

iSERV Measured Data Analysis by HVAC Component and Activity - Czech Republic

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30th May 2014

Intelligent Energy – Europe (IEE) SAVE Project

May 7th 2011 to May 6th 2014

Project websites:

Main website: <http://www.iservcmb.info>

Database website: <http://www.iservcmb.eu>

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iSERV Measured Data Analysis – Czech Republic



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1 Introduction

This report presents the measured HVAC component and end use activity data obtained for Czech Republic 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 Czech Republic 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 summarises the data collected for the HVAC Components and the iSERV Activity types available in Czech Republic. It can be seen that the HVAC components in this country service 10 total activity types with areas ranging in size from 49.4 to 19,132.56 m². There was an average of 1 meter available for each system analysed. The most frequently encountered component type in this country was Terminal Units. The number following the comma for each component type shows how many had sub-metering which addressed their energy use. This sub-metering could be either dedicated to the component or cover a series of HVAC components.

Table 1 – Overall Systems Summary for Czech Republic showing numbers of components and meters associated with each activity type. For the components columns, the first number shows total components associated with each activity. The number after the comma shows the number of submeters associated with this component type.

Activity type	Floor Area / m ²	# of spaces	Electricity	Gas	Oil	Heat	Water	Heat Generators	Cold Generators	All-in-One	Heat Pumps	Air Handling Units	Humidifiers	Dehumidifiers	Pumps	Storage Systems	Terminal Units	Heat Recovery	Heat Rejection
Cellular Office Area	19,132.56	18	20						8		11	15			13	1	29		
Cellular Office Area - multiple occupation	2,377.87	1	1						1						3		2		
Open Plan Office Area	11,600	2	2						2			5					2		
Meeting Room	332.83	4	4						2			3							
Library - open stacks	11,577.72	1	5						1			2			3		2		
IT: LAN Rooms	541.05	1	3						1			1					1		
Catering: Eating/drinking area	625	2	5						4			2			6				
Catering: Full Kitchen Preparing Hot Meals	90	1	3						2			1			3				
Catering: Kitchenette (small appliances, fridge and sink)	49.4	1	1						1			1							
Assembly areas / halls	433.3	2	1						1			3							

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2.2 Summary by Activity type of measured Electrical Power Demands

This summary section contains 9 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:

- Only 9 activities had measured data
- Of these activities only 5 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from, and 4 activities had only 1 metered sample.

A summary of the average **maximum** power demand benchmarks is shown in Table 2. 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 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 2 – Benchmarks for measured Average and Standard Deviation Power Demands in W/m² Summary by HVAC Component and Activity Type for Czech Republic.

Activity type	Meter Type	Sample Size	Air Handling Units		Cold Generators	
Assembly areas / halls	Electricity	1	0,00	(0,00)	0,71	(0,00)
Catering: Eating/drinking area	Electricity	4	0,00	(0,00)	2,22	(0,00)
Catering: Kitchenette (small appliances, fridge and sink)	Electricity	1	0,00	(0,00)	8,81	(0,00)
Cellular Office Area	Electricity	8	0,00	(0,00)	2,50	(0,51)
Cellular Office Area - multiple occupation	Electricity	1	0,00	(0,00)	0,60	(0,00)
IT: LAN Rooms	Electricity	1	9,83	(0,00)	33,30	(0,00)

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Activity type	Meter Type	Sample Size	Air Handling Units	Cold Generators
Library - open stacks	Electricity	2	0,07 (0,10)	0,21 (0,00)
Meeting Room	Electricity	3	16,69 (0,00)	13,52 (18,25)
Open Plan Office Area	Electricity	2	0,00 (0,00)	1,69 (0,21)

