iSERV Measured Data Analysis by HVAC Component and Activity - LUXEMBOURG

By

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May, 20th 2014

Intelligent Energy – Europe (IEE) SAVE Project

May 7th 2011 to May 6th 2014

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Main website: http://www.iservcmb.info
Database website: http://www.iservcmb.eu

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Contents

1 Introduction

This report presents the measured HVAC component and end use activity data obtained for Luxembourg 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 Luxembourg 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	Heat
Catering: Kitchenette (small appliances, fridge and sink)	12	4
Circulation area (corridors and stairways)	22	6
Multi-storey car parks (office and private use)	1	
Open Plan Office Area	22	6
Small Shop Unit Sales area - general	6	2
Toilet	12	4

2.1 Overall HVAC Components and Activities Summary

Table 1b summarises the data collected for the HVAC Components and the iSERV Activity types available in Luxembourg. It can be seen that the HVAC components in this country service six total activity types with areas ranging in size from 109 to 31328 m^2. The most frequently encountered component type in this country was pumps.

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

Activity type	Floor Area m2	Num Spaces	Air Handling	Cold Generators	Heat Generators	Heat Recovery	Heat Rejection	Humidifiers	Pumps	Storage Systems	Terminal Units
Catering: Kitchenette (small appliances, fridge and sink)	109	20	16	12	4	8		4	64	8	16
Circulation area (corridors and stairways)	5571	47	21	14	5	12	2	7	87	8	18
Multi-storey car parks (office and private use)	6703	2	4								
Open Plan Office Area	31328	46	21	14	5	12	2	7	87	8	18
Small Shop Unit Sales area - general	556	3	8	6	2	4		2	32	4	8
Toilet	819	24	16	12	4	8		4	64	8	16

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

This summary section contains tables 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.

A summary of the measured average annual energy use benchmarks by activity type and HVAC component type is shown in Table 2. 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.

Table 2 – Benchmarks for Electrical measured Average and Standard Deviation Annual Energy Use in kWh/m2 Summary by HVAC Component and Activity Type for Luxembourg.

Activity type	Air-Handling Units		Cold Generators		Heat rejection		Pumps	
Catering: Kitchenette (small appliances, fridge and sink)	14.92	(15.76)	3.55	(5.40)	0.00	(0.00)	0.53	(0.61)
Circulation area (corridors and stairways)	2.36	(2.49)	5.73	(9.98)	0.00	(0.00)	0.57	(0.65)
Multi-storey car parks (office and private use)	0.35	(0.00)	0.00	(0.00)	0.00	(0.00)	0.00	(0.00)
Open Plan Office Area	7.06	(7.44)	10.62	(18.48)	0.00	(0.00)	0.59	(0.66)
Small Shop Unit Sales area - general	8.58	(9.52)	8.93	(14.75)	0.00	(0.00)	1.31	(1.58)
Toilet	4.32	(4.59)	1.54	(2.30)	0.00	(0.00)	0.50	(0.58)

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

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Air-Handling 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 3 – Overall Data Summary by Air-Handling Units Sub-component types. Average and Standard Deviation Annual kWh/m² in Luxembourg

Activity type	Extract only		Supply and extract		Supply and extract with heating and cooling variants, etc	
Catering: Kitchenette (small appliances, fridge and sink)	6.23	(2.03)	40.98	(4.50)	0.00	(0.00)
Circulation area (corridors and stairways)	1.09	(0.40)	7.26	(0.83)	1.50	(0.56)
Multi-storey car parks (office and private use)	0.35	(0.00)	0.00	(0.00)	0.00	(0.00)
Open Plan Office Area	3.29	(1.11)	21.70	(2.41)	4.39	(1.64)
Small Shop Unit Sales area - general	3.55	(1.47)	23.65	(4.23)	0.00	(0.00)
Toilet	1.79	(0.63)	11.89	(1.34)	0.00	(0.00)

2.2.2 Activity types – annual energy use/m² summary by Cold Generators sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Cold Generators 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 4 – Overall Data Summary by Cold Generators Sub-component types. Average and Standard Deviation Annual kWh/m² in Luxembourg

Activity type	Absorption chiller		Dry Coolers & Cooling Tower		Screw Liquid Chillers	
Catering: Kitchenette (small appliances, fridge and sink)	0.00	(0.00)	0.17	(0.02)	10.30	(3.93)
Circulation area (corridors and stairways)	0.01	(0.00)	0.07	(0.01)	15.93	(11.01)
Open Plan Office Area	0.02	(0.00)	0.14	(0.01)	29.51	(20.40)
Small Shop Unit Sales area - general	0.00	(0.00)	0.16	(0.02)	26.46	(12.88)
Toilet	0.00	(0.00)	0.10	(0.01)	4.42	(1.68)

