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ENERGY COMPARISON STUDY, DUBAI AND ABU DHABI

PROJECT TITLE	Munters, Energy Comparison Study
PROJECT NO.	100262

This report presents the study undertaken for Munters on the comparison of the energy and water performance of the Munters OASIS/DCiE cooling units against other traditional cooling methods, namely legacy air cooled chiller, water cooled chiller, and high efficiency air cooled chiller.
This study focuses on the following locations:

- Dubai
- Abu Dhabi

The analysis focuses on estimating energy and water efficiency using the following metrics:

Power usage effectiveness (PUE): measured as the ratio of estimated whole facility energy usage and IT energy usage;

Water usage effectiveness (WUE): measured as the ratio of whole facility water usage and IT energy usage.
The metrics are analysed on an annual basis.

1.0 MODELLING INFORMATION

1.1 Description

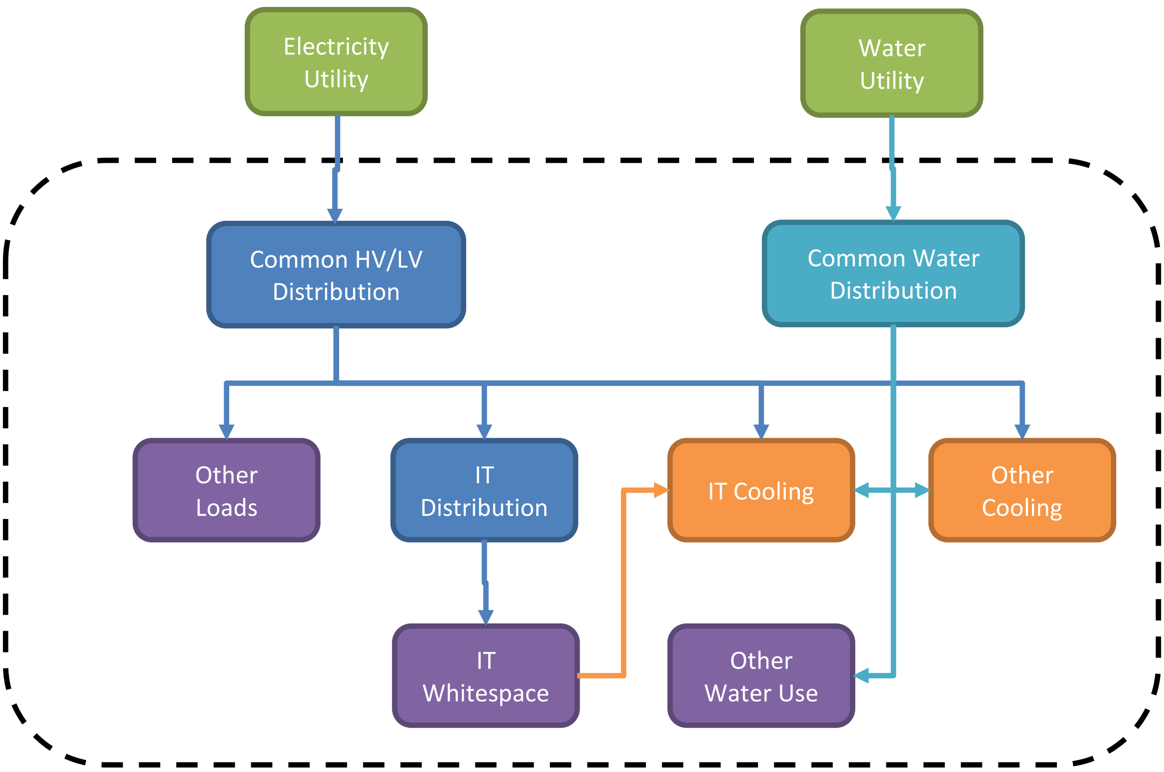
The modelling is based on a representation of the data centre electrical and cooling infrastructure, which is depicted below in a generic manner. The electrical infrastructure is composed of electrical equipment to the IT whitespace, the cooling system and other loads, such as BMS system, lighting, etc. The cooling system consists of the cooling equipment serving the IT whitespace, typically CRAH units and associated chilled water cooling plant, mass air free cooling units, and cooling equipment serving other loads, such as split system for battery rooms, etc. A similar process is modelled for the water usage.

This diagrammatic representation is generic and adapted for each modelled cooling infrastructure.

The modelled data centre is based on the following:

2 data halls of design IT capacity of 1,000kW each;

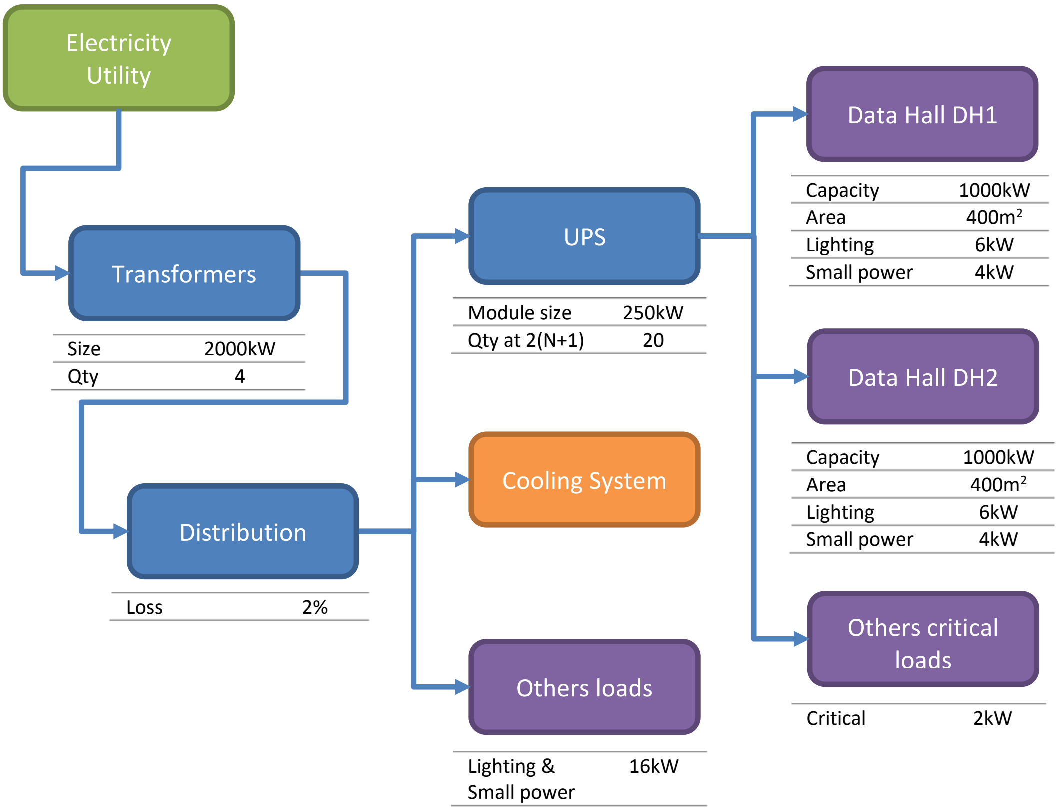
Electrical distribution to the IT based on a 2N system with 2(N+1) UPS module.



