DATA CENTER FORUM COPENHAGEN 2025

How to enhance efficiency in datacenter systems granting long working life of the equipment

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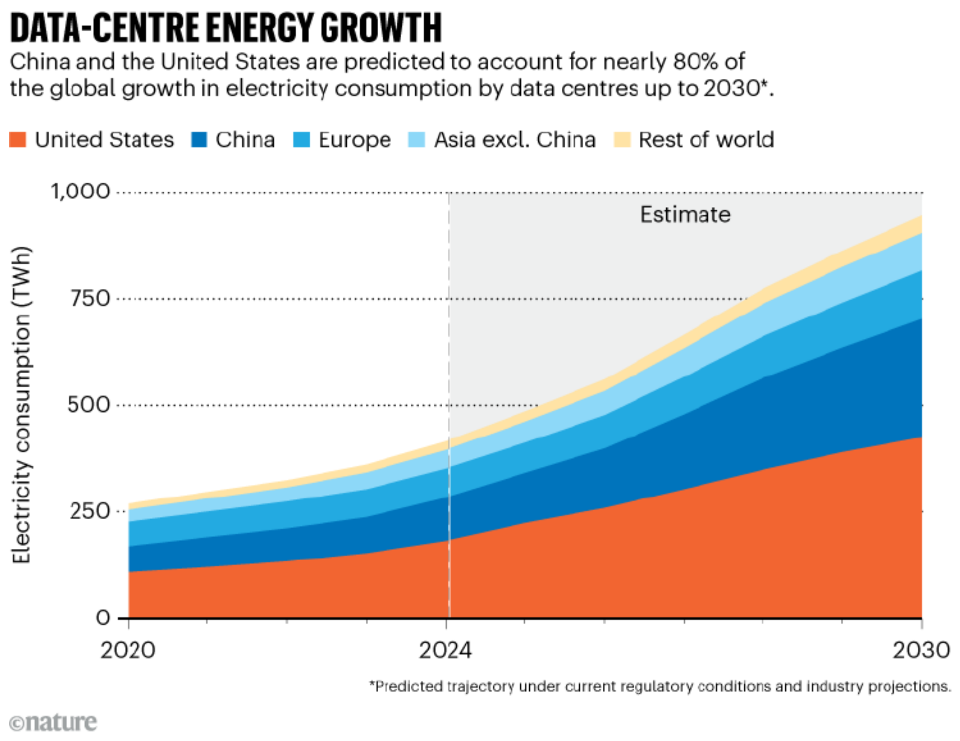
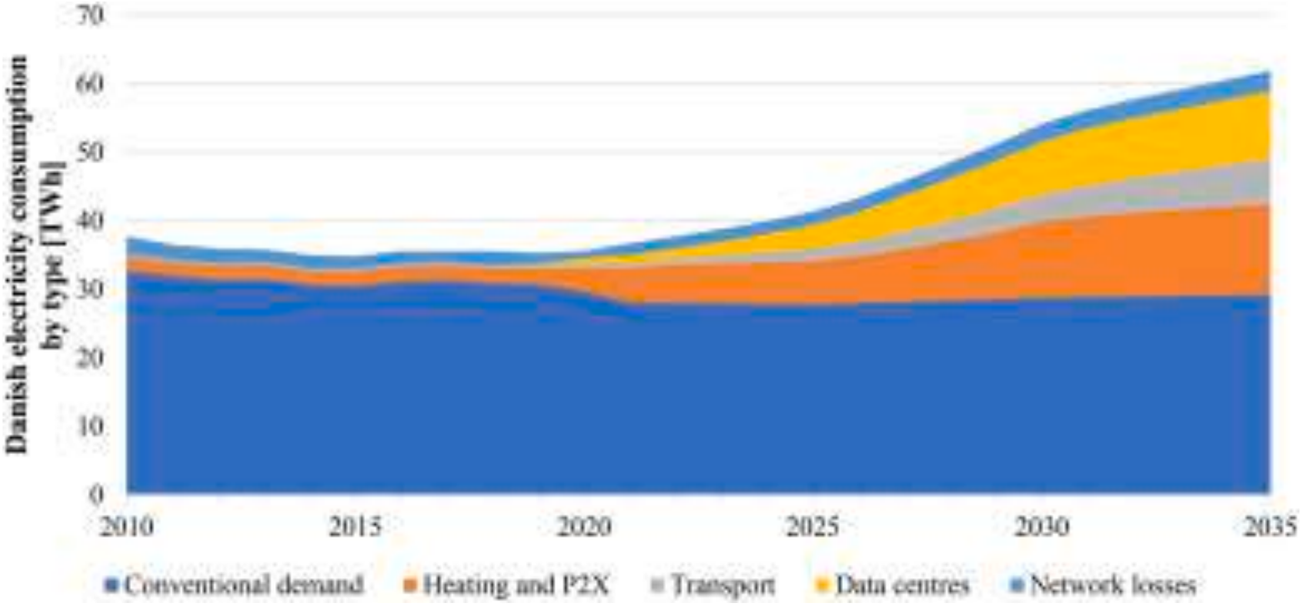
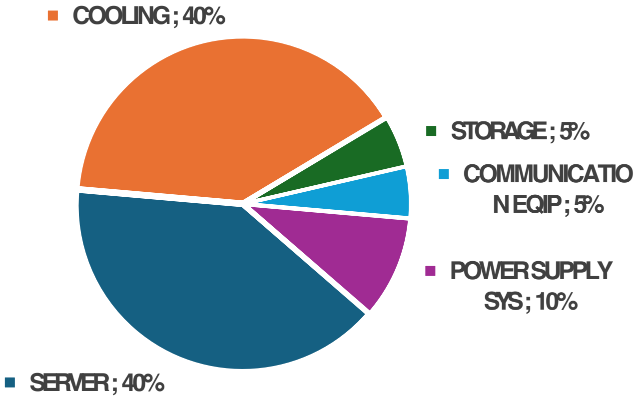
ENERGY CONSUMPTION IN DATA CENTER