2.2.3 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 5 – Overall Data Summary by Heat rejection Sub-component types. Average and Standard Deviation Annual kWh/m² in Luxembourg

Activity type	Open Circuit Cooling Towers	
Circulation area (corridors and stairways)	0.0015	(0.00)
Open plan office area	0.0029	(0.00)

2.2.4 Activity types – annual energy use/m^2 summary by Pumps sub-components

The table shows the average and standard deviation annual energy use found from the data for all activity types for the Pumps 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 6 – Overall Data Summary by Pumps Sub-component types. Average and Standard Deviation Annual kWh/m^2 in Luxembourg

Activity type	Chilled water primary pumps		Chilled water secondary pumps		Condenser water pumps		Hot water primary pumps		Hot water secondary pumps	
Catering: Kitchenette (small appliances, fridge and sink)	0.41	(0.04)	0.48	(0.05)	0.06	(0.01)	2.75	(0.32)	0.55	(0.06)
Circulation area (corridors and stairways)	0.34	(0.13)	0.46	(0.24)	0.05	(0.02)	2.06	(1.15)	0.83	(0.64)
Open Plan Office Area	0.36	(0.13)	0.47	(0.24)	0.05	(0.02)	2.16	(1.21)	0.84	(0.62)
Small Shop Unit Sales area - general	1.04	(0.12)	1.21	(0.13)	0.05	(0.01)	6.90	(0.99)	1.38	(0.15)
Toilet	0.39	(0.04)	0.46	(0.05)	0.06	(0.01)	2.61	(0.31)	0.52	(0.05)
Catering: Kitchenette (small appliances, fridge and sink)	0.41	(0.04)	0.48	(0.05)	0.06	(0.01)	2.75	(0.32)	0.55	(0.06)

2.3 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 Luxembourg. Whilst this data has the same caveats as for the annual data in Table 2, what it does illustrate is how the consumption of each sub-component varies with the month of the year.

2.3.1 Activity types – monthly energy use/m^2 summary by Air-Handling Units component

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

Table 7 – Measured average monthly energy consumption and standard deviation in kWh/m^2 by Air-Handling Units components servicing the given activity for Luxembourg

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCOTBER	NOVEMBER	DECEMBER
Catering: Kitchenette (small appliances, fridge and sink)	28.26 (8.59)	2.29 (0.87)	2.48 (1.12)	2.58 (0.85)	2.39 (0.74)	2.40 (0.77)	2.29 (0.71)	2.65 (0.71)	2.72 (0.76)	2.24 (0.70)	2.25 (0.74)	1.97 (0.77)	2.13 (0.87)
Circulation area (corridors and stairways)	6.52 (2.18)	0.51 (0.20)	0.58 (0.28)	0.56 (0.19)	0.56 (0.19)	0.58 (0.21)	0.55 (0.19)	0.62 (0.19)	0.62 (0.20)	0.54 (0.19)	0.51 (0.18)	0.45 (0.18)	0.49 (0.21)
Multi-storey car parks (office and private use)	0.35 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)	0.03 (0.00)
Open Plan Office Area	19.45 (6.24)	1.51 (0.58)	1.72 (0.82)	1.67 (0.56)	1.67 (0.55)	1.73 (0.59)	1.64 (0.54)	1.84 (0.55)	1.85 (0.56)	1.62 (0.54)	1.52 (0.53)	1.35 (0.53)	1.45 (0.59)
Small Shop Unit Sales area - general	17.49 (5.95)	1.50 (0.53)	1.52 (0.60)	1.61 (0.57)	1.48 (0.49)	1.44 (0.53)	1.40 (0.54)	1.60 (0.55)	1.65 (0.64)	1.34 (0.54)	1.34 (0.52)	1.24 (0.49)	1.34 (0.54)
Toilet	8.18 (2.64)	0.66 (0.26)	0.72 (0.34)	0.75 (0.26)	0.69 (0.22)	0.69 (0.24)	0.66 (0.22)	0.77 (0.22)	0.79 (0.23)	0.65 (0.21)	0.65 (0.23)	0.57 (0.23)	0.62 (0.27)