1.2 Common infrastructure

1.2.1 Electrical Infrastructure

The following diagram highlights the electrical infrastructure used in the study. The electrical infrastructure is topologically common to all cooling system modelled. As indicated in the diagram, the cooling system energy demand is included in the electrical infrastructure. Hence different cooling systems will affect the distribution and transformer losses – although this effect is not expected to be significant compared to the cooling system energy consumption itself.



The electrical infrastructure equipment is modelled on the basis of the following equipment information:

UPS System:

Module size	250kW
Qty at N	9
Qty at 2(N+1)	20
Efficiency:	25% load: 95.5% 50% load: 96.0% 75% load: 95.5% 100% load: 95.0%

Distribution:

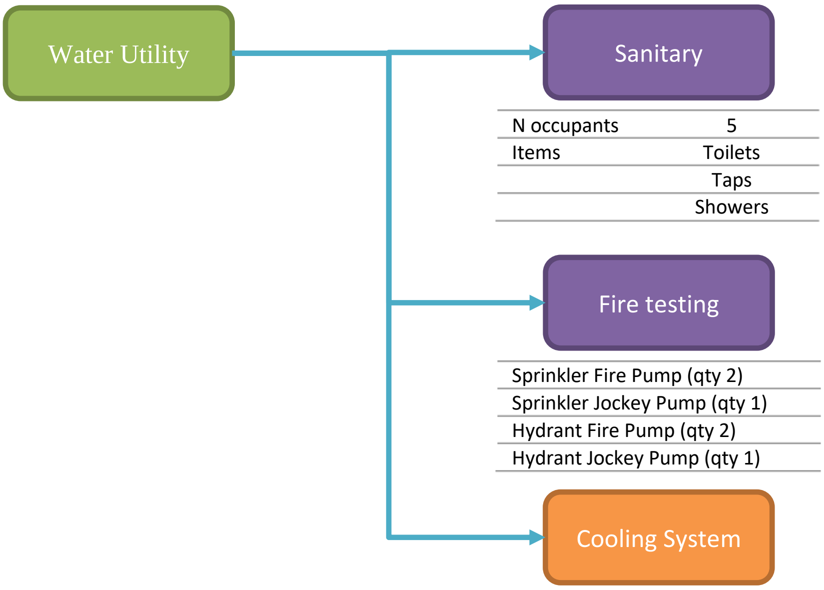
Loss	2% of load

Transformers:

Size	2000kW
Quantity	4
Loss	Quadratic polynomial function
100% load Losses	44kW

1.2.2 Water Infrastructure

The diagram below shows the modelled water infrastructure, which is common to all cooling systems. The water usage is divided into constant uses for sanitary and fire testing purposes and cooling system use. The air-cooled chiller cooling system do not use water, and the water usage for these system is solely for sanitary and fire testing.



The water demand is modelled on the basis of the following equipment information:

Sanitary:

Number of occupants	5
Toilets	4l/flush
	0.24flush/h/p
Taps	8l/use
	0.24use/h/p
Showers	9l/min
	5min
	10% occupants

Fire Testing systems:

N test	1 per month
Test duration	1h
% water discharged to sewer	10%
Sprinkler Fire Pump (qty 2)	50l/s
Sprinkler Jockey Pump (qty 1)	50l/s
Hydrant Fire Pump (qty 2)	50l/s
Hydrant Jockey Pump (qty 1)	50l/s

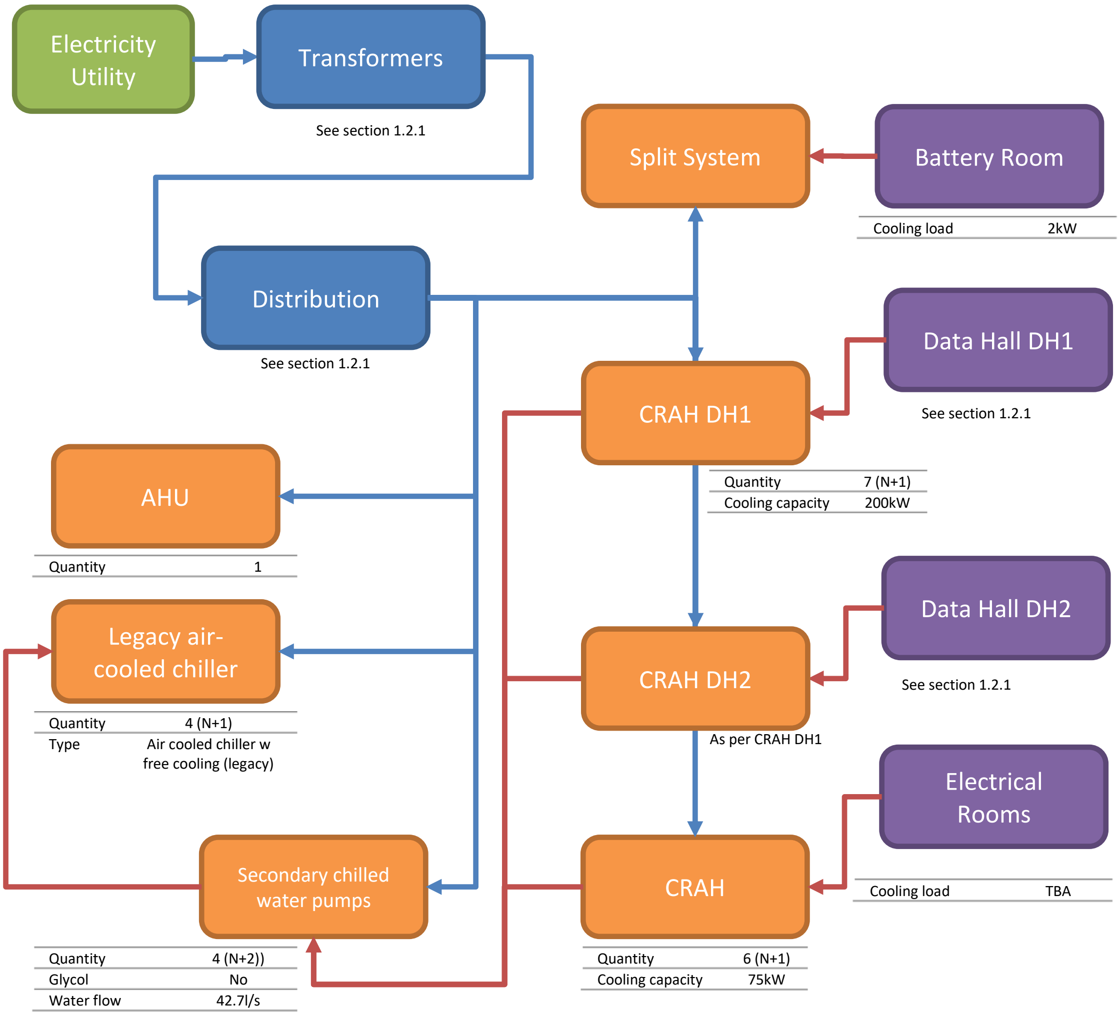
1.3 System 1: Legacy air cooled chilled water system

The image below highlights the legacy air-cooled cooling system modelled.

