iSERV Measured Data Analysis by HVAC Component and Activity - Germany

By

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1 Introduction

This report presents the measured HVAC component and end use activity data obtained for Germany 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 Germany 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 Germany. It can be seen that the HVAC components in this country service 5 total activity types with areas ranging in size from 128 to 12,871 m^2. There were averages of 8, 3 or 1 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 Germany showing numbers of components and meters associated with each activity type

Activity type	Floor Area / m2	# of spaces	All-in-One Systems	Cold Generators	Heat Rejection
Cellular Office Area	12871.36	1		2	1
Generic Ward	128	1	1		
IT: High Density IT Suite	112.51	1		2	1
IT: LAN Rooms	263.64	1		2	1
Lecture theatre	343.34	1		2	1

Table 2 - Number of meters serving each activity

Activity type	Coolth	Electricity	Heat
Cellular Office Area	8	3	1
Generic Ward		1	
IT: High Density IT Suite	8	3	1
IT: LAN Rooms	8	3	1
Lecture theatre	8	3	1

2.2 Summary by Activity type of measured Electrical Power Demands

This summary section contains 4 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:

- 4 activities had measured data
- Of these activities 4 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from (at least 2 samples)
- The measured electrical power demand for LAN 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 Germany

Activity type	Section reference	Sample Size	Cold Generators		Heat Rejection	
Cellular Office Area	2.2.1	2	0.05	(0.06)	0.11	(0.00)
IT: High Density IT Suite	2.2.2	2	1.33	(1.73)	0.24	(0.00)
IT: LAN Rooms	2.2.3	2	2.79	(3.63)	1.45	(0.00)
Lecture theatre	2.2.4	2	0.03	(0.04)	0.27	(0.00)

Figure 1: Measured Overall Power Demand in W/m2 by HVAC Component type. Summary for Germany (max SD: 3.63; sample size: 2)
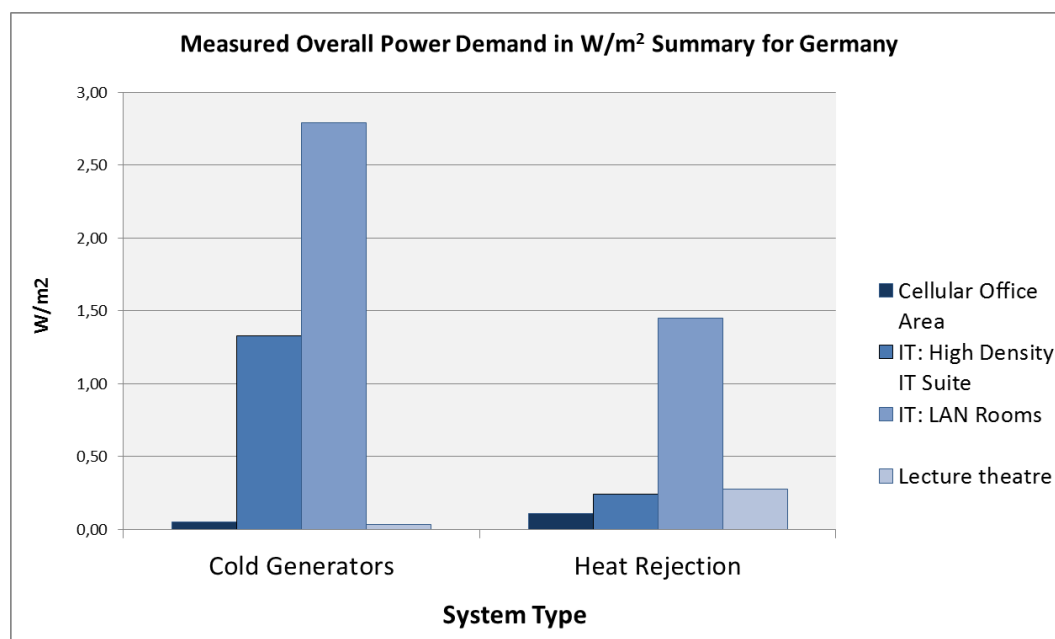
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2.2.1   Cellular Office Area - power demand summary by component

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 4 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Cellular Office Area for Germany

Parameter	Cold Generators		Heat Rejection	
Average (Standard Deviation)	0.05	(0.06)	0.11	(0.00)
Maximum (Standard Deviation)	0.46	(0.65)	2.11	(0.00)
Minimum (Standard Deviation)	0.00	(0.00)	0.00	(0.00)
Sample Size (number)	2		1	

2.2.2   IT: High Density IT Suite - 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 IT: High Density IT Suite for Germany

Parameter	Cold Generators		Heat Rejection	
Average (Standard Deviation)	1.33	(1.73)	0.24	(0.00)
Maximum (Standard Deviation)	12.78	(17.79)	4.68	(0.00)
Minimum (Standard Deviation)	0.09	(0.12)	0.00	(0.00)
Sample Size (number)	2		1	