The **efficiency** of the cooling system play a key role in Data Center Saving

DATA-CENTRE ENERGY CONSUMPTION



METHODS TO OPTIMIZE THE EFFICIENCY IN DATA CENTER INSTALLATION WITH HYDRONIC SYSTEM

TECHNICAL DATA
EER / COP / SCOP /SEPR → NOT ENOUGH

BMS CONTROL:
SEQUENCE
HOMOGENEOUS → NOT ENOUGH

PUMPS FAN WALL CDU
AND CONTROL → NOT ENOUGH

DATA HALLS:
COOLING LOAD
HEATING RECOVERY
MAINTENANCE
ETC….. → NOT ENOUGH

Fase I: Definition of the variables

- Technologies and units for the energy production
- Project objectives.
- Related to the installation

Technologies and units for the energy production

- **Type of unit**
- Technology of compression.
- Design criteria
- Type of Evaporator
- Type of Compressor
- Activation Sequency

- Unit Type:
  - Air Condensation
  - Water Condensation
- Evaporator Type:
  - Plates
  - Shell & Tubes
- Versatility
  - Cooling only
  - 4 Pipes
  - 6 Pipes

- Compression Technology:
  - Scroll
  - Screw
  - Centrífugal

  (Scroll, Screw: ON/OFF ; Stepless; Inverter)
- Condenser Type
  - Coils Cu/AL
  - Microchannel
- Opportunity
  - Heat Recovery
  - Free Cooling
  - Geothermal

- Design criteria:
  - High Efficiency
  - Low Noise
  - Dimensions
  - Redundancy
- External Contraints
  - Cost
  - Space
  - Ceritification
  - Other…

WE NEED A CLEAR METHOD WITH ALL ACTORS JOINT TOGETHER

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Fase I: Definition of the variables

- Technologies and units for the energy production
- Project objectives.
- Related to the installation

Fase II: Simulation and possible alternatives

- Different unit type
- Different n° of units
- Different setting of the multichiller