The cooling system is based on a central chilled water system with CRAH units serving the data halls and electrical rooms. The chilled water system is supported by legacy air cooled chillers with primary chilled water pumps.

In addition to the main cooling system, the following systems are included: (a) split system serving the battery room, which is modelled on the basis of an annualised COP, and (b) fresh air AHU. These systems are included for completeness but are not expected to have a significant influence on the modelling outcomes and are modelled identically in all systems.

This cooling system uses water for the AHU humidity control system only.



The cooling system is modelled on the basis of the equipment information listed in section 1.9.

An energy derating of 20% has been applied to CRAH units and secondary pumps to represent performance degradation due to aging.

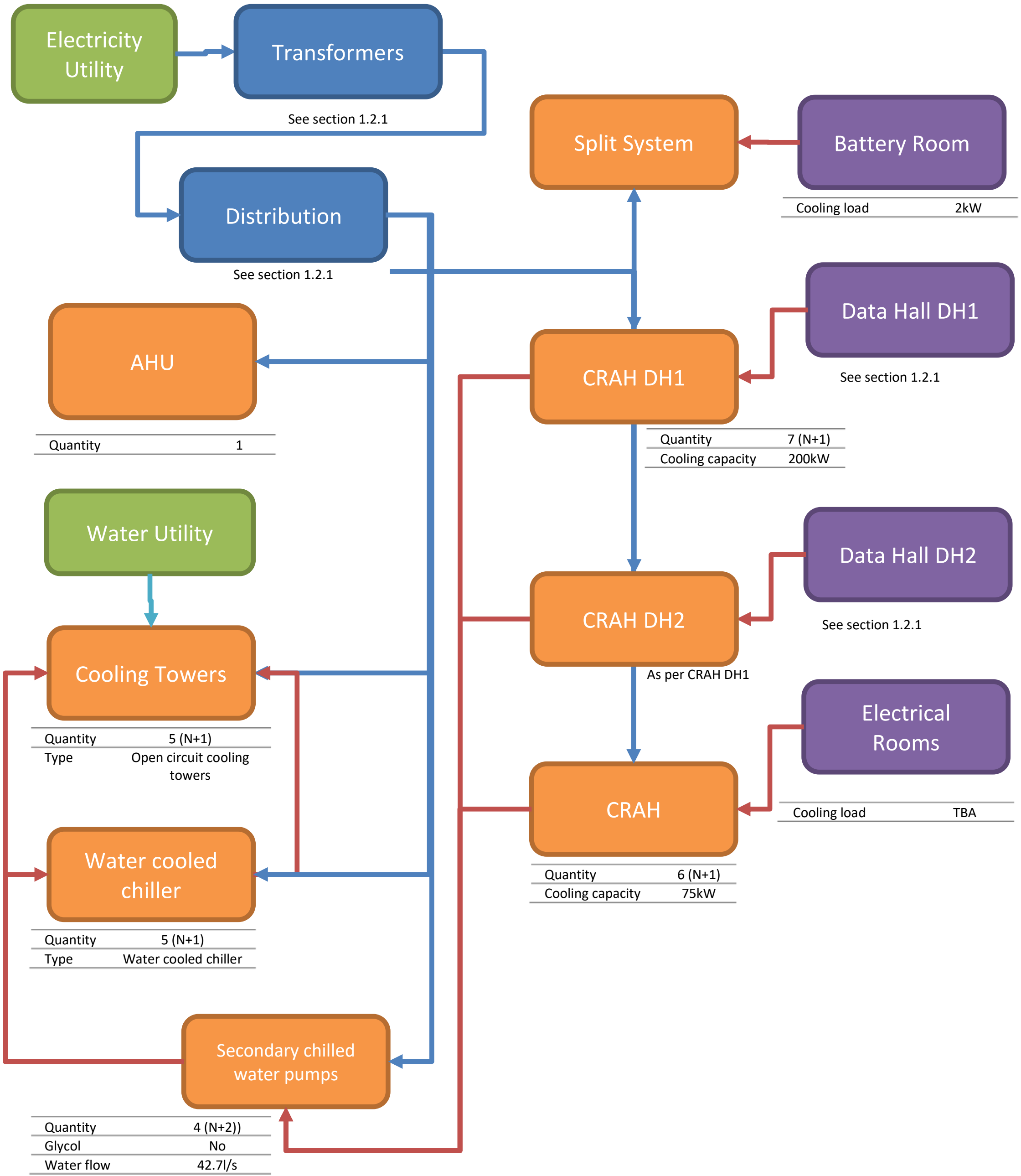
1.4 System 2: Water cooled chilled water system with open-circuit cooling towers

The image below highlights the water cooled cooling system modelled.

The cooling system is based on a central chilled water system with CRAH units serving the data halls and electrical rooms. The chilled water system is supported by water cooled chillers with primary chilled water pumps and open-circuit cooling towers for heat rejection.

In addition to the main cooling system, the following systems are included: (a) split system serving the battery room, which is modelled on the basis of an annualised COP, and (b) fresh air AHU.

This cooling system uses water for the cooling tower heat rejection and AHU humidity control system.



The cooling system is modelled on the basis of the equipment information listed in section 1.9.

