iSERV Measured Data Analysis by HVAC Component and Activity - Hungary

By

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Project websites:

Main website: http://www.iservcmb.info
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Contents

1 Introduction

This report presents the measured HVAC component and end use activity data obtained for Hungary 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 Hungary 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 Hungary. It can be seen that the HVAC components in this country service 8 total activity types with areas ranging in size from 113 to 36.172 m^2. 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 Hungary 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 / m2	# of spaces	Electricity	Gas	Oil	Heat	Water	Heat Generators	Cold Generators	All-in-One Systems	Heat Pumps	Air Handling Units	Humidifiers	Dehumidifiers	Pumps	Storage Systems	Terminal Units	Heat Recovery	Heat Rejection
Cellular Office Area	36,172.3	8	21	1				2	6		1	7	4		10		4		
Consulting/treatment room	748	11	1						1								11		
Open Plan Office Area	2,926	29	29							44		18					45		
IT: Server Room	142	23	23							23							23		
Catering: Eating/drinking area	1731.2	4	12	1				2	6			4			9		15		
Lecture theatre	540	1						2	2						4		1		
Laboratory	113	2	3						1		1	1							
Retail Warehouse Sales area - chilled	7,903	12	12						12								60		

2.2 Summary by Activity type of measured Electrical Power Demands

This summary section contains 5 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 5 activities had measured data
- Of these activities 3 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from, and 2 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.

Table 2 – Benchmarks for measured Average and Standard Deviation Power Demands in W/m^2 Summary by HVAC Component and Activity Type for Hungary

Activity type	Meter Type	Sample Size	Air Handling Units		Cold Generators		Heat Pump		Terminal Units	
Catering: Eating/drinking area	Electricity	4	5,21	(4,84)	1,51	(0,18)	0,00	(0,00)	0,16	(0,11)
Cellular Office Area	Electricity	7	3,25	(0,18)	1,89	(1,30)	0,00	(0,00)	2,60	(0,00)
Consulting/treatment room	Electricity	1	0,00	(0,00)	6,00	(0,00)	0,00	(0,00)	0,00	(0,00)
Laboratory	Electricity	1	5,53	(0,00)	6,17	(0,00)	26,03	(0,00)	0,00	(0,00)
Retail Warehouse Sales area - chilled	Electricity	12	0,00	(0,00)	3,42	(0,38)	0,00	(0,00)	0,77	(0,08)