Fase III: Definition of the best solution

- Lower operating cost
- Lower payback time
- Less investments

SAMPLE OF PROFESSIONAL SIMULATION

PROJECT REFERENCE: DUBLIN DATA CENTER

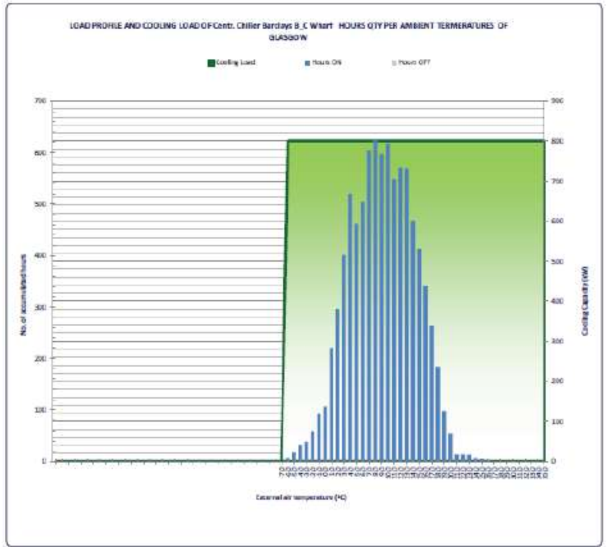
PROJECT NOMINAL CONDITIONS

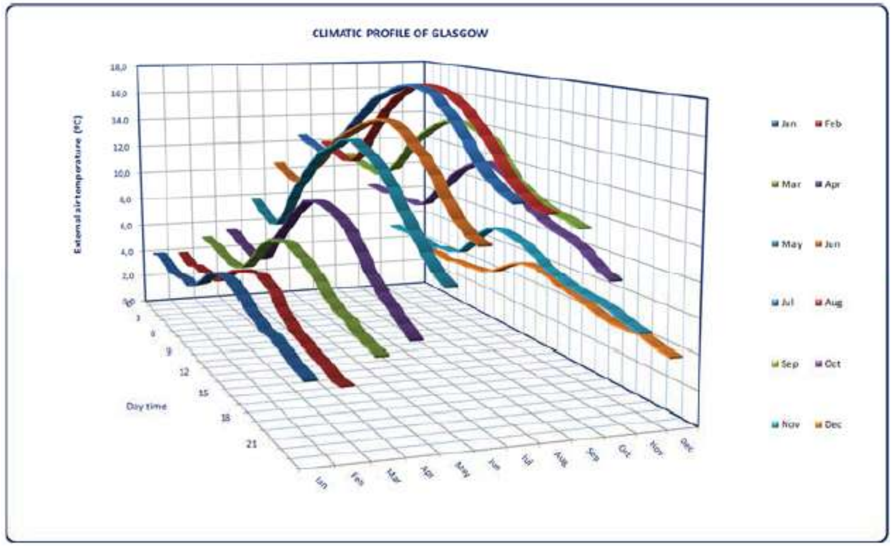
Project Design Conditions	
Design Ambient Tª (ºC)	45,0
Water Set point (ºC)	22,0
Climatic Area	DUBLIN
Maximum LOAD (kW):	1.127,0
ΔT S/ Return Free Cooling O	3,0
Amb. Tª for Homogeneous	27,0