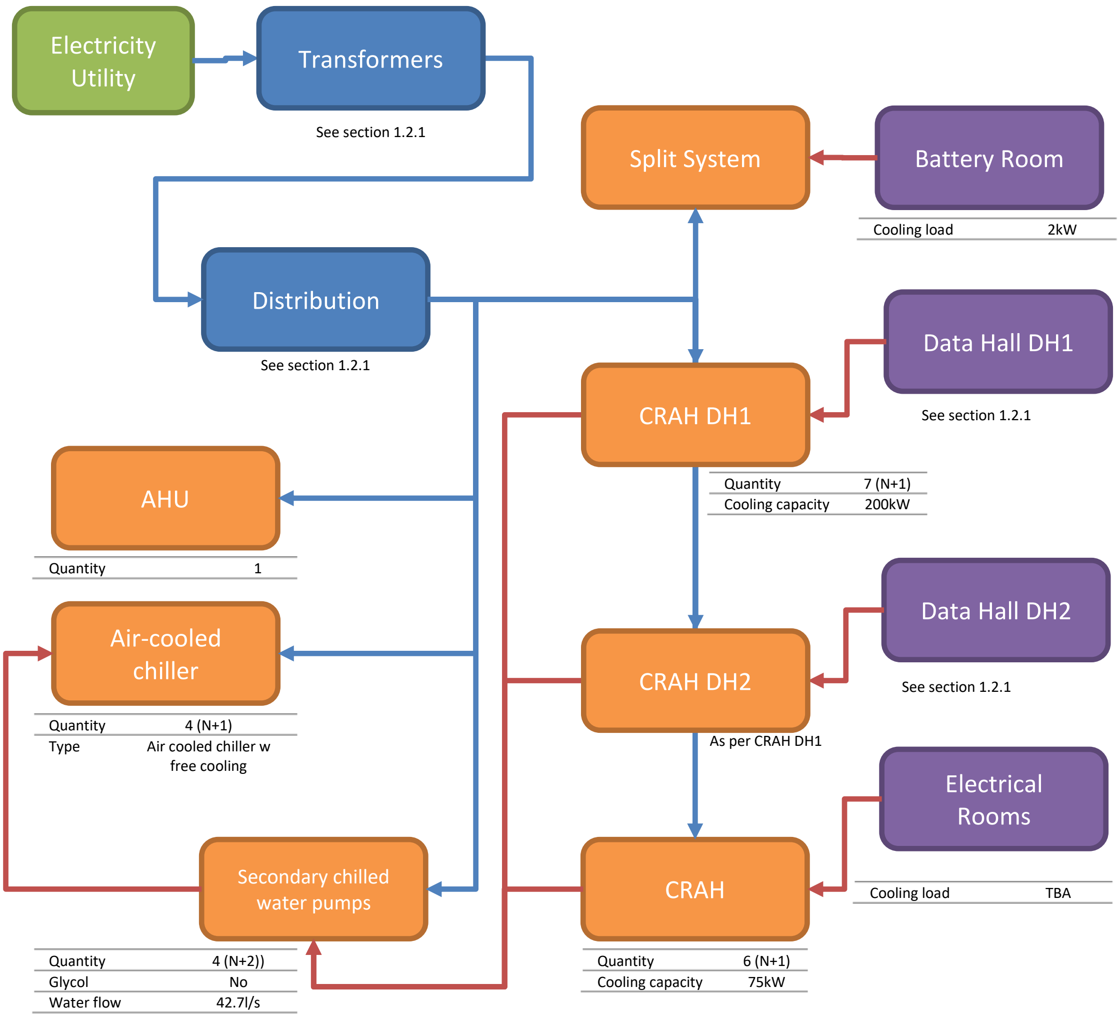
1.5 System 3: High efficiency air cooled chilled water system

The image below highlights the high efficiency air-cooled cooling system modelled.

The cooling system is based on a central chilled water system with CRAH units serving the data halls and electrical rooms. The chilled water system is supported by high efficiency air cooled chillers with primary chilled water pumps.

In addition to the main cooling system, the following systems are included: (a) split system serving the battery room, which is modelled on the basis of an annualised COP, and (b) fresh air AHU.

This cooling system uses water for AHU humidity control system.



The cooling system is modelled on the basis of the equipment information listed in section 1.9.

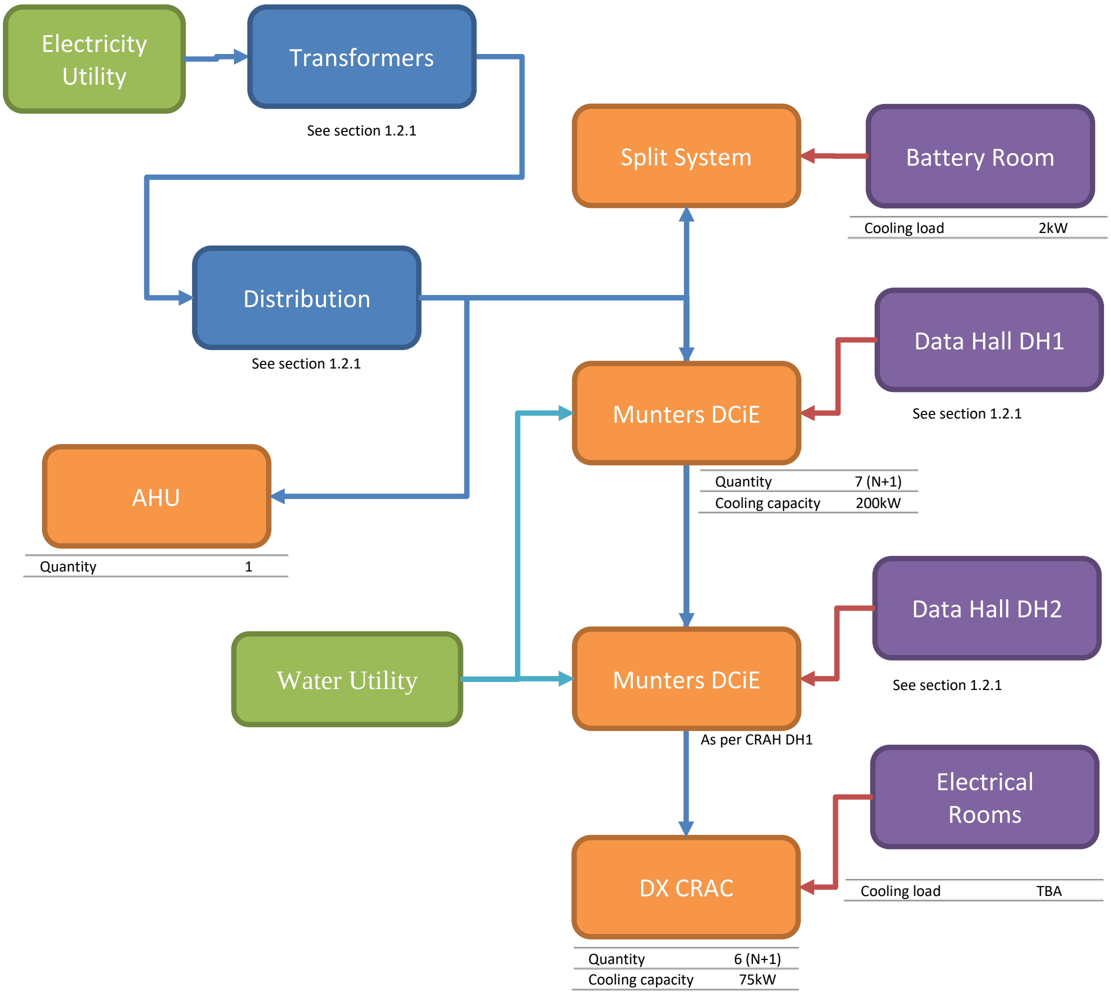
1.6 System 4 & 5: Munters DCiE 24°C and 27°C supply temperature

The image below highlights the Munters DCiE cooling system modelled.

The cooling system is based on Munters DCiE Indirect Evaporative Cooling (IEC) cooling units serving the data halls and DX condenser CRAC units for the electrical rooms.

In addition to the main cooling system, the following systems are included: (a) split system serving the battery room, which is modelled on the basis of an annualised COP, and (b) fresh air AHU.