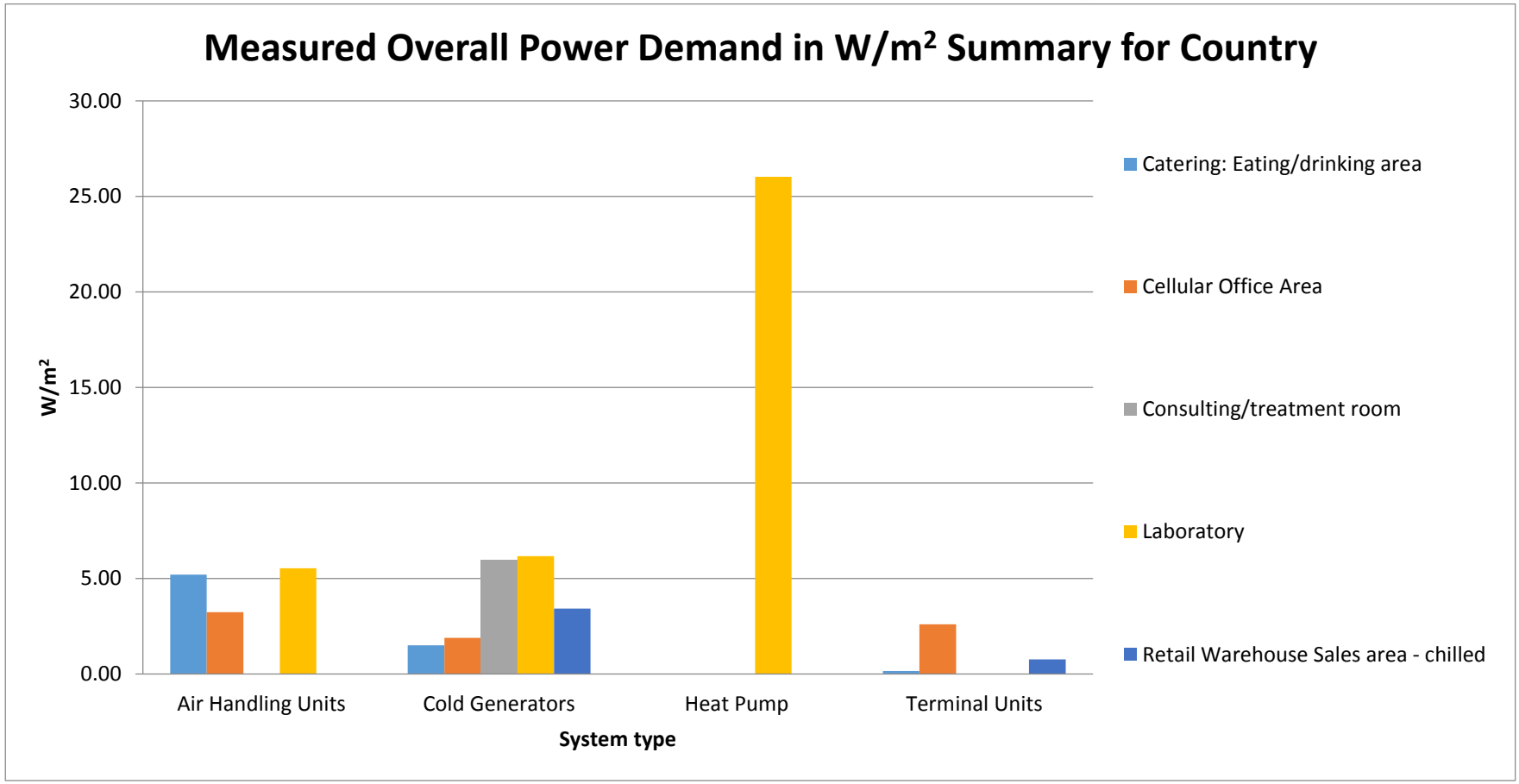

Figure 1: Measured Overall Power Demand in W/m² by HVAC Component type. Summary for Hungary.

2.2.1 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. 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 Catering, Eating/drinking area for Hungary

Parameter	Air Handling Units		Cold Generators		Terminal Units	
Average	5,21	(4,84)	1,51	(0,18)	0,16	(0,11)
Maximum	19,72	(6,99)	6,90	(3,04)	1,06	(0,71)
Minimum	0,06	(0,10)	0,01	(0,00)	0,00	(0,00)
Sample Size	3,00	(0,00)	3,00	(0,00)	13,00	(0,00)

2.2.2 Cellular Office Area – power demand summary by component

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

Parameter	Air Handling Units		Cold Generators		Terminal Units	
Average	3,25	(0,18)	1,89	(1,30)	2,60	(0,00)
Maximum	10,15	(1,06)	11,29	(11,90)	19,06	(0,00)
Minimum	0,01	(0,00)	0,02	(0,02)	0,03	(0,00)
Sample Size	2,00	(0,00)	3,00	(0,00)	1,00	(0,00)

2.2.3 Consulting/treatment room – power demand summary by component

Table 5 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Consulting/treatment room for Hungary

Parameter	Cold Generators	
Average	6,00	(0,00)
Maximum	27,67	(0,00)
Minimum	0,01	(0,00)
Sample Size	1,00	(0,00)

2.2.4 Laboratory – power demand summary by component

Table 6 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Laboratory for Hungary

Parameter	Air Handling Units		Cold Generators		Heat Pump	
Average	5,53	(0,00)	6,17	(0,00)	26,03	(0,00)
Maximum	105,98	(0,00)	45,59	(0,00)	90,32	(0,00)
Minimum	0,01	(0,00)	0,08	(0,00)	1,84	(0,00)
Sample Size	1,00	(0,00)	1,00	(0,00)	1,00	(0,00)

2.2.5 Retail Warehouse Sales area – power demand summary by component

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

Parameter	Cold Generators		Terminal Units	
Average	3,42	(0,38)	0,77	(0,08)
Maximum	6,90	(0,93)	1,56	(0,20)
Minimum	0,78	(0,18)	0,18	(0,04)
Sample Size	11,00	(0,00)	55,00	(0,00)

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

This summary section contains 4 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 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 country. 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 Hungary

Activity Name	Air Handling Units	Cold Generators	Heat Pump	Terminal Units
Catering: Eating/drinking area	16,63 (0,00)	10,27 (0,00)	0,00 (0,00)	1,13 (0,75)

Consulting/treatment room	0,00 (0,00)	52,94 (0,00)	0,00 (0,00)	0,00 (0,00)
Laboratory	0,00 (0,00)	0,00 (0,00)	127,79 (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 Hungary. 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/m^2 summary by Air Handling units