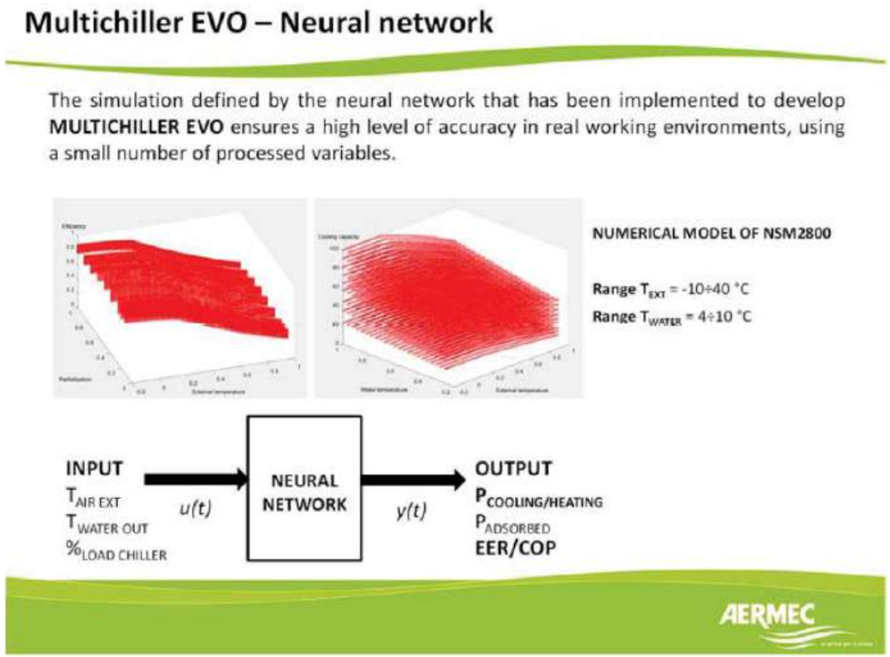
Dynamic T water set point	NO
Dynamic T water set point	LOAD 100% / Two °C
Dynamic T water set point	LOAD 0% / Two °C
ΔT nominal	8,0
Minimum Load (kW):	1.127
Tª mín (ºC) P=0 kW	-10,0
Glycol %	0
Water Density	1,301