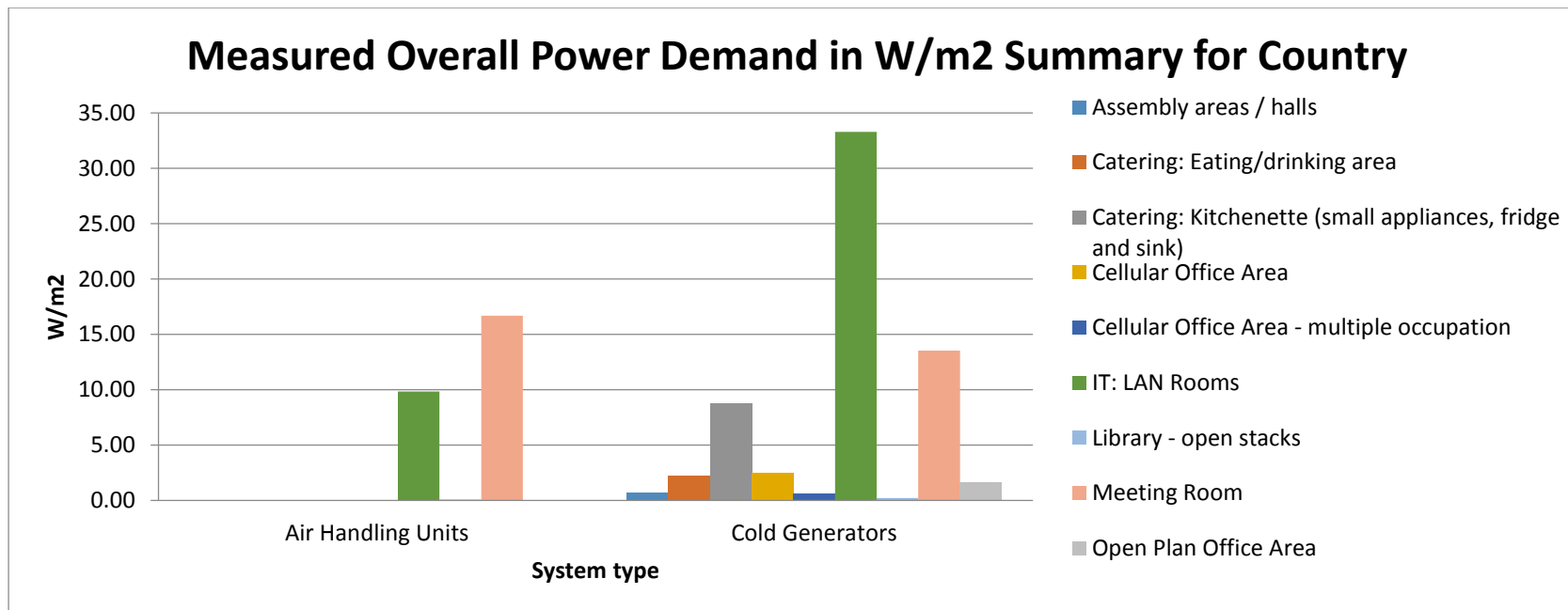


Figure 1: Measured Overall Power Demand in W/m2 by HVAC Component type. Summary for Czech Republic

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2.2.1 Assembly areas/halls – 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. The breakdown of these component types into the power demand ranges found for each subcomponent type are given in section 3.

Table 3 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Assembly areas / halls for Czech Republic

Parameter	Cold Generators	
Sample size (number)	1	
Average (Standard Deviation)	0,71	(0,00)
Maximum (Standard Deviation)	40,39	(0,00)
Minimum (Standard Deviation)	0,23	(0,00)

2.2.2 Catering: Eating/drinking area – power demand summary by component

Table 4 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Eating/drinking area for Czech Republic

Parameter	Cold Generators	
Sample size (number)	2	
Average (Standard Deviation)	2,22	(0,00)
Maximum (Standard Deviation)	20,26	(0,00)
Minimum (Standard Deviation)	0,18	(0,00)

2.2.3 Catering: Kitchenette (small appliances, fridge and sink) – power demand summary by component

Table 5 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Catering: Kitchenette (small appliances, fridge and sink) for Czech Republic

Parameter	Cold Generators	
Sample size (number)	1	
Average (Standard Deviation)	8,81	(0,00)
Maximum (Standard Deviation)	43,98	(0,00)
Minimum (Standard Deviation)	0,14	(0,00)

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2.2.4 Cellular Office Area – power demand summary by component

Table 6 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Cellular Office Area for Czech Republic

Parameter	Cold Generators	
Sample size (number)	4	
Average (Standard Deviation)	2,50	(0,51)
Maximum (Standard Deviation)	15,69	(3,61)
Minimum (Standard Deviation)	0,25	(0,09)

2.2.5 Cellular Office Area - multiple occupation – power demand summary by component

Table 7 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Cellular Office Area - multiple occupation for Czech Republic h

Parameter	Cold Generators	
Sample size (number)	1	
Average (Standard Deviation)	0,60	(0,00)
Maximum (Standard Deviation)	6,24	(0,00)
Minimum (Standard Deviation)	0,01	(0,00)

