.71)	1.55 (0.20)	2.02 (0.23)	2.71 (0.56)	3.16 (0.94)	3.77 (1.45)
IT: LAN Rooms	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	4.87 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: Server Room	1850.89 (925.39)	216.72 (141.36)	218.19 (159.68)	265.27 (208.84)	277.77 (234.10)	304.21 (281.11)	56.55 (78.97)	84.10 (45.54)	94.05 (16.69)	112.47 (18.63)	146.60 (45.68)	164.85 (76.72)	190.37 (118.64)
Laboratory	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	9.67 (10.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	54.23 (0.00)	5.88 (0.00)	6.15 (0.00)	7.67 (0.00)	8.23 (0.00)	9.34 (0.00)	21.08 (29.80)	0.59 (0.00)	1.53 (0.00)	2.33 (0.00)	3.32 (0.00)	4.07 (0.00)	5.09 (0.00)

2.4.5 Activity types – monthly energy use/m² summary by Cold Generators – Reciprocating Liquid Chillers

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 45 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Cold Generators – Reciprocating Liquid Chillers servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.17 (0.00)	1.43 (0.00)	1.28 (0.00)	0.67 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Full Kitchen Preparing Hot Meals	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.75 (0.00)	6.28 (0.00)	5.59 (0.00)	2.95 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Catering: Vending Machines	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.06 (0.00)	0.48 (0.00)	0.42 (0.00)	0.22 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cellular Office Area	3.17 (0.50)	0.07 (0.00)	0.05 (0.02)	0.07 (0.01)	0.26 (0.14)	1.06 (0.86)	0.59 (0.59)	0.85 (0.71)	0.57 (0.76)	0.44 (0.21)	0.10 (0.02)	0.07 (0.00)	0.03 (0.00)
Circulation area (corridors and stairways)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.20 (0.00)	1.45 (0.00)	1.27 (0.00)	0.54 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Exhibition rooms, museum	1.18 (0.18)	0.03 (0.00)	0.02 (0.01)	0.03 (0.00)	0.10 (0.05)	0.40 (0.32)	0.29 (0.25)	0.16 (0.00)	0.04 (0.01)	0.12 (0.00)	0.04 (0.01)	0.03 (0.00)	0.01 (0.00)
Generic Checkin areas	4.07 (0.64)	0.09 (0.00)	0.07 (0.02)	0.09 (0.02)	0.34 (0.18)	1.36 (1.11)	1.00 (0.86)	0.54 (0.00)	0.13 (0.03)	0.40 (0.00)	0.13 (0.03)	0.09 (0.00)	0.04 (0.00)
Generic Ward	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.29 (0.12)	2.20 (0.70)	1.93 (0.59)	0.90 (0.14)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
IT: Server Room	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	12.99 (5.36)	99.46 (31.58)	87.48 (26.63)	40.54 (6.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Lecture theatre	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.19 (0.00)	1.40 (0.00)	1.22 (0.00)	0.52 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	3.42 (0.53)	0.08 (0.00)	0.06 (0.02)	0.08 (0.01)	0.28 (0.15)	1.15 (0.93)	0.64 (0.64)	0.92 (0.77)	0.61 (0.82)	0.47 (0.22)	0.11 (0.02)	0.07 (0.00)	0.03 (0.00)
Stage (theatres and event buildings)	7.65 (1.20)	0.17 (0.00)	0.13 (0.04)	0.17 (0.03)	0.63 (0.33)	2.56 (2.08)	1.87 (1.61)	1.01 (0.01)	0.24 (0.06)	0.75 (0.01)	0.24 (0.05)	0.17 (0.00)	0.07 (0.00)

