iSERV Measured Data Analysis by HVAC Component and Activity - Greece

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11-06-2014

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

Supported by
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EUROPE

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Contents

1   Introduction

This report presents the measured HVAC component and end use activity data obtained for Greece 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 Greece as well as summarising the measured data from the more detailed parts of this report.

Table 1a - Number of meters serving each activity

Activity type	Electricity	Gas	Heat	Water
Catering: Eating/drinking area	1			
Catering: Full Kitchen Preparing Hot Meals	1			
Cellular Office Area	16			
Circulation area (corridors and stairways)	2			
Dept Store Sales area - general	47			
External Space	2			
IT: Server Room	1			
Library – open stacks	2			
Library – reading room	3			
Light Plant Room	1			
Meeting Room	4			
Open Plan Office Area	10			
Reception	1			
Toilet	1			
Unoccupied space	1			

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 Greece. It can be seen that the HVAC components in this country service (15) total activity types with areas ranging in size from 13 to 64542.84 m^2. There was an average of 1 meter available for each system analysed.

The most frequently encountered component type in this country was Heat Pump. 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 1b – Overall Systems Summary for Greece 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	Air Handling Units	All-in-One Systems	Cold Generators	Heat Generators	Heat Pump	Heat Recovery	Heat Rejection	Humidifiers	Pumps	Terminal Units
Catering: Eating/drinking area	61	1					1					
Catering: Full Kitchen Preparing Hot Meals	32	1					1					
Cellular Office Area	5788	19	4				53					31
Circulation area (corridors and stairways)	693	8	4				6				5	
Dept Store Sales area - general	64542.84	54	46				176					159
External Space	700	1					13					13
IT: Server Room	20	1	4				5				5	
Library – open stacks	1526	4	4				1					
Library – reading room	1630	4	7				2					
Light Plant Room	13	1	4				5				5	
Meeting Room	208	11	11				7				5	
Open Plan Office Area	3228	48	11				16				5	14
Reception	88	1	4				5				5	
Toilet	35	2					1					
Unoccupied space	109	5	4				5				5	

2.2   Summary by Activity type of measured Electrical Power Demands

This summary section contains 6 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 15 activities had measured data
- Of these activities only 6 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from.
- Other observations, such as components where only a small variation is found in the ranges, etc

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 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 Greece -Average W/m2 and SD for component and activity (Standard Deviation)

Activity type	Meter Type	Sample Size	Air Handling Units	Heat Pump	Terminal Units
Cellular Office Area	Electricity	4	0.1675 (0.00)	5.2778 (6.0601)	0.1997 (0.00)
Dept Store Sales area - general	Electricity	46	7.3671 (4.6962)	1.3404 (1.6599)	0.2599 (0.2143)
Library – open stacks	Electricity	4	1.4241 (0.5157)	10.0016 (0.00)	0.00 (0.00)
Library – reading room	Electricity	7	3.8853 (2.4798)	6.1305 (5.4745)	0.00 (0.00)
Meeting Room	Electricity	11	2.6923 (1.1368)	6.1295 (5.4744)	0.00 (0.00)
Open Plan Office Area	Electricity	11	1.8614 (0.6247)	6.3681 (6.6436)	0.3715 (0.4068)

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

The following tables shows the average, maximum and minimum power demands found from the data for specific activity types 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.

2.2.1 Cellular Office Area - Electricity Power Demand – Electricity power demand summary by component

Table 3– Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Cellular Office Area - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump	Terminal Units
Average	0.1675 (0.00)	5.2778 (6.0601)	0.1997 (0.00)
Maximum	1.0839 (0.00)	21.9427 (25.533)	0.717 (0.00)
Minimum	0.0009 (0.00)	0.3326 (1.6596)	0.0127 (0.00)
Sample size	4	47	24

2.2.2 Dept Store Sales area - general - Electricity Power Demand – Electricity power demand summary by component

Table 4 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Dept Store Sales area - general - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump	Terminal Units
Average	7.3671 (4.6962)	1.7326 (1.6599)	0.2599 (0.2143)
Maximum	26.6538 (18.4439)	8.0144 (5.7815)	1.4106 (1.4156)
Minimum	0.0281 (0.0412)	0.0877 (0.0764)	0.0089 (0.0153)
Sample size	44	153	116