This cooling system uses water for the Munters DCiE cooling units and AHU humidity control system.



The cooling system is modelled on the basis of the equipment information listed in section 1.9.

1.7 Modelling Approach

This study is based on numerical models of the energy and water usage within the site. The energy and water usage is associated with the equipment electrical and cooling demand, as well as fixed loads associated with the operation of the data centre.

The aim of this model is to represent the system using laws and physical equations. This results in a 'law-driven' model, which enables parametric modelling of the system. The numerical model represents the performance of groups of components, such as UPS, CRAHs, etc using performance curves or maps together with a representation of their control.

The scope of this study is limited to typical components serving the electrical and cooling infrastructure of a data centre with a view of comparing the performance of different cooling systems in relation to energy and water usage. This study is not aimed at providing a performance benchmark for a given system at a specific site.

1.8 Limitations

The use of numerical modelling to simulate building performance provides an estimate only. This estimate is based on a necessarily simplified and idealised version of the building attributes that does not and cannot fully represent all the intricacies of the live building in operation. As a result, results only represent an interpretation of the potential performance. No guarantee or warrantee of building performance in practice can be based solely on results of simulation.

The modelling presented in this study is based on nominal equipment performance and loads, which are not based on a specific site.

1.9 Cooling System Model Parameters Schedule

The following table shows the modelling parameters for the considered systems:

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
Battery Room Split System					
COP (annualised)	2.0	2.0	2.0	2.0	2.0
Cooling units serving Data Hall 1					
Type	Water cooled CRAH	Water cooled CRAH	Water cooled CRAH	Munters DCiE	Munters DCiE
Quantity	7	7	7	6	6
Resilience	N+1	N+1	N+1	N+1	N+1
Cooling capacity	200kW	200kW	200kW	220kW	220kW
Control	Fixed speed of 70%	Controlled to meet the load	Controlled to meet the load	Controlled to meet the flow	Controlled to meet the flow
Data hall fan input power	8.7kW	8.7kW	8.7kW	17.3kW	17.3kW
Data hall airflow	12.3m^3/s	12.3m^3/s	12.3m^3/s	14.9m^3/s	14.9m^3/s
Design supply/return air temperature	15/23°C	22/36°C	22/36°C	24/36°C	27/39°C
Achieved temperature differential	8°C	12°C	12°C	12°C	12°C
Derating	20%	-	-	-	-
Design ambient conditions	-	-	-	42.8°C 10.75g/kg	42.8°C 10.75g/kg
Minimum temperature for wet use	-	-	-	5°C	5°C
Scavenger airflow	-	-	-	12.3m^3/s	12.3m^3/s
Scavenger fan input power	-	-	-	11.9kW	11.9kW

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
Compressor COP	-	-	-	3.77	3.77
Affinity law coefficient	3	3	3	3	3
Bleed rate	-	-	-	20%	20%
Derating	20%	-	-	-	-
Cooling units serving Data Hall 2	**As per Data Hall 1**	**As per Data Hall 1**	**As per Data Hall 1**	**As per Data Hall 1**	**As per Data Hall 1**
Cooling units serving electrical room					
Type	Water cooled CRAH	Water cooled CRAH	Water cooled CRAH	DX cooled CRAC	DX cooled CRAC
Quantity	6	6	6	6	6
Resilience	N+1	N+1	N+1	N+1	N+1
Cooling capacity	75kW	75kW	75kW	75kW	75kW
Control	Fixed speed at 70%	Controlled to meet the load	Controlled to meet the load	Controlled to meet the load	Controlled to meet the load
Fan input power	8.9kW	4.5kW	4.5kW	4.5kW	4.5kW
Airflow	12.6m^3/s	6.3m^3/s	6.3m^3/s	6.3m^3/s	6.3m^3/s
Supply air temperature	18°C	22°C	22°C	22°C	22°C
Return air temperature	23°C	32°C	32°C	32°C	32°C
DX COP	-	-	-	2.38 @ 45°C	2.38 @ 45°C
Affinity law coefficient	3	3	3	3	3
Derating	20%	-	-	-	-
Secondary chilled water pumps					
Quantity	4	4	4	-	-
Redundancy	N+2	N+2	N+2	-	-
Glycol	No	No	No	-	-
Water flow rate	42.7l/s	42.7l/s	42.7l/s	-	-

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
Pump control	Pressure control to 30% minimum pump speed	Pressure control to 30% minimum pump speed	Pressure control to 30% minimum pump speed	-	-
Pump power	17.1kW	17.1kW	17.1kW	-	-
Design chilled water flow/return temperature	12/18°C	18/24°C	18/24°C	-	-
Achieved chilled water temperature differential	4.5°C	6°C	6°C	-	-
Affinity law coefficient	2	2	2	-	-
Derating	20%	-	-	-	-
Chiller					
Type	Air cooled chiller with free cooling (legacy)	Water cooled chiller	High efficiency air cooled chiller	-	-
Quantity	4	5	4	-	-
Redundancy	N+1	N+1	N+1	-	-
Cooling capacity	847kW	819kW	847kW	-	--
COP	2.0 @ 50°C DB ambient	4.3	2.92 @ 50°C DB ambient	-	-
Efficiency	Load and ambient temperature dependent	0.9% efficiency per degree of condenser water temperature	Load and ambient temperature dependent	-	-
Water flow rate	33.8l/s	24.8l/s	33.8l/s	-	-
Water flow/return temperature	12/18°C	18/24°C	18/24°C	-	-
Pump power	4.7kW	4.7kW	4.7kW	-	-
Water side economiser approach temperature	-	3°C	-	-	-
Cooling towers					
Type	-	Open circuit cooling tower	-	-	-
Quantity	-	4	-	-	-

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
Redundancy	-	N+1	-	-	-
Cooling capacity	-	1500kW	-	-	-
Water flow rate	-	45.2l/s	-	-	-
Pump input power	-	4.4kW	-	-	-
Water flow/return temperature	-	38.5/48.5°C	-	-	--
Water approach temperature	-	6.3°C	-	-	-
Airflow	-	21.9m^3/s	-	-	-
Fan power	-	8.7kW	-	-	-
Pan heater	-	6kW	-	-	-
Cycle of concentration	-	6.0	-	-	-
AHU					
Quantity	1	1	1	1	1
Air volume	2200m^3/h	2200m^3/h	2200m^3/h	2200m^3/h	2200m^3/h
Supply temperature	24°C	24°C	24°C	24°C	24°C
Supply relative humidity	60%	60%	60%	60%	60%
DX cooling coil COP (annual)	2.0	2.0	2.0	2.0	2.0
Heating COP	1.0	1.0	1.0	1.0	1.0
Humidifier	Based on latent heat of evaporation	Based on latent heat of evaporation	Based on latent heat of evaporation	Based on latent heat of evaporation	Based on latent heat of evaporation

2.0 RESULTS PRESENTATION

2.1 Weather

The modelling uses the following weather information:

- IWEC hourly weather file;
- Location: Abu Dhabi;
- Weather station: WMO 412170;
- Latitude: 24.43° N and longitude: 54.65° E;
- Elevation: 27m.