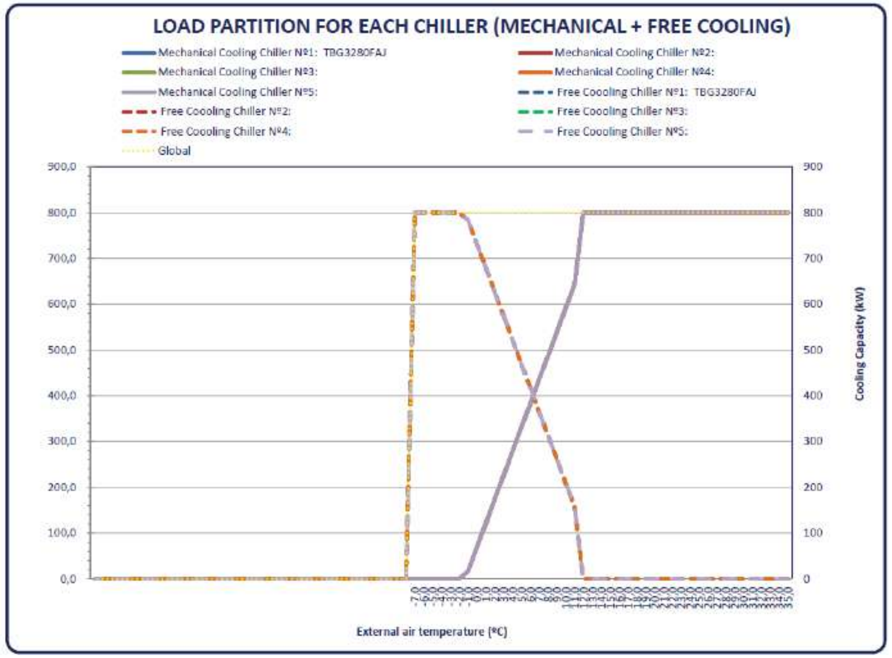
CLIMATIC PROFILE OF DUBLIN

SAMPLE OF PROFESSIONAL SIMULATION









SAMPLE OF PROFESSIONAL SIMULATION

		Max Mechanical Cooling Capacity				
External air temperature	Load	NSGi6402FA				
45,0	1.127,0	1.601,7				
44,0	1.127,0	1.623,5				
43,0	1.127,0	1.645,2				
42,0	1.127,0	1.666,8				
41,0	1.127,0	1.688,3				
40,0	1.127,0	1.709,7				
39,0	1.127,0	1.731,0				
38,0	1.127,0	1.752,2				
37,0	1.127,0	1.773,3				
36,0	1.127,0	1.794,2				
35,0	1.127,0	1.815,1				
34,0	1.127,0	1.835,9				
33,0	1.127,0	1.856,6				
32,0	1.127,0	1.877,2				
31,0	1.127,0	1.897,6				
30,0	1.127,0	1.918,0				
29,0	1.127,0	1.938,3				
28,0	1.127,0	1.958,4				
27,0	1.127,0	1.978,5				
26,0	1.127,0	1.998,5				
25,0	1.127,0	2.018,4				
24,0	1.127,0	2.038,1				
23,0	1.127,0	2.057,8				
22,0	1.127,0	2.077,4				
21,0	1.127,0	2.096,9				
20,0	1.127,0	2.116,2				
19,0	1.127,0	2.135,5				
18,0	1.127,0	2.154,7				
17,0	1.127,0	2.173,8				
16,0	1.127,0	2.192,7				
15,0	1.127,0	2.211,6				
14,0	1.127,0	2.230,4				
13,0	1.127,0	2.249,1				
12,0	1.127,0	2.267,7				
11,0	1.127,0	2.286,2				
10,0	1.127,0	2.318,8				
9,0	1.127,0	2.333,2				
8,0	1.127,0	2.346,3				
7,0	1.127,0	2.358,1				
6,0	1.127,0	2.368,6				
5,0	1.127,0	2.378,0				
4,0	1.127,0	2.386,3				
3,0	1.127,0	2.393,5				
2,0	1.127,0	2.399,8				
1,0	1.127,0	2.405,1				
0,0	1.127,0	2.409,6				
-1,0	1.127,0	2.413,3				
-2,0	1.127,0	2.416,2				
-3,0	1.127,0	2.418,5				
-4,0	1.127,0	2.420,2				
-5,0	1.127,0	2.421,3				
-6,0	1.127,0	2.422,0				
-7,0	1.127,0	2.422,2				
-8,0	1.127,0	2.422,0				
-9,0	1.127,0	2.421,6				
-10,0	1.127,0	2.420,9				

		Max Free Cooling Capacity				
External air temperature	Load	NSGi6402FA				
45,0	1.127,0					
44,0	1.127,0					
43,0	1.127,0					
42,0	1.127,0					
41,0	1.127,0					
40,0	1.127,0					
39,0	1.127,0					
38,0	1.127,0					
37,0	1.127,0					
36,0	1.127,0					
35,0	1.127,0					
34,0	1.127,0					
33,0	1.127,0					
32,0	1.127,0					
31,0	1.127,0					
30,0	1.127,0					
29,0	1.127,0					
28,0	1.127,0					
27,0	1.127,0					
26,0	1.127,0	226,5				
25,0	1.127,0	283,1				
24,0	1.127,0	339,7				
23,0	1.127,0	396,3				
22,0	1.127,0	452,9				
21,0	1.127,0	509,5				
20,0	1.127,0	566,2				
19,0	1.127,0	622,8				
18,0	1.127,0	679,4				
17,0	1.127,0	736,0				
16,0	1.127,0	792,6				
15,0	1.127,0	849,2				
14,0	1.127,0	905,8				
13,0	1.127,0	962,5				
12,0	1.127,0	1.019,1				
11,0	1.127,0	1.075,7				
10,0	1.127,0	1.132,3				
9,0	1.127,0	1.188,9				
8,0	1.127,0	1.245,5				
7,0	1.127,0	1.302,1				
6,0	1.127,0	1.358,8				
5,0	1.127,0	1.415,4				
4,0	1.127,0	1.472,0				
3,0	1.127,0	1.528,6				
2,0	1.127,0	1.585,2				
1,0	1.127,0	1.641,8				
0,0	1.127,0	1.698,5				
-1,0	1.127,0	1.755,1				
-2,0	1.127,0	1.811,7				
-3,0	1.127,0	1.868,3				
-4,0	1.127,0	1.924,9				
-5,0	1.127,0	1.981,5				
-6,0	1.127,0	2.038,1				
-7,0	1.127,0	2.094,8				
-8,0	1.127,0	2.151,4				
-9,0	1.127,0	2.208,0				
-10,0	1.127,0	2.264,6				