2.2.3   Library – open stacks - Electricity Power Demand – Electricity power demand summary by component

Table 5 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Library – open stacks - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump
Average	1.4241 (0.5157)	10.0016 (0.00)
Maximum	2.5483 (0.9227)	155.078 (0.00)
Minimum	0.0043 (0.0015)	0.0484 (0.00)
Sample size	4	1

2.2.4   Library – reading room - Electricity Power Demand – Electricity power demand summary by component

Table 6 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Library – reading room - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump
Average	3.8853 (2.4798)	6.1305 (5.4745)
Maximum	6.9523 (4.4373)	98.0553 (80.642)
Minimum	0.0117 (0.0074)	0.094 (0.0645)
Sample size	7	2

2.2.5   Meeting room - Electricity Power Demand – Electricity power demand summary by component

Table 7 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Meeting room - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump
Average	2.6923 (1.1368)	6.1295 (5.4744)
Maximum	4.8173 (2.0341)	98.0441 (80.637)
Minimum	0.0081 (0.0034)	0.0939 (0.0644)
Sample size	7	2

2.2.6 Open Plan Office Area - Electricity Power Demand – Electricity power demand summary by component

Table 8 – Measured Overall Power Demands in W/m² Summary by HVAC Component Type for Open Plan Office Area - Electricity Power Demand summary by component for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Parameter	Air Handling Units	Heat Pump	Terminal Units
Average	1.8614 (0.6247)	6.3681 (6.6436)	0.3715 (0.4068)
Maximum	3.3306 (1.1178)	39.5242 (49.7675)	1.4179 (1.3293)
Minimum	0.0056 (0.0019)	1.2447 (3.5884)	0.0105 (0.0104)
Sample size	7	10	13

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

This summary section contains 3 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:

- Only 15 activities had measured data
- Of these activities only 3 had a sufficient number of metered samples to obtain reasonably accurate benchmarks from.
- Other observations, such as components where only a small variation is found in the ranges, etc

A summary of the measured average annual energy use benchmarks by activity type and HVAC component type is shown in Table 9. 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.

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Table 9 – Benchmarks for measured Average and Standard Deviation Annual Energy Use in kWh/m2 Summary by HVAC Component and Activity Type for Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Activity type	Air Handling Units	Heat Pump	Terminal Units
Cellular Office Area	0.00 (0.00)	37.2948 (46.994)	1.7829 (0.00)
Dept Store Sales area - general	43.4645 (36.1939)	12.3937 (35.6684)	1.6821 (1.6928)
Open Plan Office Area	0.00 (0.00)	55.7982 (63.3883)	0.4125 (1.0108)

2.3.1 Air Handling Units – Electricity Energy Demand - Annual kWh/m2 in Greece

The table 10 shows the average and standard deviation annual energy use found from the data for all activity types for the Air Handling Units 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 – Air Handling Units – Electricity Energy Demand - Annual kWh/m^2 in Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Activity type	Supply and extract with heating and cooling variants, etc
Dept Store Sales area - general	43.4645 (36.1939)

Table 10 provides the range of annual energy consumptions found in different Air Handling Units Component sub-types servicing the activities shown in buildings across Greece. 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 Heat Pump – Electricity Energy Demand - Annual kWh/m2 in Greece

The table 11 shows the average and standard deviation annual energy use found from the data for all activity types for the Heat 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 11 – Heat Pump – Electricity Energy Demand - Annual kWh/m^2 in Greece - Average W/m2 and SD for component and activity (Standard Deviation).