This weather file is also the closest IWEC hourly weather file to Dubai and hence is also used for this location.

2.2 Utility Costs

The modelling uses publicised utility costs for the Abu Dhabi and Dubai location as follows:

- **Abu Dhabi**: Costs are based on the Water & Electricity Tariffs 2017 document issued by Abu Dhabi Distribution Co and are as follows:
    - Water costs: AED7.84 per 1,000 litres;
    - Electricity costs: 27.0 fils per kWh outside of peak hours and 36.6 fils per kWh during peak hours.
- **Dubai**: Costs are based on the Slab Tariff published on the Dubai Electricity and Water Authority website. Costs exclude fuel surcharge. The costs use the following sliding scales:
    - Water costs: 3.5 fils per Imperial gallons (IG) for consumption between 0 and 10000 IG, 4.0 fils per IG for 10001 to 20000 IG and 4.6 fils per IG for consumption above 20001 IG;
    - Electricity costs: 23 fils per kWh for consumption between 0 to 10000kWh, and 38 fils per kWh for consumption above 10001kWh.

2.3 Results

The analysis is repeated for all systems at the following IT utilisation rates:

- 40% IT utilisation;
- 60% IT utilisation;
- 80% IT utilisation; and
- 100% IT utilisation.

Figure 1 shows the predicted monthly energy and water usage for the 5 modelled systems under 100% IT utilisation. The air-cooled chiller based solutions (systems 1 and 3) have very low water consumption compared to the other systems, but generally have higher energy consumption.

System 2, water cooled chillers, water consumption is dominated by the cooling towers, which uses evaporation as the primary means of heat dissipation. The energy consumption for this system is showing a drop in winter months due to the system operating in free cooling, i.e. the cooling towers are used to provide cooling directly to the chilled water using a free cooling heat exchanger. This effect is limited to the winter months when the ambient temperature is adequate.

The Munters DCiE cooling systems shown as systems 4 and 5 are showing the lowest energy consumption and a water consumption lower than the water-cooled chiller system 2. Increasing the supply air temperature (system 5) allows for the energy and water consumption to be further reduced as the ambient air provides a higher amount of heat dissipation in relation to the data hall environment. An additional benefit of the increased supply air temperature is the lower reliance on mechanical cooling.

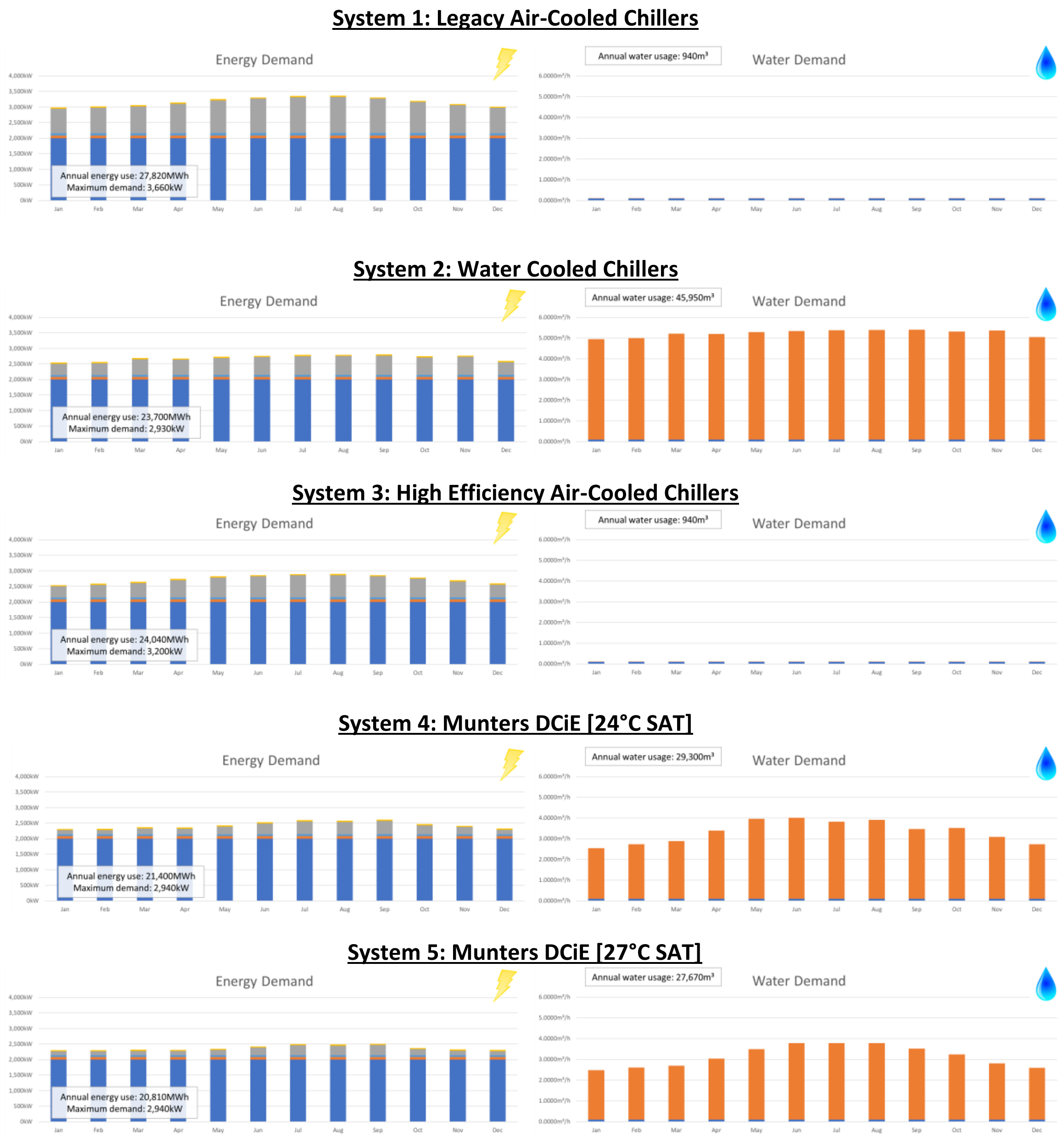


Figure 1 - Monthly energy and water usage for all system modelled at 100% IT utilisation.

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The following table summarises the modelling results, including energy and water usage as well as estimated annual operating costs. Operating costs are based on utility costs only derived from the modelling.