2.4.6 Activity types – monthly energy use/m² summary by Cold Generators – Screw Liquid Chillers

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 46 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Cold Generators – Screw Liquid Chillers servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Bars	3.35 (1.86)	0.04 (0.03)	0.02 (0.02)	0.04 (0.03)	0.09 (0.03)	0.28 (0.20)	0.64 (0.61)	0.71 (0.53)	0.64 (0.53)	0.43 (0.41)	0.18 (0.12)	0.04 (0.04)	0.02 (0.02)
Catering: Eating/drinking area	3.70 (2.06)	1.18 (3.01)	0.78 (2.26)	0.78 (2.21)	0.79 (2.07)	0.90 (1.77)	0.71 (0.68)	0.79 (0.58)	0.70 (0.58)	1.65 (2.66)	1.55 (3.02)	0.65 (1.35)	1.05 (2.29)
Catering: Full Kitchen Preparing Hot Meals	39.05 (33.52)	4.47 (8.51)	3.26 (6.70)	3.18 (6.42)	3.26 (6.04)	3.66 (5.41)	3.64 (2.80)	4.22 (2.47)	7.96 (9.57)	5.57 (7.92)	4.64 (8.34)	3.06 (3.91)	3.87 (5.98)
Catering: Kitchenette (small appliances, fridge and sink)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	110.71 (0.00)	344.46 (0.00)	564.78 (0.00)	297.40 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Cellular Office Area	8.39 (7.14)	152.22 (532.42)	133.82 (540.55)	201.40 (873.87)	343.79 (862.36)	616.82 (1416.37)	731.49 (1666.97)	929.75 (1847.11)	1048.22 (2095.61)	701.24 (1249.68)	274.40 (903.43)	1.23 (2.71)	1.32 (2.44)
Consulting/treatment room	0.00 (0.00)	1438.01 (1186.16)	639.44 (1129.81)	903.93 (1791.51)	882.94 (1220.62)	1694.89 (1960.48)	2611.15 (2350.79)	2783.74 (2407.72)	3337.27 (2732.69)	1647.90 (1562.78)	866.79 (1524.06)	12.20 (0.00)	9.76 (0.00)
Generic Checkin areas	11.69 (9.38)	0.85 (0.92)	0.65 (0.81)	0.63 (0.69)	0.66 (0.67)	0.80 (0.76)	1.03 (0.74)	1.18 (0.66)	2.33 (2.67)	1.00 (0.85)	0.77 (0.91)	0.75 (0.85)	0.84 (1.01)
Hotel room	7.40 (5.39)	0.61 (0.53)	0.48 (0.48)	0.46 (0.40)	0.47 (0.39)	0.53 (0.47)	0.61 (0.42)	0.68 (0.38)	1.42 (1.59)	0.64 (0.53)	0.50 (0.57)	0.48 (0.49)	0.54 (0.59)
IT: Server Room	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	46.01 (0.00)	0.00 (0.00)	1788.93 (0.00)	5563.11 (0.00)	9121.63 (0.00)	4803.07 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Meeting Room	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.85 (0.00)	0.00 (0.00)	332.14 (0.00)	1033.39 (0.00)	1694.33 (0.00)	892.21 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Reception	0.00 (0.00)	5.15 (0.00)	4.38 (0.00)	4.28 (0.00)	4.05 (0.00)	3.59 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	4.08 (0.00)	4.47 (0.00)	1.97 (0.00)	3.30 (0.00)
Retail Warehouse Sales area - electrical	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	304.78 (0.00)	948.25 (0.00)	1554.75 (0.00)	818.71 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Retail Warehouse Sales area - general	0.00 (0.00)	0.00 (0.00)	0.08 (0.02)	0.09 (0.07)	0.09 (0.07)	0.13 (0.17)	0.16 (0.35)	0.20 (0.37)	0.19 (0.36)	0.13 (0.23)	0.10 (0.07)	0.07 (0.02)	0.06 (0.02)
Storage Area/Cupboard	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.01 (0.01)	0.01 (0.01)	0.01 (0.02)	0.02 (0.04)	0.02 (0.04)	0.02 (0.04)	0.01 (0.02)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)
Teaching Areas	0.00 (0.00)	294.98 (243.31)	131.17 (231.76)	185.42 (367.49)	181.12 (250.38)	347.67 (402.15)	535.62 (482.21)	571.02 (493.89)	684.57 (560.55)	338.03 (320.57)	177.80 (312.63)	2.50 (0.00)	2.00 (0.00)
Toilet	0.00 (0.00)	0.00 (0.00)	0.01 (0.00)	0.01 (0.01)	0.01 (0.01)	0.02 (0.03)	0.02 (0.05)	0.03 (0.06)	0.03 (0.06)	0.02 (0.04)	0.01 (0.01)	0.01 (0.00)	0.01 (0.00)
Unoccupied space	0.00 (0.00)	147.49 (121.66)	65.58 (115.88)	92.71 (183.74)	90.56 (125.19)	173.84 (201.07)	267.81 (241.11)	285.51 (246.95)	342.28 (280.28)	169.02 (160.29)	88.90 (156.31)	1.25 (0.00)	1.00 (0.00)
Warehouse storage	0.00 (0.00)	147.49 (121.66)	65.58 (115.88)	92.71 (183.74)	90.56 (125.19)	173.84 (201.07)	267.81 (241.11)	285.51 (246.95)	342.28 (280.28)	169.02 (160.29)	88.90 (156.31)	1.25 (0.00)	1.00 (0.00)

2.4.7 Activity types – monthly energy use/m² summary by Cold Generators – Scroll Liquid Chillers

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 47 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Cold Generators – Scroll Liquid Chillers servicing the given activity for Austria