2.2.6 IT: LAN Rooms – power demand summary by component

Table 8 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for IT: LAN Rooms for Czech Republic

Parameter	Air Handling Units		Cold Generators	
Sample size (number)	1		1	
Average (Standard Deviation)	9,83	(0,00)	33,30	(0,00)
Maximum (Standard Deviation)	18,48	(0,00)	344,36	(0,00)
Minimum (Standard Deviation)	0,60	(0,00)	0,45	(0,00)

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2.2.7 Library - open stacks – power demand summary by component

Table 9 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Library - open stacks for Czech Republic

Parameter	Air Handling Units		Cold Generators	
Sample size (number)	2		1	
Average (Standard Deviation)	0,07	(0,10)	0,21	(0,00)
Maximum (Standard Deviation)	0,30	(0,43)	2,21	(0,00)
Minimum (Standard Deviation)	0,00	(0,00)	0,00	(0,00)

2.2.8 Meeting Room – power demand summary by component

Table 10 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Meeting Room for Czech Republic

Parameter	Air Handling Units		Cold Generators	
Sample size (number)	1		2	
Average (Standard Deviation)	16,69	(0,00)	13,52	(18,25)
Maximum (Standard Deviation)	58,16	(0,00)	69,16	(88,77)
Minimum (Standard Deviation)	0,61	(0,00)	0,21	(0,28)

2.2.9 Open Plan Office Area – power demand summary by component

Table 11 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Open Plan Office Area for Czech Republic

Parameter	Cold Generators	
Sample size (number)	2	
Average (Standard Deviation)	1,69	(0,21)
Maximum (Standard Deviation)	17,14	(2,30)
Minimum (Standard Deviation)	0,02	(0,02)

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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 m² found across all the HVAC sub-component types monitored in iSERV.

A summary of the measured average annual energy use benchmarks by activity type and HVAC component type is shown in Table 12. 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 country. The more detailed tables also show the annual maximum and minimum annual energy use ranges found for this 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 12 – Benchmarks for measured Average and Standard Deviation Annual Energy Use in kWh/m² Summary by HVAC Component and Activity Type for Czech Republic.

Activity type	Air Handling Units		Cold Generators	
	Average	SD	Average	SD
Catering: Eating/drinking area	0,00	(0,00)	151,12	(0,00)
Cellular Office Area	0,00	(0,00)	140,33	(0,00)
IT: LAN Rooms	45,91	(0,00)	0,00	(0,00)
Library - open stacks	0,03	(0,00)	0,00	(0,00)
Meeting Room	18,14	(0,00)	0,00	(0,00)

Next tables show the average and standard deviation annual energy use found from the data for all activity types for HVAC sub-component types servicing the activities shown in buildings across Czech Republic. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

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

Table 13 – Electricity : Air Handling Units - Average Annual Energy Consumption in kWh/m² per year and SD by Component Type, Sub-Type and Activity

Activity type	Supply and extract with heating and cooling variants, etc	
	Average	SD
IT: LAN Rooms	45,91	(0,00)
Library - open stacks	0,03	(0,00)
Meeting Room	18,14	(0,00)

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

Table 14 – Electricity : Cold Generators - Average Annual Energy Consumption in kWh/m² per year and SD by Component Type, Sub-Type and Activity

Activity type	Screw Liquid Chillers	
Catering: Eating/drinking area	151,12	(0,00)
Cellular Office Area	140,33	(0,00)

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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 Czech Republic i.e. it further subdivides Table 15 and Table 16. **Error! Reference source not found..**

2.4.1 Activity types – monthly energy use/m² summary by Air Handling Units sub-component

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

Table 15 – Measured average monthly energy consumption and standard deviation in kWh/m² by Air Handling Units servicing the given activity for Czech Republic

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCOTBER	NOVEMBER	DECEMBER
IT: LAN Rooms	22,99 (2,16)	1,93 (0,46)	1,81 (0,28)	1,83 (0,34)	1,85 (0,34)	1,90 (0,29)	1,70 (0,37)	1,52 (0,28)	1,69 (0,36)	1,98 (0,51)	2,17 (0,36)	2,10 (0,32)	2,07 (0,30)
Meeting Room	20,85 (5,95)	0,95 (0,54)	1,42 (0,30)	1,48 (0,32)	1,86 (0,57)	2,28 (1,09)	1,34 (1,09)	0,68 (0,55)	1,44 (0,98)	1,97 (1,18)	2,67 (1,57)	2,96 (2,15)	1,71 (1,51)