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
40% IT utilisation					
PUE	1.72	1.37	1.40	1.19	1.16
WUE	0.133l/kWh	3.013l/kWh	0.133l/kWh	2.122l/kWh	1.902l/kWh
Annual energy use	12,350MWh	9,820MWh	10,020MWh	8,550MWh	8,330MWh
Annual water use	940m^3	21,130m^3	940m^3	14,890m^3	13,350m^3
Annual operating costs – Abu Dhabi	AED 3,600k	AED 3,000k	AED 2,900k	AED 2,600k	AED 2,500k
Annual operating costs - Dubai	AED 4,700k	AED 3,900k	AED 3,800k	AED 3,400k	AED 3,300k
60% IT utilisation					
PUE	1.63	1.33	1.35	1.18	1.14
WUE	0.089l/kWh	2.776l/kWh	0.089l/kWh	1.916l/kWh	1.737l/kWh
Annual energy use	17,560MWh	14,350MWh	14,510MWh	12,640MWh	12,280MWh
Annual water use	940m^3	29,190m^3	940m^3	20,170m^3	18,280m^3
Annual operating costs – Abu Dhabi	AED 5,100k	AED 4,400k	AED 4,200k	AED 3,800k	AED 3,700k
Annual operating costs - Dubai	AED 6,700k	AED 5,700k	AED 5,600k	AED 5,000k	AED 4,800k
80% IT utilisation					
PUE	1.57	1.32	1.34	1.18	1.15
WUE	0.067l/kWh	2.671l/kWh	0.067l/kWh	1.780l/kWh	1.646l/kWh
Annual energy use	22,520MWh	18,940MWh	19,240MWh	16,900MWh	16,430MWh
Annual water use	940m^3	37,440m^3	940m^3	24,980m^3	23,100m^3

Item	System 1 Legacy air-cooled chillers	System 2 Water cooled chillers	System 3 High efficiency air-cooled chillers	System 4 Munters DCiE [24°C Supply temperature]	System 5 Munters DCiE [27°C Supply temperature]
					
Annual operating costs – Abu Dhabi	AED 6,500k	AED 5,800k	AED 5,600k	AED 5,100k	AED 4,900k
Annual operating costs - Dubai	AED 8,600k	AED 7,500k	AED 7,300k	AED 6,600k	AED 6,500k
100% IT utilisation					
PUE	1.55	1.32	1.34	1.19	1.16
WUE	0.053l/kWh	2.622l/kWh	0.053l/kWh	1.670l/kWh	1,577l/kWh
Annual energy use	27,820MWh	23,700MWh	24,040MWh	21,400MWh	20,810MWh
Annual water use	940m^3	45,950m^3	940m^3	29,300m^3	27,670m^3
Annual operating costs – Abu Dhabi	AED 8,000k	AED 7,200k	AED 7,000k	AED 6,400k	AED 6,200k
Annual operating costs - Dubai	AED 10,600k	AED 9,400k	AED 9,200k	AED 8,400k	AED 8,200k

APPENDIX – MANUFACTURER DATASHEETS

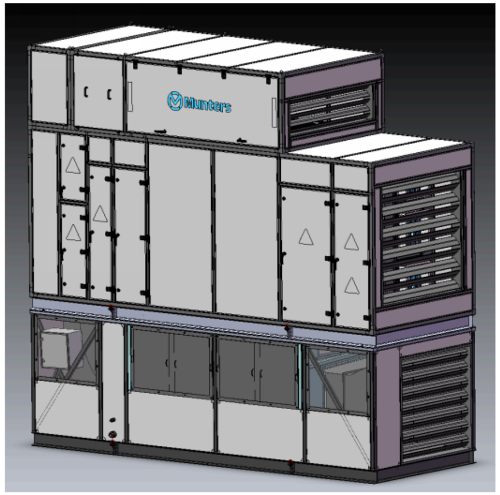
Munters
Your Perfect Climate

Preliminary

Page 1 (20)

Oasis DCiE

Unit Submittal Data



System name	UKWYBSIYO_14/09/2017_17:28:14
Labels	
Prepared by	Simon Young
Print date	14/09/2017 18:19:01
Program version	Genesys 2017.08.31

Munters
Your Perfect Climate

Preliminary

Page 2 (20)

Program version:
2017.08.31

System Type	Oasis DCiE	Prepared by	Simon Young
Model	DCiE V2	Print date	14/09/2017 18:19:04
Number of systems	1		

Project Summary

System configurations	1 x BEANRHAGO_14/09/2017_17:28:14 (G169121-1)

Design data	
Location name	United Arab Emirates, All Regions, Dubai International
Elevation	5.00 m
Total IT load	200.00 kW
Return air temperature	36.0 °C
Supply air temperature	24.0 °C
Room humidity	9.00 g/kg
External static pressure	102 Pa
Number of units	1
Number of redundant units	0
Design ambient temperature (Peak 47.4°C db)	42.8 °C
Design ambient humidity (Peak 32.5°C wb)	10.75 g/kg

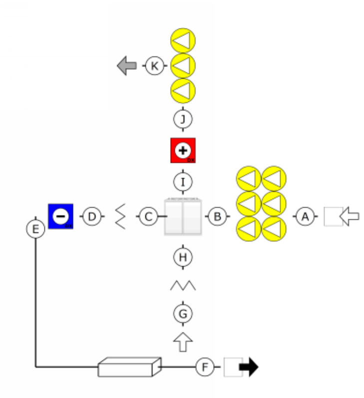
Energy and water consumption annual cost	
Electricity cost	0.10 EUR /kWh
Water cost	100.00 EUR /m^3
Total annual electricity cost	0 EUR
Total water supply cost	0 EUR

Equipment selection and performance	
Model	DCiE V2
Cooling capacity per unit (under N)	220.0 kW
Cooling capacity per unit (under N+1)	200.0 kW
Total cooling capacity	220.0 kW
Air flow per unit (under N)	53552 Sm^3/h
Air flow per unit (under N+1)	48689 Sm^3/h
Total airflow (under N)	53552 Sm^3/h
Predicted annual power use	
Total annual water consumption	
Annual water consumption per unit	
DX capacity per unit	156.3 kW
Number of hours of operation for DX	
Min temperature for spray operation	5.0 °C
Number of hours of water spray operation	
Percent annual hours DX is inactive	1.00
CO2 emission	0.01 kg/kWh
Annual CO2 emission	0.0 kg
Water consumption 12h at peak	6304 L

System measurements	
Estimated system annual partial PUE	1.00
Estimated system annual WUE	0.00 l/kWh

System Type	Oasis DCiE	Prepared by	Simon Young
Model	DCiE V2	Print date	14/09/2017
Genesys No	G169121-1	Labels	
Name	BEANRHAGO_14/09/2017_17:28:14		

Flow diagram



Climate data location: United Arab Emirates, Dubai International 5 m / 1012.6 mbar

Standard

	A	B	C	D	E	F	G	H	I	J	K
Sm³/h	48689	48689	48689	48689	48689	48689	44348	44348	44348	44348	44348
°C	36.0	36.7	28.1	28.1	23.6	23.6	42.8	42.8	27.7	33.7	34.5
g/kg	9.00	9.00	9.00	9.00	8.95	8.95	10.75	10.75	20.73	20.61	20.61
Pa	0	591	433	319	201	101	0	-33	-236	-377	-2

Peak

	A	B	C	D	E	F	G	H	I	J	K
Sm³/h	53552	53552	53552	53552	53552	53552	42614	42614	42614	42614	42614
°C	39.0	39.8	33.9	33.9	26.9	26.9	47.4	47.4	33.7	44.4	45.2
g/kg	9.00	9.00	9.00	9.00	8.95	8.95	20.89	20.89	29.59	29.42	29.42
Pa	0	677	488	347	202	102	0	-31	-224	-358	-2

APPENDIX – MUNTERS DCIE MODEL VALIDATION

The modelling undertaken in this study uses a model representation of the Munters DCiE unit. This model is parametrised and compared to the energy consumption estimates provided by Munters and shown in Figure 2. The comparison of the manufacturer data and calibrated model is show in Figure 3.