Activity type	Air source reverse cycle – cooling optimised	Ground source reverse cycle – cooling optimised
Cellular Office Area	37.2948 (46.994)	0.00 (0.00)
Dept Store Sales area - general	10.2508 (26.1771)	286.6802 (0.00)
Open Plan Office Area	55.7982 (63.3883)	0.00 (0.00)

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Table 11 provides the range of annual energy consumptions found in different Heat Pump Component sub-types servicing the activities shown in buildings across Greece. 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 Terminal Units – Electricity Energy Demand - Annual kWh/m2 in Greece

The table 12 shows the average and standard deviation annual energy use found from the data for all activity types for the Terminal Units 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 12 – Terminal Units – Electricity Energy Demand - Annual kWh/m^2 in Greece - Average W/m2 and SD for component and activity (Standard Deviation).

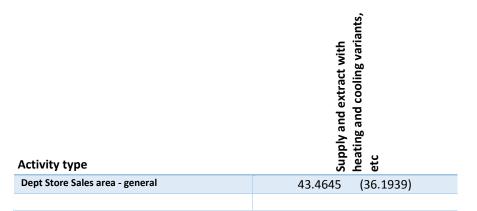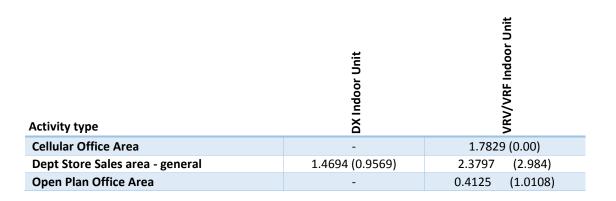| Activity type	DX Indoor Unit	VRV/VRF Indoor Unit
Cellular Office Area	-	1.7829 (0.00)
Dept Store Sales area - general	1.4694 (0.9569)	2.3797 (2.984)
Open Plan Office Area	-	0.4125 (1.0108)

Table 12 provides the range of annual energy consumptions found in different Terminal Unit Component sub-types servicing the activities shown in buildings across Greece. 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 Greece.

Whilst this data has the same caveats as for the annual data in Table 9, 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:

In the activity "Dept Store Sales area – general" the Air Handling unit -component consumes more energy during the period of June – September.

In the activity "Library – open stacks" the Air Handling unit -component consumes more energy during the period of September – December.

In the activities "Library – reading room" and "Meeting room" the Air Handling unit -component consumes more energy during the period of July – November.

In the activity "Cellular Office Area" the Heat Pump- component consumes more energy during the period of June – September.

In the activity "Dept Store Sales area – general" the Heat Pump -component consumes more energy during the period of June – August.

In the activities "Library – reading room" and "Meeting Room" the Heat Pump -component consumes more energy during January.

In the activity "Open Plan Office Area" the Heat Pump -component consumes more energy during the period of June – August and during January.

In the activities "Cellular Office Area", "Dept Store Sales area – general" and "Open Plan Office Area" the Terminal Units-component consumes more energy during the period of June – September.

2.4.1.1   Activity types – monthly energy use/m² summary by Air Handling Units - Electricity Consumption

This table shows the measured ranges of monthly energy use recorded for this sub-component type.
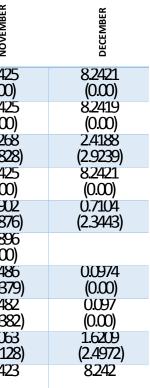
Table 13 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Air Handling Units - Electricity Consumption servicing the given activity for Greece