FROM ASHRAE TEMPERATURE DATA OR DATA PROVIDED BY THE CONSULTANT OF THE SPECIFIC AREA WE CAN HAVE A TRUE PERFORMANCE OF THE UNIT OR UNITS AT THE SPECIFIC TEMPERATURE AND AT THE SPECIFIC LOAD. THIS RESULTS AS THE MOST RELIABLE AND REALISTIC DATA TO PROVIDE TO THE DATA CENTER

	Cooling Energy (kWh)		Input Energy (kWhe)						
	Mechanical Cooling Energy	Free Cooling Energy	Mechanical Input Energy	Free Cooling Input Energy	(Pumps + CRACS) Input Energy	Total Input Energy	EER Mechanical	EER Chiller	EER System
January	525.957	339.579	66.042,9	476,7	12.842,2	79.361,7	7,96	13,01	10,91
February	452.076	305.268	55.432,8		11.483,3	66.916,1	8,16	13,66	11,32
March	618.029	220.459	80.846,8		12.058,6	92.905,4	7,64	10,37	9,03
April	643.860	167.580	86.490,0		11.327,9	97.817,9	7,44	9,38	8,30
May	759.057	79.431	109.389,8		10.730,9	120.120,8	6,94	7,67	6,98
June	783.246	28.194	117.695,7		9.845,5	127.541,2	6,65	6,89	6,36
July	842.481	1.642	137.021,2		9.864,0	146.885,2	6,15	6,16	5,75
August	825.297	13.191	132.078,2		9.961,2	142.039,4	6,25	6,35	5,90
September	773.168	38.272	116.086,8		9.951,4	126.038,2	6,66	6,99	6,44
October	757.302	81.186	107.906,6		10.747,2	118.653,8	7,02	7,77	7,07
November	606.437	205.003	79.188,8		11.564,1	90.752,9	7,66	10,25	8,94
December	570.812	267.676	72.916,8		12.282,5	85.199,4	7,83	11,50	9,84
Global	8.157.722	1.747.481	1.161.096	477	132.659	1.294.232	7,03	8,53	7,65

SAMPLE OF PROFESSIONAL SIMULATION

SOLUTION / SIMULATION			
CHILLER TYPE		SCREW FC - CENTRIFUGAL FC	
		5,00	
WATER OUT	FIX	8	
	DYNAMIC	NO	———————
DELTA T		6 K	
FANS			
		INVVERTER	

$$LCC = I + f_{pv}(C_o + C_m)$$

$$f_{pv} = \frac{1-(1+r_i)^{-n}}{r_i} \qquad r_i = \frac{r-i}{1+i}$$

INTEREST RATE	0,00100	r	%
INFLATION RATE	0,02000	i	%
ri	-0,01863		%
fpv	17,49		
n	15	years	
REFRIGERANT GWP	1300	R134a	
REFRIGERANT GWP	6	R1234ze	

Exc rate 0,85 Alpha Co2 0,6

Energy cost 0,1575 £/kWh

Refrigerant Charge 180 Kg (R1234ze)

1			
CHILLER TYPE	CENTR. HIGH EFF FC		
CHILLER MODEL	TBG3280FAJ		
CHILLER QTY	1		
COOLING CAPACITY	822,2	kW	100%
EER	3,32		100%
ESEER			#DIV/0!
SEER WITHOUT PUMP	9,50		100%
SEER WITH PUMP	8,90		100%
PRICE €	229.412	€	100%
PRICE £	195.000	£	100%
MAINTENANCE COST € (YEAR)	25.745	€	100%
MAINTENANCE COST £ (YEAR)	21.883	£	100%
ENERGY CONSUMPTION kWh	787.236	kWh	100%
C0 (YEARLY ENERGY COST) €	123.990	€	100%
C0 (YEARLY ENERGY COST) £	105.391	£	100%
LCC €	2.848.647	€	100%
LCC £	2.421.350	£	100%
TEWI	7.086.205	Kg	100%