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

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

Table 8 – Measured average monthly energy consumption and standard deviation in kWh/m^2 by Cold Generators components servicing the given activity for Luxembourg

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCOTBER	NOVEMBER	DECEMBER
Catering: Kitchenette (small appliances, fridge and sink)	10.93 (2.78)	0.60 (0.32)	0.53 (0.27)	0.72 (0.25)	0.82 (0.25)	1.07 (0.30)	1.12 (0.29)	1.34 (0.33)	1.35 (0.34)	1.04 (0.31)	0.96 (0.34)	0.79 (0.33)	0.53 (0.36)
Circulation area (corridors and stairways)	19.12 (7.66)	0.92 (0.71)	0.67 (0.63)	0.91 (0.76)	1.25 (0.77)	1.63 (0.98)	1.72 (1.01)	2.05 (1.19)	2.06 (1.21)	1.59 (0.98)	1.46 (0.95)	1.21 (0.83)	0.80 (0.74)
Open Plan Office Area	35.42 (14.18)	1.70 (1.32)	1.25 (1.17)	1.70 (1.41)	2.32 (1.43)	3.03 (1.82)	3.18 (1.87)	3.79 (2.21)	3.82 (2.25)	2.94 (1.81)	2.71 (1.76)	2.23 (1.54)	1.49 (1.37)
Small Shop Unit Sales area - general	29.72 (8.76)	1.44 (0.83)	1.46 (0.81)	2.19 (0.86)	2.33 (0.77)	2.79 (0.85)	2.92 (0.70)	3.44 (0.72)	3.46 (0.87)	2.57 (0.70)	2.41 (0.89)	2.09 (1.16)	1.67 (1.23)
Toilet	4.72 (1.20)	0.26 (0.14)	0.23 (0.11)	0.31 (0.11)	0.36 (0.11)	0.46 (0.13)	0.48 (0.12)	0.58 (0.14)	0.58 (0.15)	0.45 (0.14)	0.41 (0.15)	0.34 (0.14)	0.23 (0.16)

2.3.3 Activity types – monthly energy use/m^2 summary by Pumps component

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

Table 9 – Measured average monthly energy consumption and standard deviation in kWh/m^2 by Pumps components servicing the given activity for Luxembourg

Activity type	ANNUAL TOTAL	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCOTBER	NOVEMBER	DECEMBER
Catering: Kitchenette (small appliances, fridge and sink)	4.67 (0.96)	0.37 (0.13)	0.38 (0.14)	0.45 (0.16)	0.42 (0.12)	0.40 (0.10)	0.39 (0.09)	0.48 (0.11)	0.50 (0.11)	0.38 (0.09)	0.36 (0.07)	0.30 (0.07)	0.32 (0.09)
Circulation area (corridors and stairways)	4.14 (1.50)	0.31 (0.19)	0.28 (0.21)	0.33 (0.25)	0.34 (0.19)	0.33 (0.18)	0.32 (0.17)	0.39 (0.20)	0.40 (0.20)	0.31 (0.18)	0.30 (0.16)	0.25 (0.15)	0.27 (0.16)
Open Plan Office Area	4.33 (1.55)	0.32 (0.20)	0.29 (0.22)	0.35 (0.25)	0.35 (0.20)	0.34 (0.19)	0.34 (0.18)	0.40 (0.21)	0.42 (0.21)	0.33 (0.18)	0.31 (0.17)	0.27 (0.15)	0.28 (0.17)
Small Shop Unit Sales area - general	12.47 (3.43)	1.11 (0.41)	1.12 (0.43)	1.26 (0.55)	1.15 (0.42)	1.03 (0.34)	0.97 (0.31)	1.14 (0.32)	1.13 (0.33)	0.89 (0.24)	0.89 (0.17)	0.86 (0.22)	0.93 (0.30)
Toilet	4.44 (0.91)	0.35 (0.13)	0.36 (0.13)	0.43 (0.16)	0.40 (0.12)	0.38 (0.10)	0.37 (0.09)	0.45 (0.10)	0.47 (0.11)	0.36 (0.09)	0.34 (0.07)	0.29 (0.06)	0.30 (0.09)
Catering: Kitchenette (small appliances, fridge and sink)	4.67 (0.96)	0.37 (0.13)	0.38 (0.14)	0.45 (0.16)	0.42 (0.12)	0.40 (0.10)	0.39 (0.09)	0.48 (0.11)	0.50 (0.11)	0.38 (0.09)	0.36 (0.07)	0.30 (0.07)	0.32 (0.09)

2.4 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 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.