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Cellular Office Area		0.0042 (0.00)								0.1068 (0.00)	0.0675 (0.00)	0.0249 (0.00)	0.0182 (0.00)
Dept Store Sales area - general	43.4645 (36.1939)	2.093 (2.3601)	1.9941 (2.2633)	1.609 (2.2027)	2.4205 (2.7046)	3.8803 (3.2385)	5.6038 (4.3303)	6.9437 (5.2423)	6.814 (5.0334)	5.3995 (4.3724)	3.7994 (3.6212)	2.68 (2.7568)	2.1152 (2.5613)
Library – open stacks		0.3413 (0.1236)	0.277 (0.1003)	0.0741 (0.0268)			0.2702 (0.0978)	0.4352 (0.1576)	0.465 (0.1684)	0.4706 (0.1704)	0.5138 (0.186)	0.4922 (0.1782)	0.401 (0.1452)
Library – reading room		0.9312 (0.5944)	0.7557 (0.4823)	0.2022 (0.129)			0.7371 (0.4704)	1.1872 (0.7577)	1.2685 (0.8096)	1.2839 (0.8194)	1.4017 (0.8947)	1.3429 (0.8571)	1.094 (0.6983)
Meeting Room		0.6454 (0.2725)	0.5238 (0.2212)	0.1401 (0.0592)			0.5109 (0.2157)	0.8229 (0.3475)	0.8793 (0.3713)	0.8899 (0.3758)	0.9716 (0.4103)	0.9308 (0.393)	0.7583 (0.3202)
Open Plan Office Area		0.4462 (0.1497)	0.3621 (0.1215)	0.0969 (0.0325)			0.3531 (0.1185)	0.5688 (0.1909)	0.6078 (0.204)	0.6151 (0.2064)	0.6716 (0.2254)	0.6434 (0.2159)	0.5242 (0.1759)

2.4.1.2   Activity types – monthly energy use/m² summary by Heat Pump - Electricity Consumption

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

Table 14 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Heat Pump - Electricity Consumption servicing the given activity for Greece

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Catering: Eating/drinking area		7.9705 (0.00)										8.0425 (0.00)	8.2421 (0.00)
Catering: Full Kitchen Preparing Hot Meals		7.9703 (0.00)										8.0425 (0.00)	8.2419 (0.00)
Cellular Office Area	37.2948 (46.994)	2.2783 (2.5941)	2.4096 (2.6533)	2.1246 (2.5868)	2.6018 (3.227)	3.3969 (4.1824)	4.7119 (5.7547)	5.9746 (7.0001)	5.7259 (6.7289)	4.5884 (5.7155)	3.3222 (4.5117)	2.5268 (3.3828)	2.4188 (2.9239)
Circulation area (corridors and stairways)		7.9705 (0.00)										8.0425 (0.00)	8.2421 (0.00)
Dept Store Sales area - general	12.3937 (35.6684)	0.7057 (2.202)	0.6591 (2.0636)	0.5165 (1.8856)	0.8123 (2.1387)	1.2303 (2.5129)	1.5512 (2.6745)	1.8804 (3.004)	1.8415 (2.9576)	1.4768 (2.7789)	1.0639 (2.3428)	0.8902 (2.4876)	0.7104 (2.3443)
Library – open stacks							1.4767 (0.00)	2.2823 (0.00)	2.4408 (0.00)	2.3016 (0.00)	2.5606 (0.00)	2.9896 (0.00)	
Library – reading room		3.0997	2.2192	0.13 (0.00)			2.2896 (1.1495)	1.1862 (1.5502)	1.2647 (1.6632)	1.194 (1.5663)	1.3261 (1.7458)	1.5486 (2.0379)	0.0974 (0.00)
Meeting Room		3.0995 (0.00)	2.2187 (0.00)	0.1298 (0.00)			2.2892 (1.1493)	1.1859 (1.5503)	1.2646 (1.6633)	1.1939 (1.5663)	1.3259 (1.7458)	1.5482 (2.0382)	0.097 (0.00)
Open Plan Office Area	55.7982 (63.3883)	3.2017 (3.3587)	1.3234 (0.8416)	1.0782 (0.4601)	2.3989 (2.2474)	2.2525 (3.2326)	3.1988 (4.6035)	4.0926 (6.568)	4.3892 (6.4987)	2.667 (3.6841)	1.4303 (1.9601)	1.7063 (2.5128)	1.6209 (2.4972)
Toilet		7.9703										8.0423	8.242

2.4.1.3   Activity types – monthly energy use/m² summary by Terminal Units - Electricity Consumption

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

Table 15 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Terminal Units - Electricity Consumption servicing the given activity for Greece

