Urban Data Centre Definition and Specification

Final adjusted version
ICTroom, EATON, Credit Suisse
14/01/2015
Rev 1.3
[Keywords]

TABLE OF CONTENTS

REVISION SHEET

Revision Number	Date	Brief summary of changes
Rev 0.1	17/02/2014	First concept
Rev 0.2	25/04/2014	Baseline document as presented in Conference Call
Rev 0.3	28/04/2014	Concept document
Rev 1.0	27/05/2014	Final version
Rev 1.1	22/10/2014	Remarks from Review Board implemented
Rev 1.2	30/12/2014	Remarks from Technical review implemented
Rev 1.3	14/01/2015	Changes on Energy management Paragraph

1. INTRODUCTION

1.1 DOCUMENT BACKGROUND

The FP7 Smart Cities 2013 GreenDataNet project aims at designing and validating a new, system-level optimisation solution, allowing Urban Data Centres to radically improve their energy and environmental performance. The GreenDataNet project is the result of the European call FP7 ICT-2013.6.2 'Data Centres in an energy-efficient and environmentally friendly internet'.

The objective of GreenDataNet is to develop a set of beyond state-of-the-art technologies that will allow Urban Data Centres (Urban DCs) to reach 80% of renewable power and decrease their average Power Usage Effectiveness (PUE) from 1.6-2.0 today to less than 1.3.

GreenDataNet will enable energy monitoring and optimisation of ICT, power, cooling and storage at three levels:

1. servers and racks;
2. individual data centres;
3. networks of data centres.

To further reduce the need for grid power, GreenDataNet will also work on the integration of local PhotoVoltaic (PV) energy in combination with an innovative, large-scale storage solution that will facilitate the connection of data centres to smart grids. Within this project, second-life electric vehicle Li-ion batteries will be investigated as a more advantageous solution for data centres to become actual smart grid nodes.

The whole solution will be implemented as an open-source platform to allow third parties to provide additional optimisation modules and ensure the long-term sustainability of the project. Three demonstration sites will be utilised to test and validate the GreenDataNet concept: a data centre from Credit Suisse in Switzerland, a data centre from CEA in France that includes a large photovoltaic area and a smart grid test platform, and a pilot site in the Netherlands that is being used by a Dutch consortium working on Green ICT technologies.
In addition, research on heat reuse vs. free cooling will be conducted in a new data centre built by ICTroom in Belgium.
Performance indicators that go beyond PUE will be experimented in the project and will support the work of the consortium in standardisation bodies like CEN/CENELEC/ETSI. Based on the project outcome, GreenDataNet will release guidelines to help make data centres more sustainable in the future.

1.2 DOCUMENT POSITION

The project is organised into work packages (WPs), as shown in the following figure. The work flow represents interdependencies between WPs and the main milestones supporting the project goals.

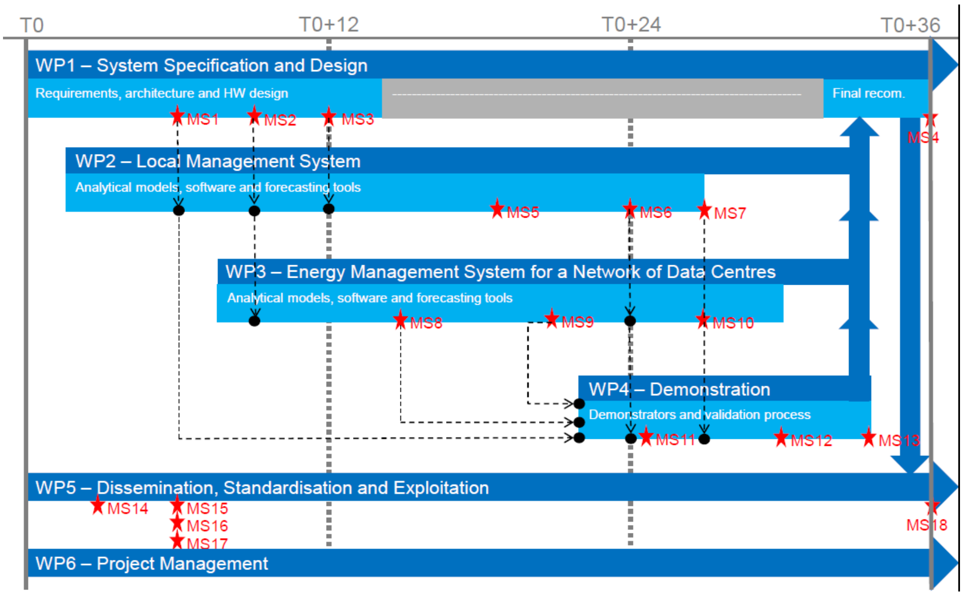

Figure 1-1 Work flow of GreenDataNet project with work packages interdependencies

WP 1 is the system specification and Design, Task 1.1 of WP1 comprises the Urban DC definition and specification. The intent of this document is to answer this part of the Work Package 1 (WP1) purpose and is a defined deliverable of WP1.