Table 9 – 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 with heating and cooling variants
Catering: Eating/drinking area	16,63 (0,00)

2.3.2 Activity types – annual energy use/m^2 summary by Cold Generators

Table 10 – Electricity: Scroll liquid chillers - Average Annual Energy Consumption in kWh/m2 per year and SD by Component Type, Sub-Type and Activity

Activity type	Scroll Liquid Chillers
Catering: Eating/drinking area	10,27 (0,00)
Consulting/treatment room	52,94 (0,00)

2.3.3 Activity types – annual energy use/m^2 summary by Heat pumps

Table 11 – Electricity: Heat pump - Average Annual Energy Consumption in kWh/m2 per year and SD by Component Type, Sub-Type and Activity

Activity type	Ground source reverse cycle - heating optimised
Laboratory	127,79 (0,00)

2.3.4 Activity types – annual energy use/m^2 summary by Terminal units

Table 12 – Electricity: Terminal units - Average Annual Energy Consumption in kWh/m2 per year and SD by Component Type, Sub-Type and Activity

Activity type	Fan Coils – 2 or 4 tubes
Catering: Eating/drinking area	1,13 (0,75)

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 Hungary, i.e. it further subdivides Table 13 – Table 16.

2.4.1 Activity types – monthly energy use/m^2 summary by Air Handling Units

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

Table 13 – Measured average monthly energy consumption and standard deviation in kWh/m^2 by Air Handling Units servicing the given activity for Hungary

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	16,63 (0,00)	6,67 (0,53)	6,09 (0,44)	6,43 (0,41)	5,72 (0,00)	2,49 (0,00)	3,17 (0,00)	3,60 (0,00)	3,52 (0,00)	2,91 (0,00)	0,92 (0,00)	0,00 (0,00)	0,00 (0,00)

2.4.2 Activity types – monthly energy use/m^2 summary by Cold Generators

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

Table 14 – Measured average monthly energy consumption and standard deviation in kWh/m^2 by Cold Generators servicing the given activity for Hungary

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	5,14 (2,41)	0,00 (0,00)	0,90 (0,02)	0,99 (0,11)	0,01 (0,00)	0,77 (0,49)	0,98 (0,62)	1,11 (0,70)	1,09 (0,69)	0,90 (0,57)	0,28 (0,18)	0,00 (0,00)	0,00 (0,00)
Consulting/treatment room	52,77 (1,08)	2,84 (0,19)	3,03 (0,31)	4,25 (0,80)	4,83 (0,04)	4,86 (0,69)	5,22 (0,60)	6,32 (0,87)	6,81 (1,58)	4,66 (0,43)	4,11 (0,44)	3,62 (0,23)	2,64 (0,11)

2.4.3 Activity types – monthly energy use/m^2 summary by Heat pumps

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/m^2 by Heat pumps servicing the given activity for Hungary

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Laboratory	141,94 (15,55)	15,49 (0,82)	13,88 (0,73)	14,63 (0,88)	11,10 (0,00)	9,22 (0,00)	8,53 (0,00)	7,39 (2,22)	6,67 (3,11)	10,70 (2,34)	14,25 (7,39)	17,33 (9,84)	16,84 (1,60)

2.4.4 Activity types – monthly energy use/m^2 summary by Terminal Units

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/m^2 by Terminal Units servicing the given activity for Hungary

Activity type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Catering: Eating/drinking area	1,13 (0,73)	0,00 (0,00)	0,00 (0,00)	0,00 (0,00)	0,00 (0,00)	0,17 (0,11)	0,22 (0,14)	0,24 (0,16)	0,24 (0,16)	0,20 (0,13)	0,06 (0,04)	0,00 (0,00)	0,00 (0,00)

2.5 Summary Conclusions

The power demand benchmarks were presented for 5 types of activities, such as retail warehouse, cellular office, catering, consulting/treatment room and laboratory, although enough samples were available only for the first three, especially for retail warehouse sales area, where 12 supermarkets provided data. These activities have several HVAC components, which were analyzed, such as air handling units, cold generators, heat pumps, and terminal units.

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 the heat pump system is the biggest from the analyzed HVAC components, which is 26.06 W/m^2. This benchmark is not representative, because there is only 1 sample for heat pump, and it is a demonstration laboratory in a university.