Activity Name	January	February	March	April	May	June	July	August	September	October	November	December
Bedroom	0.00 (0.00)	2.13 (2.36)	3.17 (2.59)	3.39 (2.85)	4.76 (3.81)	5.47 (5.45)	6.44 (7.05)	6.81 (6.89)	4.94 (5.14)	4.01 (4.51)	2.22 (2.81)	0.14 (0.00)
Cellular Office Area	0.00 (0.00)	3.46 (3.84)	5.15 (4.22)	5.50 (4.63)	7.74 (6.19)	8.89 (8.85)	10.47 (11.45)	11.07 (11.20)	8.02 (8.36)	6.52 (7.32)	3.61 (4.57)	0.22 (0.00)
Consulting/treatment room	0.00 (0.00)	3.46 (3.84)	5.15 (4.22)	5.50 (4.63)	7.74 (6.19)	8.89 (8.85)	10.47 (11.45)	11.07 (11.20)	8.02 (8.36)	6.52 (7.32)	3.61 (4.57)	0.22 (0.00)
Generic Checkin areas	0.00 (0.00)	4.44 (4.92)	6.61 (5.41)	7.05 (5.93)	9.92 (7.94)	11.39 (11.34)	13.42 (14.68)	14.20 (14.35)	10.29 (10.71)	8.36 (9.39)	4.63 (5.86)	0.28 (0.00)
Generic Ward	0.00 (0.00)	4.44 (4.92)	6.61 (5.41)	7.05 (5.93)	9.92 (7.94)	11.39 (11.34)	13.43 (14.68)	14.20 (14.35)	10.29 (10.71)	8.36 (9.39)	4.63 (5.86)	0.28 (0.00)
IT: LAN Rooms	0.00 (0.00)	200.62 (222.43)	298.79 (244.46)	318.92 (268.15)	448.66 (358.86)	515.19 (513.01)	607.13 (663.95)	641.99 (649.16)	465.18 (484.54)	378.02 (424.54)	209.32 (265.13)	12.87 (0.00)
Laboratory	0.00 (0.00)	6.31 (7.00)	9.40 (7.69)	10.04 (8.44)	14.12 (11.29)	27.56 (34.97)	19.11 (20.89)	20.20 (20.43)	14.64 (15.25)	11.90 (13.36)	6.59 (8.34)	0.40 (0.00)
Library - reading room	0.00 (0.00)	3.33 (3.69)	4.96 (4.06)	5.29 (4.45)	7.45 (5.96)	8.55 (8.52)	10.08 (11.02)	10.66 (10.78)	7.72 (8.04)	6.28 (7.05)	3.48 (4.40)	0.21 (0.00)
Waiting Rooms	0.00 (0.00)	4.44 (4.92)	6.61 (5.41)	7.05 (5.93)	9.92 (7.94)	11.39 (11.34)	13.43 (14.68)	14.20 (14.36)	10.29 (10.71)	8.36 (9.39)	4.63 (5.86)	0.28 (0.00)

2.4.8 Activity types – monthly energy use/m² summary by Heat Generators – Electric Resistance

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 48 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Heat Generators – Electric Resistance servicing the given activity for Austria

Activity Name	January	February	March	April	May	June	July	August	September	October	November	December
Lecture theatre	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Open Plan Office Area	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