1.3 DOCUMENT PURPOSE

The purpose of this document is to describe and specify the typical definition of urban Data CentreData Centre, or a network of Data CentreData Centres, as targeted by the GreenDataNet project.
This definition will provide guidance in the requirements and limitations for all technical developments carried out in the GreenDataNet project. Key parameters of the definition such as size or geographical location will be utilized to evaluate a data centres capability to leverage the use of renewable energy (primarily solar in this project), efficiently reuse the heat that it produces, and to reduce its power consumption.

Based on this initial definition and specification, tools will be developed to estimate the energy and environmental performance of an existing data centre, a data centre to be retrofitted or a new data centre to be built. The specification will be used as the baseline scenario, against which all improvements brought by the project will be benchmarked.

1.4 DOCUMENT SCOPE

The scope of this document is targeted at providing a practical applicable framework of Urban DC design and specification. It will provide the boundaries of the definition of an Urban DC in order to project and compare future energy efficiency opportunities for these types of facilities.

1.5 CONSTRAINTS

This document will constrain to the scope of the GreenDataNet project.

1.6 ASSUMPTIONS AND DEPENDENCIES

Practical assumptions have been made concerning the detail level of information in this document. This definition of Urban DCs will be the starting point for the next work packages within the GreenDataNet project.

1.7 DEFINITION, ACRONYMS AND ABBREVATIONS

1.7.1 KEY DEFINITIONS

Data centre [1]
A structure, or group of structures, dedicated to the centralized accommodation, interconnection and operation of information technology and network telecommunications equipment providing data storage, processing and transport services together with all the facilities and infrastructures for power distribution and environmental control together with the necessary levels of resilience and security required to provide the desired service availability
Note: A structure can consist of multiple buildings and/or spaces with specific functions to support the primary function.

1.7.2 KEY ACRONYMS AND ABBREVATIONS

AC	Alternating Current
AEMS	Aggregated Energy Management System
BACnet	Building Automation and Control Network
BMS	Battery Management System / Building Management System
CPU	Central Processing Unit
CUE	Carbon Usage Effectiveness
DC	Data Centre or Direct Current
DCIM	Data Centre Infrastructure Management
DSO	Distribution System Operator
EC	European Commission
EPA	Environmental Protection Agency
EV	Electric Vehicle
ESD	Electro Static Discharge
GHG	Greenhouse Gas
HVAC	Heating, Ventilation and Air Conditioning
ICT	Information and Communication Technology
IPR	Intellectual Property Rights
ICT	Information and Communication Technology
KPI	Key Performance Indicator
LEED	Leadership in Energy and Environmental Design
NOC	Network Operating Centre
OPC	Object Linking and Embedding for Process Control
PDU	Power Distribution Unit
PUE	Power Usage Effectiveness
PV	Photovoltaic
SEMS	Smart Energy Management System
SLA	Service Level Agreement
SME	Small or Medium size Enterprise
SNMP	Simple Network Management Protocol
TCP/IP	Transfer Control Protocol / Internet Protocol
TSO	Transmission System Operator
UDC	Urban Data Centre
UPS	Uninterruptible Power Supply
VM	Virtual Machine
VRLA	Valve Regulated Lead Acid (battery)
WP	Work Package
WUE	Water Usage Effectiveness

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1.9 DOCUMENT OVERVIEW

This document is organized in three main parts: firstly a general definition of the Urban Data Centre is provided, and the main indicators used to measure the performances of these structures. A description of Data Centres and their relations to other types and its surroundings is presented in Chapter 2. Chapter 3 zooms in on the specific Urban DC definition (as used in the GreenDataNet project) and its relevant items. In this chapter also a definition of two sizes of Urban DCs is presented.

2. DATA CENTRE DESCRIPTION

2.1 DATA CENTRES PERSPECTIVE

Data centres have become an important factor in the ICT infrastructure. It's the place where the computing, storage and communication of data takes place. The data centre is there to facilitate these ICT functions. Over years a very large variety of data centres have emerged, and are still being developed. The total data centre market can be categorized from different points of view. Some examples are given in the table below.