The average power demand of air handling units and cold generators are close to each other:

- The minimum and maximum power demands of the analyzed air handling units regarding the cellular office area were between 0-10 W/m^2, with an average of 3.25 W/m^2. Regarding the catering activity, the air handling units' minimum and maximum power demands were between 0-20 W/m^2, with an average of 5.21 W/m^2 and laboratory activity's power demand was between 0-106 W/m^2, with an average of 5.53 W/m^2
- The minimum and maximum power demands of the cold generators regarding the cellular office area were between 0-11 W/m^2, with an average of 1.89 W/m^2. Regarding the catering the cold generators' minimum and maximum power demands were between 0-7 W/m^2, with an average of 1.51 W/m^2. Laboratory activity's power demand was between 0-46 W/m^2, with an average of 6.17 W/m^2.

Taking into consideration the annual energy consumption of the different HVAC components, it can be seen regarding the catering activity the air handling units have 16.6 kWh/m^{2}a, while cold generators have 10.3 kWh/m^{2}a annual energy consumption. The reason for this, that the power demand are close to each other, but the fresh air supplying is necessary during the whole year, while the usage of cold generator is needed just in a period of the year.

Concerning the consultant/treatment room, the cold generator has 52.94 kWh/m^{2}a annual energy consumption, but it is not representative, due to the small sample size.

Concerning heat pumps, the situation is similar: the heat pump has 127.8 kWh/m^{2}a annual energy consumption, but it is not representative, due to the small sample size, and as it is mentioned earlier, this heat pump is demonstrational equipment in a university.

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 ± 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.

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 Cold Generator Power Demands by Sub-Component types

Error! Reference source not found. 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 Hungary 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 Cold Generator Sub-component types in Hungary

	Dry Coolers & Cooling Tower	Scroll Liquid Chillers
Sample Size	1	15
Average W/m2	1,0760	3,4763
SD Average W/m2		1,2546
Average Max W/m2	2,3194	10,8432
SD Max W/m2		10,3041
Average Min W/m2	0,0058	0,5810
SD Min W/m2		0,3814

3.2.1.1 Conclusions for Cold Generators

From the data it can be seen that:

- The average power demands across all Cold Generators range from 1.07 to 3.47 W/m²
- The maximum power demands across all Cold Generators range from 2.3 to 10.8 W/m²
- The minimum power demands across all Cold Generators range from 0.005 to 0.58 W/m²
- The lowest power demands come from dry coolers & cooling towers

3.2.2 Heat Pump Power Demands by Sub-Component types

Error! Reference source not found. 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 Hungary 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 Heat Pump Sub-component types in Hungary

	Ground source reverse cycle - heating optimised
Sample Size	1
Average W/m2	26,0254
SD Average W/m2	
Average Max W/m2	90,3226

SD Max W/m2	
Average Min W/m2	1,8433
SD Min W/m2	

3.2.3 Air Handling Unit Power Demands by Sub-Component types

Error! Reference source not found.9 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 Hungary 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 power demands in W/m² by Air Handling Unit Sub-component types in Hungary

	Supply and extract with heating and cooling variants, etc	**Supply with heating and cooling variants**
Sample Size	3	3
Average W/m2	5,7647	3,4529
SD Average W/m2	4,3653	1,7992
Average Max W/m2	16,0286	45,7809
SD Max W/m2	10,2109	52,1367
Average Min W/m2	0,0635	0,0032
SD Min W/m2	0,0891	0,0046

3.2.3.1 Conclusions for Air Handling Units

From the data it can be seen that:

- The average power demands across all Air Handling Units range from 3.45 to 5.76 W/m²
- The maximum power demands across all Air Handling Units range from 16.02 to 45.78 W/m²
- The minimum power demands across all Air Handling Units range from 0.003 to 0.06 W/m²
- The lowest power demands come from supply with heating and cooling variants

3.2.4 Terminal Unit Power Demands by Sub-Component types

Error! Reference source not found. 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 Hungary 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 power demands in W/m² by Terminal Unit Sub-component types in Hungary

	Fan Coils – 2 or 4 tubes
Sample Size	69

Average W/m2	0,6852
SD Average W/m2	0,3461
Average Max W/m2	1,7199
SD Max W/m2	2,1555
Average Min W/m2	0,1418
SD Min W/m2	0,0793

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 Cold Generator Annual Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Annual Energy Consumption 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 being found in Hungary 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 annual energy consumption in kWh/m² by Cold Generator Sub-component types in Hungary

	Scroll Liquid Chillers
Sample Size	2
Average kWh/m2/year	31,5199
SD Average kWh/m2/year	30,0476
Average Max kWh/m2/year	32,1495
SD Max kWh/m2/year	30,9376
Average Min kWh/m2/year	30,3007
SD Min kWh/m2/year	28,3238