2.2.3   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 6 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for IT: LAN Rooms for Germany

Parameter	Cold Generators		Heat Rejection	
Average (Standard Deviation)	2.79	(3.63)	1.45	(0.00)
Maximum (Standard Deviation)	26.91	(37.46)	27.77	(0.00)
Minimum (Standard Deviation)	0.19	(0.25)	0.01	(0.00)
Sample Size (number)	2		1	

2.2.4   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 7 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Lecture theatre for Germany

Parameter	Cold Generators		Heat Rejection	
Average (Standard Deviation)	0.03	(0.04)	0.27	(0.00)
Maximum (Standard Deviation)	0.31	(0.43)	5.27	(0.00)
Minimum (Standard Deviation)	0.00	(0.00)	0.00	(0.00)
Sample Size (number)	2		1	

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

This summary section contains 2 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:

- 4 activities had measured data
- Of these activities 4 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from (at least 2 samples)
- The measured annual energy use for LAN Rooms is highest

A summary of the measured average annual energy use benchmarks by activity type and HVAC component type is shown in Table 8. 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 Germany. The more detailed tables also show the annual maximum and minimum annual energy use ranges found for this equipment.

Table 8 – Benchmarks for measured Average and Standard Deviation Annual Energy Use in kWh/m2 Summary by HVAC Component and Activity Type for Germany

Activity type	Sample Size	Cold Generators		Heat Rejection	
Cellular Office Area	2	0.15	(0.19)	1.32	(0.00)
IT: High Density IT Suite	2	4.10	(5.10)	2.93	(0.00)
IT: LAN Rooms	2	8.63	(10.73)	17.41	(0.00)
Lecture theatre	2	0.10	(0.12)	3.30	(0.00)

Figure 2: Measured Overall Annual Energy Use in kWh/m2 by HVAC Component type. Summary for Germany (max SD: 10.73; sample size: 2)
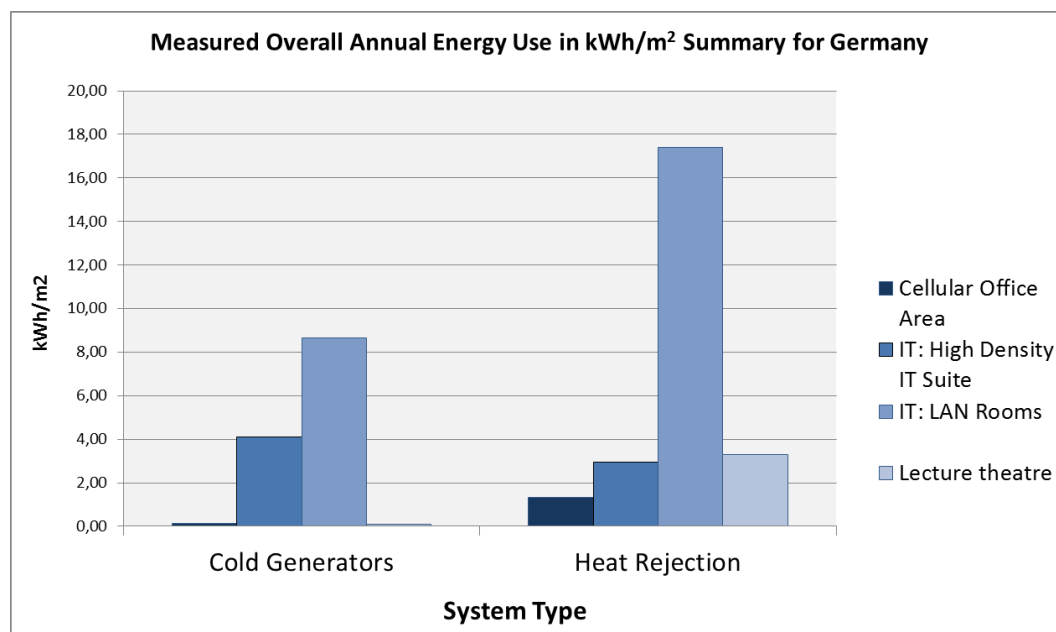
2.3.1 Activity types - annual energy use/m2 summary by Cold Generator sub-components

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 9 – Overall Data Summary by Cold Generator Sub-component types. Average and Standard Deviation Annual kWh/m^2 in Germany

Activity type	Absorption Chillers		Screw Liquid Chillers	
Cellular Office Area	0.02	(0.00)	0.28	(0.00)
IT: High Density IT Suite	0.50	(0.00)	7.70	(0.00)
IT: LAN Rooms	1.04	(0.00)	16.22	(0.00)
Lecture theatre	0.01	(0.00)	0.19	(0.00)

Table 9 provides the range of annual energy consumptions found in different Cold Generator Component sub-types servicing the activities shown in buildings across Germany. 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 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 10 – Overall Data Summary by Heat Rejection Sub-component types. Average and Standard Deviation Annual kWh/m2 in Germany

Activity type	Closed Circuit Cooling Towers	
Cellular Office Area	1.32	(0.00)
IT: High Density IT Suite	2.93	(0.00)
IT: LAN Rooms	17.41	(0.00)
Lecture theatre	3.30	(0.00)

Table 10 provides the range of annual energy consumptions found in different Heat Rejection Component sub-types servicing the activities shown in buildings across Germany. 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 Germany.