RED Dubai Model N+1

Mid point temp (°C)	Average temp (°C)	Humidity (g/kg)	Time (h)	Electric energy process fan (kWh)	Electric energy process fan (kW)	Electric energy scavenger fan (kWh)	Electric energy scavenger fan (kW)	Electric energy cooling (kWh)	Electric energy cooling (kW)	Electric energy Dx cooling (kWh)	Electric energy Dx cooling (kW)	Total electric energy (kWh)	Total electric energy (kW)	Water (m³)	Water (m³/h)	Water sewage (m³)	Water sewage (m³/h)	Evaporative cooling (kW)	Dx cooling (kW)
47	46	9.78	2	19.3	9.7	23.3	11.7	2	1.0	34.9	17.5	79.5	39.8	1.13	0.565	0.23	0.115	124.29	58.99
45	44.4	11.38	13	125.3	9.6	150.5	11.6	13	1.0	250	19.2	538.9	41.5	6.67	0.513	1.33	0.102	118.11	65.65
43	42.4	12.68	37	356.8	9.6	427.2	11.5	37	1.0	744.1	20.1	1565.2	42.3	17.06	0.461	3.41	0.092	115.01	68.96
41	40.4	13.32	169	1625.5	9.6	1970.6	11.7	169	1.0	3344	19.8	7109	42.1	71.61	0.424	14.32	0.085	115.74	67.74
39	38.6	15.28	341	3281.3	9.6	3949.5	11.6	341	1.0	7709.5	22.6	15281.4	44.8	123.19	0.361	24.64	0.072	108.26	75.69
37	36.6	16.52	612	5878	9.6	7091.8	11.6	612	1.0	15247.8	24.9	28829.6	47.1	192.56	0.315	38.51	0.063	106.01	78.35
35	34.6	16.93	757	7252.2	9.6	8971.4	11.9	757	1.0	16322.3	21.6	33302.9	44.0	216.8	0.286	43.36	0.057	109.18	74.42
33	32.7	17.74	901	8620.4	9.6	10484.4	11.6	901	1.0	19321.8	21.4	39327.6	43.6	224.58	0.249	44.92	0.050	110.1	73.98
31	30.7	16.69	894	8517.6	9.5	10755	12.0	894	1.0	16347.9	18.3	36514.5	40.8	220.34	0.246	44.07	0.049	121.51	62.09
29	28.7	14.78	792	7498.8	9.5	9449.4	11.9	792	1.0	10628.5	13.4	28368.6	35.8	203.2	0.257	40.64	0.051	138.68	43.77
27	26.7	13.43	743	6997	9.4	9210.2	12.4	743	1.0	6099.5	8.2	23049.6	31.0	193.76	0.261	38.75	0.052	153.7	27.02
25	24.6	11.9	776	6840.3	8.8	9602.8	12.4	776	1.0	0	0.0	17219.1	22.2	208.16	0.268	41.63	0.054	170.12	0
23	22.7	10.84	879	7724.2	8.8	3669.7	4.2	879	1.0	0	0.0	12272.9	14.0	203.03	0.231	40.61	0.046	173.71	0
21	20.7	10.23	743	6520.4	8.8	1431.7	1.9	743	1.0	0	0.0	8695.1	11.7	154.54	0.208	30.91	0.042	173.81	0
19	18.8	9.74	472	4134.7	8.8	535.5	1.1	472	1.0	0	0.0	5142.2	10.9	91.35	0.194	18.27	0.039	173.86	0
17	16.7	9.35	341	2986.1	8.8	270.4	0.8	341	1.0	0	0.0	3597.5	10.5	62.53	0.183	12.51	0.037	173.8	0
15	14.8	8.39	215	1879.4	8.7	158.2	0.7	215	1.0	0	0.0	2252.6	10.5	38.19	0.178	7.64	0.036	173.85	0
13	13	7.32	73	637	8.7	40.7	0.6	73	1.0	0	0.0	750.7	10.3	12.68	0.174	2.54	0.035	173.79	0
Unit Totals			**8760**	**80894.3**		**78192.3**		**8760**		**96050.3**		**263896.9**		**2241.38**		**448.29**			
Hall Totals												**1583381.4**		**13448.28**		**2689.74**			

Figure 2- Energy consumption estimates for Munters DCiE unit provided by Munters.

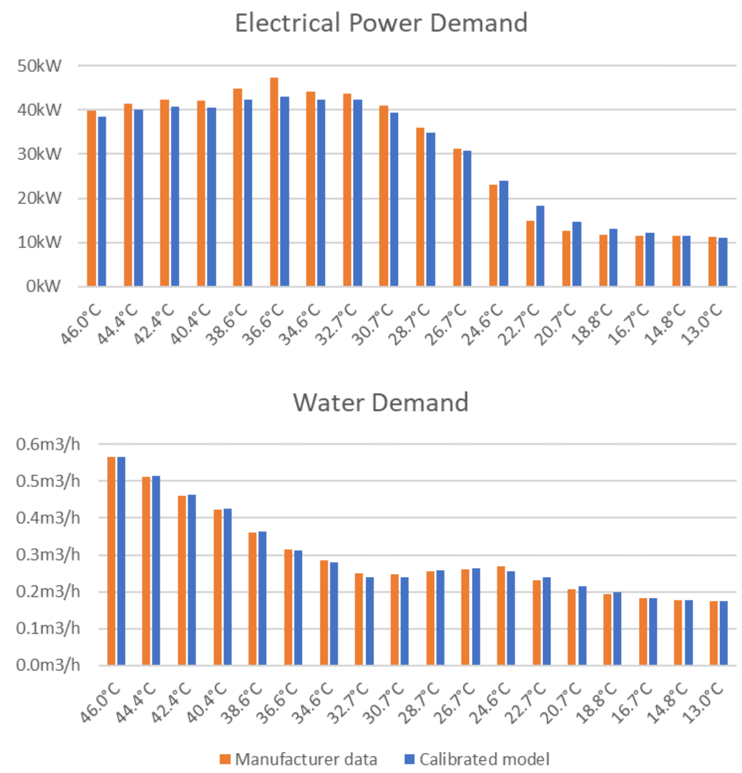


Figure 3 - Comparison of manufacturer and calibrated energy and water usage performance for Munters DCiE units.