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Cellular Office Area	1.7829 (0.00)	0.1392 (0.0107)	0.134 (0.0071)	0.1325 (0.0032)	0.1225 (0.0099)	0.1407 (0.0084)	0.1584 (0.0102)	0.1882 (0.0121)	0.1769 (0.0105)	0.1629 (0.0084)	0.1439 (0.0203)	0.1326 (0.0021)	0.1348 (0.0071)
Dept Store Sales area - general	1.6821 (1.6928)	0.0833 (0.0766)	0.089 (0.086)	0.0752 (0.059)	0.1348 (0.1971)	0.2034 (0.2635)	0.2569 (0.2909)	0.3053 (0.3577)	0.2979 (0.3705)	0.2299 (0.2907)	0.166 (0.2241)	0.1343 (0.2091)	0.092 (0.0993)
Open Plan Office Area	0.4125 (1.0108)	0.0225 (0.0499)	0.0221 (0.05)	0.0895 (0.1365)	0.0868 (0.1385)	0.1288 (0.1416)	0.1827 (0.203)	0.2673 (0.2961)	0.3171 (0.3534)	0.1919 (0.2103)	0.0822 (0.0878)	0.0548 (0.0571)	0.1093 (0.1182)

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.
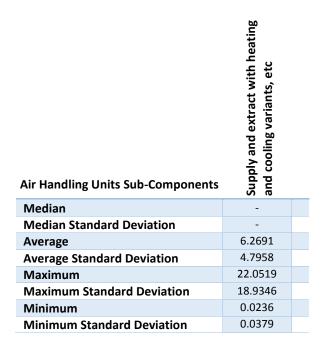
3.2   Power Demands Section

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

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

Table 16 shows the median, average, maximum and minimum (plus their standard deviations) measured power demands in W/m^2 serviced by each sub-component. 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 Greece 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 16 – Overall measured power demands in W/m^2 by Air Handling Units Sub-component types in Greece

Air Handling Units Sub-Components	Supply and extract with heating and cooling variants, etc	
Median	-	
Median Standard Deviation	-	
Average	6.2691	
Average Standard Deviation	4.7958	
Maximum	22.0519	
Maximum Standard Deviation	18.9346	
Minimum	0.0236	
Minimum Standard Deviation	0.0379	

3.2.1.1   *Conclusions for Air Handling units sub-components*
From the data it can be seen that:

- The power demands measured across all Air Handling units - Supply and extract with heating and cooling variants, etc - ranges from 0.0236 W/m^2 (min)to 22.0519 W/m^2 (max) with an average of 6.291 W/m^2
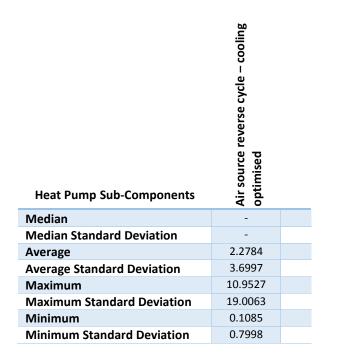
3.2.2   Heat Pump - Power Demands by Sub-Component type and Activity

Table 17 shows the median, average, maximum and minimum (plus their standard deviations) measured power demands in W/m^2 serviced by each sub-component. 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 Greece 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/m^2 by Heat Pump Sub-component types in Greece

Heat Pump Sub-Components	Air source reverse cycle – cooling optimised	
Median	-	
Median Standard Deviation	-	
Average	2.2784	
Average Standard Deviation	3.6997	
Maximum	10.9527	
Maximum Standard Deviation	19.0063	
Minimum	0.1085	
Minimum Standard Deviation	0.7998	

3.2.2.1   *Conclusions for Heat Pump sub-components*

From the data it can be seen that:

- The power demands measured across all Heat Pump - Air source reverse cycle – cooling optimised ranges from 0.1085 W/m^2 (min) to 10.9527W/m^2 (max) with an average of 2.2784 W/m^2

3.2.3   Terminal Units Power Demands by Sub-Component types

Table 18 shows the median, average, maximum and minimum (plus their standard deviations) measured power demands in W/m^2 serviced by each sub-component. 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 Greece 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 Data Summary by Terminal Units Sub-component types. Average W/m^2 in Greece