	Cooling Energy		Electrical Energy Consumed (kWhe)						
	kwh Cool. Rankine	kwh cool. Free Cooling	kWhe Chiller	kWhe Free Cooling	kWhe Pumps	kWhe Total	EER Rankine	EER Chiller	EER System
January	243.299	351.901	32.560,0	619,6	4.398,8	37.578,4	7,47	18,28	15,84
February	212.607	324.993	26.779,7	713,0	4.057,7	31.550,4	7,94	20,07	17,04
March	293.530	301.670	37.616,5	460,1	4.450,3	42.526,8	7,80	15,82	14,00
April	338.882	237.118	47.229,1	134,7	4.150,6	51.514,4	7,18	12,20	11,18
May	465.484	129.716	73.875,3		3.877,3	77.752,5	6,30	8,06	7,66
June	512.579	63.421	87.102,9		3.401,6	90.504,5	5,88	6,61	6,36
July	577.177	18.023	105.316,7		3.079,0	108.395,7	5,48	5,65	5,49
August	561.139	34.061	100.629,6		3.212,0	103.841,6	5,58	5,91	5,73
eptember	524.960	51.040	89.927,0		3.260,0	93.187,0	5,84	6,41	6,18
October	445.424	149.776	70.052,1		3.903,0	73.955,1	6,36	8,50	8,05
November	286.244	289.756	38.807,7	563,9	4.238,6	43.610,2	7,38	14,84	13,21
December	220.571	374.629	27.731,6	601,0	4.486,7	32.819,4	7,95	21,46	18,14
Global	4.681.895	2.326.105	737.628	3.092	46.516	787.236	6,35	9,50	8,90

SEER WITHOUT PUMP	9,50
SEER WITH PUMP	8,90

COMPARISON	100%

Refrigerant Charge 120 Kg (R1234ze)

2			
CHILLER TYPE	SCREW HIGH EFF FC		
CHILLER MODEL	NSG4502FAJ		
CHILLER QTY	1		
COOLING CAPACITY	844	kW	102,6%
EER	3,23		97,3%
ESEER			#DIV/0!
SEER WITHOUT PUMP	9,87		103,8%
SEER WITH PUMP	8,86		99,6%
PRICE €	170.588	€	74,4%
PRICE £	145.000	£	74,4%
MAINTENANCE COST € (YEAR)	19.244	€	74,7%
MAINTENANCE COST £ (YEAR)	16.357	£	74,7%
ENERGY CONSUMPTION kWh	790.583	kWh	100,4%
C0 (YEARLY ENERGY COST) €	124.517	€	100,4%
C0 (YEARLY ENERGY COST) £	105.839	£	100,4%
LCC €	2.685.326	€	94,3%
LCC £	2.282.527	£	94,3%
TEWI	7.115.968	Kg	100,4%

	Cooling Energy		Electrical Energy Consumed (kWhe)						
	kwh Cool. Rankine	kwh cool. Free Cooling	kWhe Chiller	kWhe Free Cooling	kWhe Pumps	kWhe Total	EER Rankine	EER Chiller	EER System
January	160.606	434.594	29.164,7	5.197,6	5.734,3	40.096,6	5,51	20,41	14,84
February	137.101	400.499	24.513,0	4.015,7	5.333,1	33.861,8	5,59	21,93	15,88
March	217.099	378.101	36.635,4	2.125,3	5.827,8	44.588,6	5,93	16,25	13,35
April	276.769	299.231	45.993,2	1.451,6	5.356,5	52.801,2	6,02	12,52	10,91
May	429.520	165.680	72.492,3	417,8	4.787,7	77.697,8	5,93	8,21	7,66
June	494.458	81.542	84.981,4		3.996,9	88.978,3	5,82	6,78	6,47
July	572.027	23.173	101.753,0		3.338,5	105.091,6	5,62	5,85	5,66
August	551.407	43.793	97.567,8		3.580,1	101.147,8	5,65	6,10	5,88
eptember	510.377	65.623	87.170,9		3.739,8	90.910,7	5,85	6,61	6,34
October	405.265	189.935	68.201,6	1.002,3	4.834,5	74.038,4	5,94	8,73	8,04
November	218.174	357.826	37.062,0	2.868,4	5.516,2	45.446,6	5,89	15,54	12,67
December	131.523	463.677	24.788,5	5.241,2	5.894,1	35.923,8	5,31	24,01	16,57
Global	4.104.326	2.903.674	710.324	22.320	57.939	790.583	5,78	9,87	8,86