2.4.2 Activity types – monthly energy use/m² summary by Cold Generators sub-component

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

Table 16 – Measured average monthly energy consumption and standard deviation in kWh/m² by Cold Generator servicing the given activity for Czech Republic

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCOTBER	NOVEMBER	DECEMBER
Catering: Eating/drinking area	93,57 (54,94)	7,87 (5,55)	7,23 (5,12)	7,56 (5,33)	7,68 (5,00)	7,98 (4,98)	6,48 (4,66)	7,25 (4,76)	7,38 (4,84)	5,88 (4,67)	6,34 (5,30)	7,68 (5,43)	5,28 (5,28)
Cellular Office Area	43,44 (25,83)	3,85 (2,52)	3,36 (2,31)	3,51 (2,40)	3,74 (2,28)	4,62 (2,35)	4,13 (2,25)	5,05 (2,42)	4,79 (2,36)	3,35 (2,50)	3,85 (2,51)	4,13 (2,51)	2,97 (2,35)

2.5 Summary Conclusions

The power demand benchmarks were presented for 9 types of activities, such as:

- Assembly areas / halls,
- Catering: Eating/drinking area,
- Catering: Kitchenette (small appliances, fridge and sink),
- Cellular Office Area,
- Cellular Office Area - multiple occupation,
- IT: LAN Rooms,
- Library - open stacks,
- Meeting Room,
- Open Plan Office Area.

These activities have several HVAC components, which were analyzed, such as air handling units and cold generators. The average power demand is calculated by aggregating all measured energy consumption up to hourly intervals then taking the average, maximum or minimum demands over the period for which we have non-zero data.

The average power demand of air handling units and cold generators are the following:

- The minimum and maximum power demands of the analyzed air handling units regarding the IT rooms were between 0.6-19 W/m², with an average of 9.83 W/m². Regarding the meeting rooms, the air handling units' minimum and maximum power demands were between 0.6-58 W/m², with an average of 16.69 W/m².
- The minimum and maximum power demands of the cold generators regarding the assembly areas/halls were between 0.2-40.4 W/m², with an average of 0.7 W/m². Regarding the catering/eating drinking area the cold generators' minimum and maximum power demands were between 0.2-20.3 W/m², with an average of 2.22 W/m². Catering/kitchenette (small appliances) activity's cold generator power demand was between 0.1-44 W/m², with an average of 8.81 W/m². Cellular office areas' cold generator power demand was between 0.25-15.7 W/m², with an average of 2.50 W/m². IT rooms' cold generator power demand was between 0.5-344.3 W/m², with an average of 33.3 W/m². Meeting rooms' cold generator power demand was between 0.2-69.2 W/m², with an average of 13.5 W/m². Libraries' cold generator power demand was between 0-2.2 W/m², with an average of 0.21 W/m². Open plan office areas' cold generator power demand was between 0-2.3 W/m², with an average of 0.21 W/m².

In conclusion, the average power demand for air handling units vary between 9.8-16.7 W/m², while the average power demand for cold generators vary between 0.2-33.3 W/m² in function of the activity of the building.

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3 Detailed Data Summary and Analysis

This section examines each System in detail, along with summaries of the measured data in the first column of each table. The summaries are used in the overview section in this report.

The data is considered at the level of consumption by HVAC component using the following metrics: W/m^2 and Annual kWh/m^2 and kWh/m^2 by month.

The data in this section is derived directly from the HERO database and is normalised to the floor areas allocated to each HVAC component within the iSERV spreadsheet for each building.

3.1 Measured data accuracy

The actual floor areas are expected to be between -1 to +4% of the value recorded in the iSERV spreadsheet, and the maximum expected error in the read for each electricity and gas meter is $\pm 2\%$ [Knight 2014]. For heat meters the expected errors are around - 10% based on studies of the actual performance of installed heat meters in Sweden [Jomni 2006] and observations of installation practice in real buildings.

The findings presented here should be read with these potential inaccuracies in mind.