2.4.9 Activity types – monthly energy use/m² summary by Heat Generators – Ground Source Heat Pump

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 49 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Heat Generators – Ground Source Heat Pump servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Bars	9253.82 (26120.66)	0.45 (0.36)	0.32 (0.20)	0.68 (0.83)	0.67 (0.90)	0.81 (1.14)	0.77 (1.10)	2.98 (0.00)	1.45 (2.04)	1.25 (1.70)	1.07 (1.42)	0.97 (1.25)	24626.19 (42653.36)
Catering: Eating/drinking area	9253.83 (26120.66)	0.45 (0.36)	0.32 (0.20)	0.68 (0.83)	0.67 (0.90)	0.81 (1.14)	0.77 (1.10)	2.98 (0.00)	1.45 (2.04)	1.25 (1.70)	1.07 (1.42)	0.97 (1.25)	24626.19 (42653.36)
Catering: Full Kitchen Preparing Hot Meals	9253.82 (26120.66)	0.45 (0.36)	0.32 (0.20)	0.68 (0.83)	0.67 (0.90)	0.81 (1.14)	0.77 (1.10)	2.98 (0.00)	1.45 (2.04)	1.25 (1.70)	1.07 (1.42)	0.97 (1.25)	24626.19 (42653.36)
Cellular Office Area	9253.83 (26120.66)	0.45 (0.36)	0.32 (0.20)	0.68 (0.83)	0.67 (0.90)	0.81 (1.14)	0.77 (1.10)	2.98 (0.00)	1.45 (2.04)	1.25 (1.70)	1.07 (1.42)	0.97 (1.25)	24626.19 (42653.36)
Generic Checkin areas	9253.83 (26120.66)	0.45 (0.36)	0.32 (0.20)	0.68 (0.83)	0.67 (0.90)	0.81 (1.14)	0.77 (1.10)	2.98 (0.00)	1.45 (2.04)	1.25 (1.70)	1.07 (1.42)	0.97 (1.25)	24626.19 (42653.36)
Generic Ward	0.00 (0.00)	6262.50 (0.00)	5065.63 (0.00)	4421.88 (0.00)	1084.38 (0.00)	818.75 (0.00)	453.13 (0.00)	0.00 (0.00)	90.63 (0.00)	1537.50 (0.00)	1965.63 (0.00)	3162.50 (0.00)	5371.88 (0.00)
Recreational : Recreational Pool	190397.82 (537433.54)	9.30 (7.43)	6.51 (4.06)	14.02 (17.14)	13.72 (18.60)	16.66 (23.48)	15.85 (22.53)	61.37 (0.00)	29.76 (42.01)	25.77 (34.91)	21.98 (29.23)	20.05 (25.66)	506684.86 (877594.49)

2.4.10 Activity types – monthly energy use/m² summary by Heat Generators – Water Source Heat Pump

This table shows the measured ranges of monthly energy use recorded for this sub-component type.

Table 50 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Heat Generators – Water Source Heat Pump servicing the given activity for Austria

Activity Name	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Bars	8.49 (0.38)	1.79 (0.55)	1.21 (0.23)	1.00 (0.30)	0.30 (0.23)	0.14 (0.13)	0.12 (0.16)	0.20 (0.09)	116.98 (261.25)	0.13 (0.17)	0.72 (0.77)	0.98 (0.39)	1.25 (0.48)
Catering: Kitchenette (small appliances, fridge and sink)	8.48 (0.38)	1.79 (0.55)	1.21 (0.23)	1.00 (0.30)	0.30 (0.23)	0.14 (0.13)	0.12 (0.16)	0.20 (0.09)	116.98 (261.25)	0.13 (0.17)	0.72 (0.77)	0.98 (0.39)	1.25 (0.48)
Cellular Office Area	8.49 (0.38)	1.79 (0.55)	1.21 (0.23)	1.00 (0.30)	0.30 (0.23)	0.14 (0.13)	0.12 (0.16)	0.20 (0.09)	116.98 (261.25)	0.13 (0.17)	0.72 (0.77)	0.98 (0.39)	1.25 (0.48)
Generic Ward	36.21 (1.61)	7.62 (2.35)	5.18 (0.99)	4.25 (1.28)	1.29 (0.98)	0.61 (0.55)	0.52 (0.69)	0.85 (0.38)	498.95 (1114.33)	0.57 (0.71)	3.05 (3.28)	4.17 (1.67)	5.31 (2.03)
Meeting Room	8.49 (0.38)	1.79 (0.55)	1.21 (0.23)	1.00 (0.30)	0.30 (0.23)	0.14 (0.13)	0.12 (0.16)	0.20 (0.09)	116.98 (261.25)	0.13 (0.17)	0.72 (0.77)	0.98 (0.39)	1.25 (0.48)

2.5 Summary Conclusions

This report summarizes the measured HVAC component and end use activity data obtained for Austria. The following information were available:

- Data from 34 different activity types from 15 to 104,176 m²; the most frequently encountered activity type was the cellular office area
- Data from 9 HVAC components; the most frequently encountered component type was the cold generator
- Data from 718 meters; the most frequently encountered meter was the cooling energy meter

The analysis from the measured electrical power demands by activity type shows, that the measured average electrical power demand for cellular office areas is between 0,2 and 76,1 W/m² (max standard deviation: 325,78). More information are available in section 2.2.

The analysis from the measured annual energy use by HVAC component type servicing a given activity shows, that the measured average annual energy use for cellular office areas is between 1,75 and 29,85 kWh/m²a (standard deviation: 37,53). More information are available in section 2.3.

The analysis from the measured monthly energy use by HVAC Sub-component type servicing a given activity shows, that the energy consumption varies over the year. The most intensive consumption for Cold Generators occurs in the months May to July. Heat Generators consume most electrical energy in the months December to February. More information are available in section 2.4.

3 References

Knight I P – "Measured Energy Use and Power Demands in European HVAC Components", CIBSE ASHRAE Technical Symposium, Dublin, Ireland, 3-4 April 2014.

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