Terminal Units Sub-Components	DX Indoor unit	VRV/VRF indoor unit
Median	-	-
Median Standard Deviation	-	-
Average	0.2573	0.2406
Average Standard Deviation	0.1645	0.3441
Maximum	1.39	1.0257
Maximum Standard Deviation	0.8568	1.9958
Minimum	0.087	0.0103
Minimum Standard Deviation	0.0171	0.0046

3.2.3.1   *Conclusions for Terminal Units sub-components*

From the data it can be seen that:

- The power demands measured across all Terminal Units – sub-components ranges from 0.087 W/m^2 (min) to 1.39 W/m^2 (max) with an average of 0.2573 W/m^2 in DX Indoor units.
- The power demands measured across all Terminal Units – sub-components ranges from 0.0103 W/m^2 (min) to 1.0257 W/m^2 (max) with an average of 0.2406 W/m^2 in VRV/VRF indoor unit.

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 Heat Pump Annual Energy Consumption by Sub-Component types

Table 19 shows the median, average, maximum and minimum (plus their standard deviations) measured Annual Energy Consumption in kWh/m^2 serviced by each sub-component. 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 Greece 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 use by Heat Pump Sub-component types. Average kWh/m^2 in Greece

Heat Pump Sub-Components	Air Source reverse cycle – cooling optimised	Ground Source reverse cycle – cooling optimised
Median	-	-
Median Standard Deviation	-	-
Average	17.1976	286.6802
Average Standard Deviation	35.4313	-
Maximum	18.8401	286.6802
Maximum Standard Deviation	37.8338	-
Minimum	12.9681	286.6802
Minimum Standard Deviation	25.3567	-

3.3.1.1 Conclusions for Heat Pumps
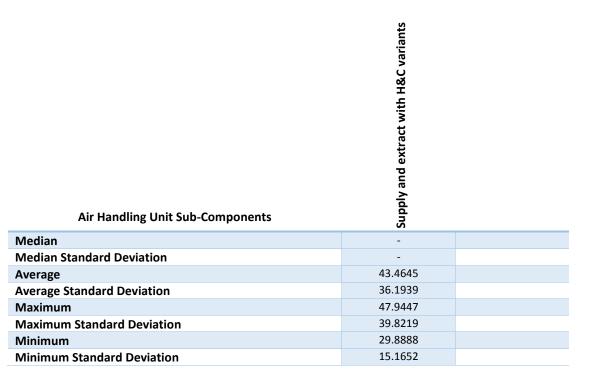
From the data it can be seen that:

- The Annual Energy Consumption measured across all Heat Pump sub-components ranges from 12.9681 kWh/m^2 (min)to 18.8401 kWh/m^2(max) with an average of 17.976 kWh/m^2 in Air Source reverse cycle – cooling optimised.

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

Table 20 shows the median, average, maximum and minimum (plus their standard deviations) measured Annual Energy Consumption in kWh/m^2 serviced by each sub-component. 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 Greece 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 use by Air Handling Unit Sub-component types. Average kWh/m^2 in Greece

Air Handling Unit Sub-Components	Supply and extract with H&C variants	
Median	-	
Median Standard Deviation	-	
Average	43.4645	
Average Standard Deviation	36.1939	
Maximum	47.9447	
Maximum Standard Deviation	39.8219	
Minimum	29.8888	
Minimum Standard Deviation	15.1652	

3.3.2.1   *Conclusions for Air Handling Units*

From the data it can be seen that:

- The Annual Energy Consumption measured across all Air Handling Unit sub-components ranges from 29.8888 kWh/m^2 to 47.9447 kWh/m^2 with an average of 43.46 45 kWh/m^2 in Supply and extract with H&C variants.