SEER WITHOUT PUMP	9,87
SEER WITH PUMP	8,86

COMPARISON	100%

WE NEED A CLEAR METHOD WITH ALL ACTORS JOINT TOGETHER

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CONCLUSIONS:

SOLUTION 1: DESPITE THE ULTIMATE TECHNOLOGY AVAILABLE FOR COMPRESSION WITH THE BEST EFFICIENCY, IT IS NOT RESULTS AS THE BEST SOLUTION IN TERM OF LIFE CYCLE COST, AS THE INITIAL COST IS HIGHER AND AS WELL THE MAINTENANCE COST COMPARED WITH THE OTHER SOLUTIONS.

SOLUTION 2: IT IS THE MOST CONVENIENT IN TERMS OF LIFE CYCLE COST DESPITE IT IS NOT THE MOST EFFICIENT. THE EFFICIENCY IS VERY CLOSE TO THE SOLUTION1 AS THE SOLUTION 2 GET THE BENEFIT OF BIGGER SURFACE OF FREECOOLING COILS.

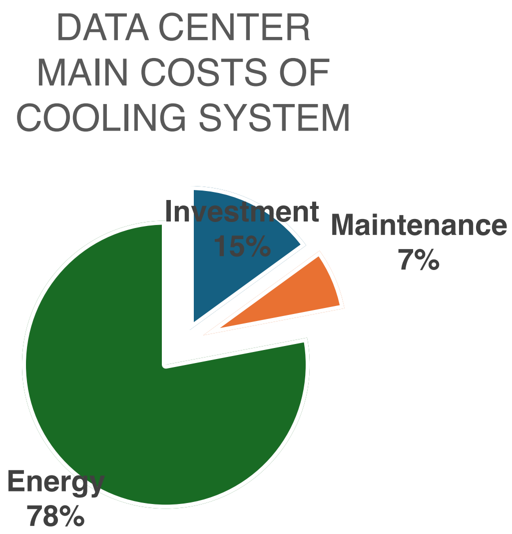
Assumptions:

- In order to calculate the pumping energy for each chiller we have taken into account that the primary circuit pressure drop is 100kPa.
- The pumps efficiency was calcilated at 80% max.
- The load profile in in compliances with the figures supplied by the customer considering the process cooling operation for data center. We have considered the same total amount of energy consumption per year and the quantities of hour with the specific load.
- The life time 15 years.
- Temperature profile in compliances with ASHRAE weather data for Glasgow.

LIFE CYCLE COST (LCC)

The data center Manufacturer of the cooling system should be able to produce a simulation taking into account the costs he can control in cooperation with the Consultant and the Data Center Provider. Those simulation should produce a final cost of ownership or better called the **Life Cycle Cost** (**LCC**) as also defined by the European standard EN13779.

Here below the approximated partition of the total life cycle cost.



The investment costs of a Data Center systems is close to 15% of the total life cycle cost.

→ The 78% of the LCC is related to the input energy the system required.

It is therefore FUNDAMENTAL to use systems with high efficiency, reliability in order to grant a better LCC or (pPUE).

LIFE CYCLE COST (LCC)

The EN 13779 standard define the Life Cycle Costs (LCC) as follows:

$$LCC = I + f_{pv}(C_o + C_m)$$

I = Amount of initial Investment

f_{pv} = actualization factor defined as: $f_{pv} = \dfrac{1-(1+r_i)^{-n}}{r_i}$

Where n is the estimated life time in Years; r_i is the real interest rate expressed as a function of the financial interest rate r ; and finally taking into account the inflation rate i :

$$r_i = \frac{r-i}{1+i}$$

C_o = Energy cost per year.

C_m = Maintanance cost per year

HAVE A GREAT DAY

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