Qty of racks	Few - Thousands
ICT-Area	Small – Medium - Large
Power	Small – Medium - Large
Business	Hosting – Colocation - Enterprise
User	Single tenant - Multi tenant
Life cycle phase	Green field - Brown field - Refurbishment
Operation	Lights out - 365/24 personnel
Equipment	Telecom equipment - Server equipment
Levels Availability	Low . . . High
Levels Security	Low . . . High
Levels Efficiency	Low . . . High
Location	Rural Industrial Urban
Etc.	

Table 2-1 Examples for categorising data centres

Specific data centres will always fall in multiple categories. Furthermore, these categories will (should) also determine the way in which a data centre is designed, built and operated. Generally the category can be based on physical aspects, the business purpose or the technical and organisational set-up. Geographical location, life-cycle status or various levels of availability, security or efficiency, are other means to typecast or identify various data centres. So there is a wide diversity, varying from the very small, technical simple and usually hardly managed basic data centre locations towards the large, complex and fully managed data centres.

It is important to be aware that several of these items may seem related but are basically uncorrelated as is shown in the following figure. A data centre that has a high level of availability can have a low level of energy efficiency (sustainability) or vice versa. A similar situation is valid for the security level.

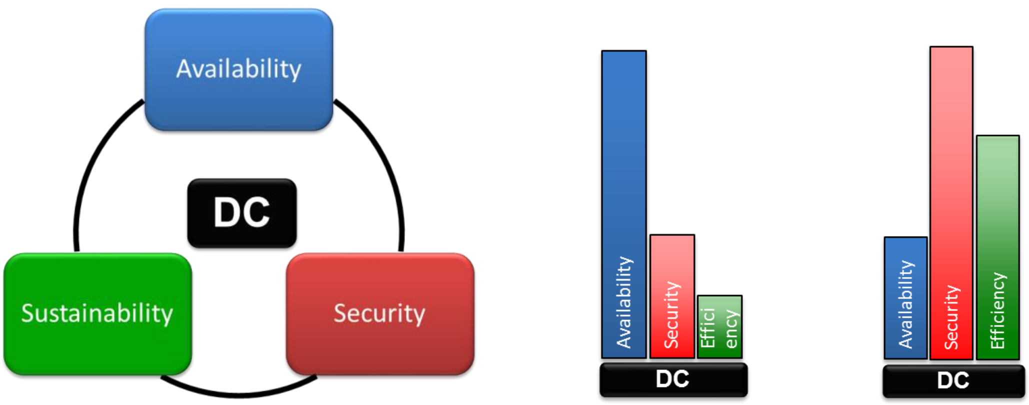

*Figure 2-1 General over-all but un-correlated entities of data centres (left),
Examples of various ratings of these entities for different data centres. (Source: ICTroom)*

In the design of the facility infrastructure and the ICT area, two major scaling factors can be distinguished. The most commonly and widely used data centre size indicators are raised floor size (sqm or sqft) and maximum ICT power capacity (kW) [18][19][23]. In relation to sustainability, more specific energy efficiency, the most common used indicator is currently Power Usage Effectiveness (PUE).

There is a large number of regional, smaller and medium-sized data centres located close to the end-users, in urban areas. These smaller data centres are outnumbering the larger data centres [38] and while they are hardly optimised, offer a feasible potential for more efficient usage. The GreenDataNet project focusses on smart energy management in these Urban DCs. This will be enabled at three levels: server and rack level, data centre level and network of distributed data centres level.

2.2 USER CHARACTERISTIC

Various types of data centres can be distinguished by their general user characteristics:

- Public cloud providers (Amazon, Google)
- Scientific computing centre (universities or national laboratories)
- Large corporate, government, hospitals or banking data centres
- Co-location centre
- In-house data centre (facilities owned and operated by organisations using their servers)

Next to these general typecasting, user characteristics also dependent on:

- ICT load during the day – The peak use and spread during the day can differ per user)
- Mix of ICT equipment type used (servers vs. storage vs. network vs. telecom equipment)
- Mix of ICT equipment age (modern equipment or legacy equipment)
- Mix of Users (single tenant or multi-tenant use)
- Mix of facility systems (cooling system, UPS)

A third dimension is related to the various supply elements:

- Renewable energy types (from utility supplier, PV, wind, hydro, etc.)
- Water sources (from utility supplier, open water, reused water, etc.)
- Energy storage types (aquifer, battery, etc.)