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 and the Heat Rejections rise up to the summer and falls then down again. The most intensive consumption occurs in the months May to June.

2.4.1 Activity types – monthly energy use/m² summary by Cold Generator – Absorption Chillers

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

Table 11 – Measured average monthly energy consumption and standard deviation in kWh/m² by Cold Generator – Absorption Chillers servicing the given activity for Germany

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Cellular Office Area	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.01)	(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: High Density IT Suite	0.82	0.08	0.08	0.08	0.09	0.10	0.10	0.12	0.04	0.04	0.04	0.04	0.03
	(0.25)	(0.09)	(0.09)	(0.10)	(0.08)	(0.07)	(0.06)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
IT: LAN Rooms	1.72	0.18	0.16	0.17	0.19	0.22	0.21	0.26	0.08	0.08	0.08	0.08	0.06
	(0.53)	(0.19)	(0.19)	(0.20)	(0.17)	(0.14)	(0.13)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lecture theatre	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

2.4.2 Activity types – monthly energy use/m² summary by Cold Generator – Screw Liquid Chillers

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

Table 12 – Measured average monthly energy consumption and standard deviation in kWh/m² by Cold Generator – Screw Liquid Chillers servicing the given activity for Germany

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Cellular Office Area	0.46	0.04	0.04	0.06	0.06	0.06	0.06	0.01	0.02	0.01	0.02	0.04	0.02
	(0.13)	(0.01)	(0.03)	(0.06)	(0.06)	(0.06)	(0.03)	(0.00)	(0.00)	(0.01)	(0.01)	(0.02)	(0.01)
IT: High Density IT Suite	12.76	1.05	0.99	1.67	1.74	1.65	1.56	0.40	0.46	0.36	0.54	0.99	0.52
	(3.51)	(0.31)	(0.72)	(1.69)	(1.70)	(1.56)	(0.74)	(0.00)	(0.00)	(0.26)	(0.21)	(0.52)	(0.24)
IT: LAN Rooms	26.86	2.20	2.09	3.53	3.67	3.48	3.29	0.85	0.96	0.76	1.14	2.08	1.10
	(7.39)	(0.65)	(1.53)	(3.56)	(3.58)	(3.29)	(1.55)	(0.00)	(0.00)	(0.54)	(0.44)	(1.10)	(0.50)
Lecture theatre	0.31	0.03	0.02	0.04	0.04	0.04	0.04	0.01	0.01	0.01	0.01	0.02	0.01
	(0.09)	(0.01)	(0.02)	(0.04)	(0.04)	(0.04)	(0.02)	(0.00)	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)

2.4.3 Activity types – monthly energy use/m² summary by Heat Rejection – Closed Circuit Cooling Towers

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

Table 13 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Heat Rejection – Closed Circuit Cooling Towers servicing the given activity for Germany

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Cellular Office Area	0.58	0.02	0.02	0.02	0.02	0.02	0.04	0.13	0.14	0.08	0.05	0.03	0.02
	(0.05)	(0.00)	(0.00)	(0.01)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.03)	(0.01)	(0.01)	(0.00)
IT: High Density IT Suite	1.29	0.05	0.04	0.03	0.04	0.04	0.08	0.29	0.31	0.17	0.11	0.06	0.05
	(0.11)	(0.01)	(0.00)	(0.03)	(0.04)	(0.04)	(0.01)	(0.00)	(0.00)	(0.06)	(0.02)	(0.02)	(0.01)
IT: LAN Rooms	7.63	0.30	0.23	0.20	0.22	0.26	0.49	1.69	1.82	1.03	0.64	0.34	0.32
	(0.66)	(0.05)	(0.02)	(0.18)	(0.21)	(0.26)	(0.04)	(0.00)	(0.00)	(0.36)	(0.09)	(0.14)	(0.04)
Lecture theatre	1.45	0.06	0.04	0.04	0.04	0.05	0.09	0.32	0.35	0.20	0.12	0.07	0.06
	(0.13)	(0.01)	(0.00)	(0.03)	(0.04)	(0.05)	(0.01)	(0.00)	(0.00)	(0.07)	(0.02)	(0.03)	(0.01)

2.5 Summary Conclusions

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

- Data from 5 different activity types from 128 to 12,871 m²; the most frequently encountered activity type was the cellular office area
- Data from 3 HVAC components; the most frequently encountered component type was the cold generator
- Data from 49 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 0,05 and 0,11 W/m² (standard deviation: 0,06). 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 0,15 and 1,32 kWh/m²a (standard deviation: 0,19). 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 occurs in the months May to June. More information are available in section 2.4.

3   References

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