3.3.3   Terminal Unit Annual Energy Consumption by Sub-Component types

Table 21 shows the median, average, maximum and minimum (plus their standard deviations) measured Annual Energy Consumption in kWh/m^2 serviced by each sub-component. 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 Greece 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 use by Terminal Unit Sub-component types. Average kWh/m^2 in Greece

Terminal Unit Sub-Components	DX indoor circuit	VRV/VRF indoor unit	
Median	-	-	
Median Standard Deviation	-	-	
Average	1.4694	1.9028	
Average Standard Deviation	0.9569	2.763	
Maximum	1.617	1.9543	
Maximum Standard Deviation	0.9692	2.7648	
Minimum	1.3587	1.786	
Minimum Standard Deviation	0.9594	2.7653	

3.3.3.1   *Conclusions for Terminal Units*

From the data it can be seen that:

- The Annual Energy Consumption measured across all Terminal Unit sub-components ranges from 1.3587 kWh/m^2 to 1.617 kWh/m^2 with an average of 1.4694kWh/m^2 in DX indoor unit.
- The Annual Energy Consumption measured across all Terminal Unit sub-components ranges from 1.786 kWh/m^2 to 1.9543 kWh/m^2 with an average of 1.9028 kWh/m^2 in VRV/VRF indoor unit.

3.4 Summary of measured monthly energy use by HVAC component type and Sub-type

The data is considered at the level of consumption by HVAC component using the following metrics: kWh/m2 by month.

The tables in this section provide the ranges of average and standard deviation monthly energy consumptions found in different HVAC sub-component types across Greece. This data does not take into account the activities being serviced.

3.4.1 Sub-component – monthly energy use/m² summary by Air Handling Units - Electricity Consumption

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

Table 22 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Air Handling Units – Supply and extract with H&C variants - monthly Electricity Consumption for Greece

Air Handling unit – Component Sub- type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
Supply and extract with H&C variants	43.4645 (36.1939)	1.9683 (2.3135)	1.9274 (2.2312)	1.543 (2.1735)	2.4205 (2.7046)	3.8803 (3.2385)	5.3085 (4.3671)	6.5895 (5.2835)	6.4709 (5.0765)	4.9772 (4.3907)	3.5227 (3.5726)	2.4988 (2.6999)	1.9688 (2.4875)

3.4.2 Sub-component – monthly energy use/m2 summary by Heat Pump - Electricity Consumption

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

Table 23 – Measured average monthly energy consumption (standard deviation) in kWh/m2 by Heat Pump – sub-component type - monthly Electricity Consumption for Greece

Component Sub- type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
ASHP reverse cycle – cooling optimised	17.7255 (35.1923)	1.1414 (2.2247)	1.1299 (2.1966)	0.8899 (1.9856)	1.2332(2.4 422)	1.8035 (3.1381)	2.4734 (4.1515)	3.1479 (5.1238)	3.0419 (4.9261)	2.3878 (4.1594)	1.6724 (3.2565)	1.2739 (2.6336)	1.1558 (2.3803)
ASHP reverse cycle – heating optimised		7.9704										8.0425	8.2421
GSHP reverse cycle – cooling optimised	286.6802	21.9381	22.3151	23.2396	21.9543	23.7257	25.0132	27.2565	26.9129	25.5681	21.5364	23.8718	23.3484

3.4.3 Sub-component – monthly energy use/m2 summary by Terminal Unit - Electricity Consumption

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

Table 24 – Measured average monthly energy consumption (standard deviation) in kWh/m² by Terminal Unit – sub-component type - monthly Electricity Consumption for Greece

Component Sub-type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
DX Indoor Unit	1.4694 (0.9569)	0.0448 (0.0678)	0.0627 (0.0952)	0.0524 (0.0615)	0.1208 (0.1744)	0.1956 (0.2193)	0.2593 (0.2205)	0.3092 (0.2485)	0.3055 (0.2486)	0.2175 (0.2067)	0.1405 (0.1791)	0.1046 (0.1735)	0.0663 (0.0876)
VRV/VRF Indoor Unit	1.8523 (2.0895)	0.1345 (0.0565)	0.1282 (0.044)	0.1206 (0.0516)	0.1099 (0.0493)	0.1457 (0.1505)	0.1709 (0.2242)	0.2136 (0.3459)	0.209 (0.3872)	0.1787 (0.2499)	0.1405 (0.0913)	0.1236 (0.0435)	0.1358 (0.1078)

4   References

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