Based on a matrix of above characteristics, users profiles can be described which generate different profiles. By pairing complementary profiles (e.g. combination of a day and a night user), useful combinations might be found resulting in more energy efficient operation. Next to this, user profiles can be used to synchronise (renewable) energy supply with demand (e.g. day user and PV power supply).

2.3 DATA CENTRES FUNCTION

A basic question to ask oneself is why a data centre is needed in the first place ? If one could start from scratch, one would only need a power source to run computers, storage and connectivity to share or send data on networks. In essence this could be in the outside environment, so no need for a data centre. However, to ensure protection against environmental impacts and outside threats, a roof and walls (a building) are constructed, resulting in the data centre as such. The roof and walls will protect the ICT equipment, but at the same time also create an internal climate, as indicated in Figure 2-2. To ensure an adequate and continuous data centre climate, active environmental control is needed. Additional items like security and facility management are needed as well.

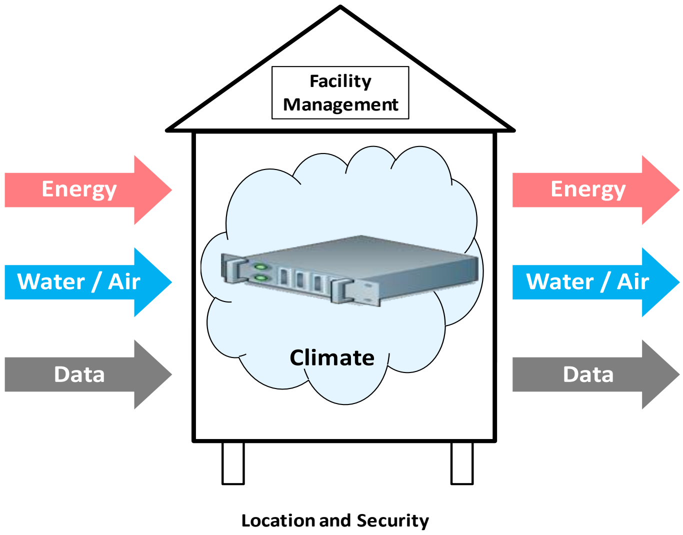

Figure 2-2 Protection of the ICT, network, and storage equipment creates the need for data centres. (Source:NPR5313)

2.4 ENVIRONMENTAL CONDITIONS

Environmental condition levels within datacentres have been described and advised by organisations like ASHRAE [3] and ETSI [12]. These publications describe conditions at the front of the ICT equipment, inside the cool alley, using cool and warm alley set-up of the racks. This in contrary to the earlier days when racks were not yet set up in this way and the condition was more or less uniform for the whole data centre area.

The publications have resulted in a recommended operating range in the data centre at the front of the ICT equipment.

However there is a tendency to allow higher temperatures and wider humidification ranges in the data centre as this will be beneficial to the energy efficiency [20][21]. Allowing higher temperatures in the data centre at the front of the ICT equipment results in higher return temperatures in the cooling systems. This allows to extend the use of free cooling capabilities.

This trend of higher temperatures thrives on three main developments [22]:

1. ICT equipment is increasingly capable of operating at higher temperatures.
2. ASHRAE has published [3] wider operating envelopes, resulting in extended allowable ranges (A1 - A4).
3. Data centre end users are more willing to accept the higher temperatures ranges and adjusting SLA's accordingly.

Some remarks:

<u>Ad 1</u>

- Not all ICT equipment is currently capable (yet) of handling these high temperatures. This is especially the case for retro-fit situations and/or when legacy equipment is present.

- Equipment with hard drives and tape drives usually require lower temperatures.
- Sometimes the UPS and batteries are also positioned in the ICT area of (smaller) data centres. Special care is needed for the temperature of the UPS batteries, as lifetime for standard VRLA batteries is decreased dramatically at higher temperatures (> 25°C).
- The benefits of energy saving by raising the temperature shouldn't be counteracted by an energy increase of the ICT equipment due to increased fan speeds. This depends on the specific ICT equipment that is used.
- Allowing higher temperatures reduces the 'spare' temperature range before a critical value is reached.

Ad 2

- For the allowable ranges extra precautions are valid, for example ESD implementation.

Ad 3

- The acceptance is still a slow process; currently Data Centre managers are making first steps to increase the temperatures from 20 to 24 degrees. The market is traditional and reluctant to make large or uncertain steps.
- Higher temperatures will have an impact on the acceptable human working conditions.
- The possibilities to adjust SLA's to the higher temperatures are sometimes limited due to long term contracts of SLA's, various clients (with various requirements) and competition. As a suggestion the SLAs should provide in the allowance of a higher temperature for short periods of time.