3.3.2 Heat Pump Annual Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Annual Energy Consumption 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 being found in Hungary 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 annual energy consumption in kWh/m² by Heat pump Sub-component types in Hungary

	Ground source reverse cycle - heating optimised
Sample Size	1
Average kWh/m2/year	141,9443
SD Average kWh/m2/year	
Average Max kWh/m2/year	164,2968
SD Max kWh/m2/year	
Average Min kWh/m2/year	126,8383
SD Min kWh/m2/year	

3.3.3 Air Handling Unit Annual Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Annual Energy Consumption 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 being found in Hungary 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 23 – Overall measured annual energy consumption in kWh/m² by Air Handling Unit Sub-component types in Hungary

	Supply with heating and cooling variants
Sample Size	2
Average kWh/m2/year	16,6325
SD Average kWh/m2/year	0,0001
Average Max kWh/m2/year	16,6329
SD Max kWh/m2/year	0,0001
Average Min kWh/m2/year	16,6321
SD Min kWh/m2/year	0,0001

3.3.4 Terminal Unit Annual Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Annual Energy Consumption 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 being found in Hungary 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 24 – Overall measured annual energy consumption in kWh/m² by Terminal Unit Sub-component types in Hungary

	Fan Coils – 2 or 4 tubes
Sample Size	13
Average kWh/m2/year	1,1289
SD Average kWh/m2/year	0,7508
Average Max kWh/m2/year	1,1289
SD Max kWh/m2/year	0,7508
Average Min kWh/m2/year	1,1289
SD Min kWh/m2/year	0,7508

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 Cold Generator Monthly Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Monthly Energy Consumption 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 being found in Hungary 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 25 – Overall measured monthly energy consumption in kWh/m² by Cold Generator Sub-component types in Hungary

Component sub- type		Annual	January	February	March	April	May	June	July	August	September	October	November	December
Scroll Chillers	**Liquid**	31,59 (0,00)	1,03 (1,57)	0,78 (1,50)	1,15 (2,07)	1,65 (2,75)	2,60 (0,86)	2,89 (0,89)	3,43 (2,55)	3,09 (1,59)	2,51 (0,85)	1,28 (1,89)	1,25 (1,62)	0,87 (1,20)

3.4.2 Heat Pump Monthly Energy Consumption by Sub-Component types

Error! Reference source not found.26 shows the average, maximum and minimum Monthly Energy Consumption 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 being found in Hungary 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 26 – Overall measured monthly energy consumption in kWh/m² by Heat Pump Sub-component types in Hungary

Component sub- type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Ground source reverse cycle - heating optimised	141,94 (0,00)	15,49 (0,00)	13,88 (0,00)	14,63 (0,00)	11,10 (0,00)	9,22 (0,00)	8,53 (0,00)	7,39 (0,00)	6,67 (0,00)	10,70 (0,00)	14,25 (0,00)	17,33 (0,00)	16,84 (0,00)

3.4.3 Air Handling Unit Monthly Energy Consumption by Sub-Component types

Error! Reference source not found.27 shows the average, maximum and minimum Monthly Energy Consumption 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 being found in Hungary 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 27 – Overall measured monthly energy consumption in kWh/m² by Air Handling Unit Sub-component types in Hungary

Component sub- type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Supply with heating and cooling variants	16,63 (0,00)	0,00 (0,00)	0,00 (0,00)	0,06 (0,10)	0,02 (0,00)	2,49 (0,00)	3,17 (0,00)	3,20 (0,69)	3,22 (0,52)	3,80 (1,55)	0,68 (0,40)	0,49 (0,84)	0,00 (0,00)

3.4.4 Terminal Unit Monthly Energy Consumption by Sub-Component types

Error! Reference source not found. shows the average, maximum and minimum Monthly Energy Consumption 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 being found in Hungary 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 28 – Overall measured monthly energy consumption in kWh/m^2 by Terminal Unit Sub-component types in Hungary

Component sub- type	Annual	January	February	March	April	May	June	July	August	September	October	November	December
Fan Coils – 2 or 4 tubes	0,91 (0,00)	0,01 (0,03)	0,00 (0,01)	0,01 (0,02)	0,00 (0,00)	0,51 (0,18)	0,57 (0,19)	0,61 (0,58)	0,57 (0,34)	0,49 (0,21)	0,08 (0,04)	0,05 (0,10)	0,04 (0,06)

4 References

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

Jomni Y, v. Deventer J and Delsing J – “Comparing heat measurement accuracy of a new adaptive algorithm with existing heat meters in accordance to the Swedish test standard”, 10th International Symposium on District Heating and Cooling, September 3 – 5, 2006.