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3.2 Power Demands Section

This section covers the sub-hourly power demands measured for each HVAC System Component and Sub-Component type by Activity served

3.2.1 Air Handling Unit Power Demands by Sub-Component type and Activity

Table 17 shows the average, maximum and minimum power demands measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of power demands being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 17 – Overall measured power demands in W/m² by Air Handling Units Sub-component type in Czech Republic

Building/ System Name	Supply and extract with heating and cooling variants, etc
Sample Size	4
Average W/m ²	6,6673
SD Average W/m ²	8,1163
Average Max W/m ²	19,3126
SD Max W/m ²	27,2826
Average Min W/m ²	0,3037
SD Min W/m ²	0,3504

3.2.2 Cold Generator Power Demands by Sub-Component type and Activity

Table 17 shows the average, maximum and minimum power demands measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of power demands being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 18 – Overall measured power demands in W/m² by Cold Generators Sub-component types in Czech Republic

Building/ System Name	Screw Liquid Chillers	Scroll Liquid Chillers
Sample Size	7	2
Average W/m ²	4,5741	2,9440
SD Average W/m ²	7,8245	0,0000
Average Max W/m ²	34,1820	12,5641
SD Max W/m ²	35,0757	0,0000
Average Min W/m ²	0,1402	0,3205
SD Min W/m ²	0,1246	0,0000

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3.3 Energy Consumption Section – Annual Data

This section covers the annual energy consumption figures measured for each HVAC System Component and Sub-Component type.

3.3.1 Air Handling Unit Annual Energy Consumption Section by Sub-Component types

Table 17 shows the average, maximum and minimum Annual Energy Consumption Section measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of Annual Energy Consumption Section being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 19 – Overall measured annual energy consumption in kWh/m² by Air Handling Units Sub-component types in Czech Republic

Building/ System Name	Supply and extract with heating and cooling variants, etc
Sample Size	3
Average kWh/m ² /year	27,6370
SD Average kWh/m ² /year	24,3343
Average Max kWh/m ² /year	34,7952
SD Max kWh/m ² /year	30,2065
Average Min kWh/m ² /year	20,7510
SD Min kWh/m ² /year	22,1554

3.3.2 Cold Generator Annual Energy Consumption Section by Sub-Component types

Table 17 shows the average, maximum and minimum Annual Energy Consumption Section measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of Annual Energy Consumption Section being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 20 – Overall measured annual energy consumption in kWh/m² by Cold Generators Sub-components types in Czech Republic

Building/ System Name	Screw Liquid Chillers
Sample Size	2
Average kWh/m ² /year	130,9220
SD Average kWh/m ² /year	0,0000
Average Max kWh/m ² /year	141,7376
SD Max kWh/m ² /year	0,0000
Average Min kWh/m ² /year	121,6884
SD Min kWh/m ² /year	0,0000

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3.4 Energy Consumption Section – Monthly Data

This section covers the monthly energy consumption figures measured for each HVAC System Component and Sub-Component type.

3.4.1 Air Handling Units Monthly Energy Consumption Section by Sub-Component types

Table 1721 shows the average, maximum and minimum Monthly Energy Consumption Section measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of Monthly Energy Consumption Section being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 21 – Overall measured monthly energy consumption in kWh/m² by Air Handling Units Sub-component types in Czech Republic

Component sub- type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Supply and extract with heating and cooling variants, etc	2,27 (0,00)	0,72 (0,92)	0,81 (0,95)	1,11 (0,97)	1,24 (1,07)	1,40 (1,22)	0,76 (0,89)	0,55 (0,72)	0,78 (0,91)	0,99 (1,14)	1,21 (1,41)	1,27 (1,50)	0,95 (1,10)

3.4.2 Cold Generators Monthly Energy Consumption Section by Sub-Component types

Table 1722 shows the average, maximum and minimum Monthly Energy Consumption Section measured for the systems shown. This data does not take into account the activities being serviced but serves to provide an indication of the in-use ranges of Monthly Energy Consumption Section being found in Czech Republic for this HVAC component. These figures include directly measured energy use and energy use apportioned by initial benchmarks from metered data serving more than one component.

Table 22 – Overall measured monthly energy consumption in kWh/m² by Cold Generators Sub-component types in Czech Republic

Component sub- type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Screw Chillers Liquid	44,97 (0,00)	1,69 (1,73)	1,57 (1,58)	3,63 (0,00)	3,69 (0,00)	3,84 (0,00)	2,27 (0,84)	4,44 (5,76)	4,29 (5,59)	3,03 (4,26)	3,27 (4,03)	3,10 (3,72)	1,50 (1,29)

4 References

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