In the following psychometric chart the recommended and allowable environmental classes for data centres are presented, as defined by ASHRAE (2011) [3].

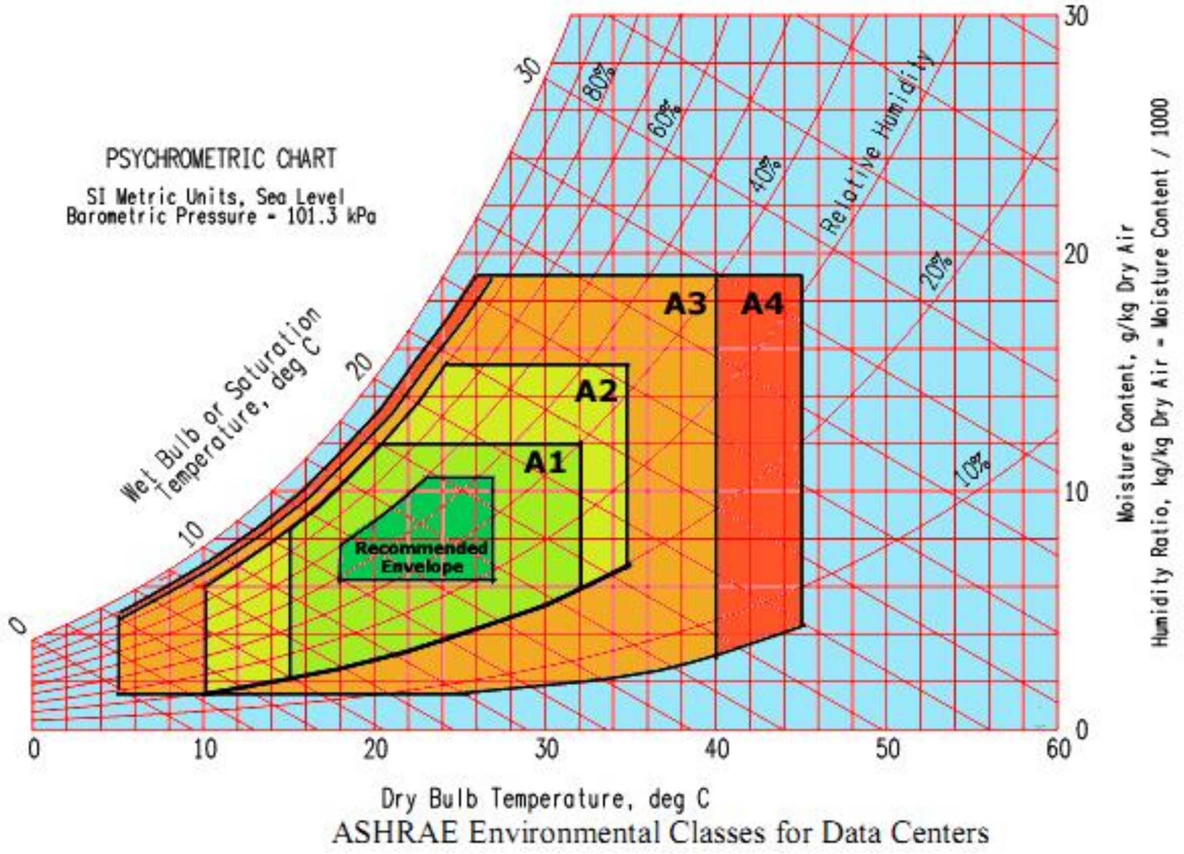

Figure 2-3 Environmental classes for data centres as defined by ASHRAE, 2011 (source: ASHRAE)

The specific ranges above, for both the recommended and the allowable climate ranges, are specified in the table below.

Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (˚C) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (˚C)	Maximum Elevation (m)	Maximum Rate of Change(˚C/hr) (f)	Dry-Bulb Temperature (˚C)	Relative Humidity (%)	Maximum Dew Point (˚C)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	18 to 27	5.5ºC DP to 60% RH and 15ºC DP						
Allowable								
A1	15 to 32	20% to 80% RH	17	3050	5/20	5 to 45	8 to 80	27
A2	10 to 35	20% to 80% RH	21	3050	5/20	5 to 45	8 to 80	27
A3	5 to 40	-12˚C DP & 8% RH to 85% RH	24	3050	5/20	5 to 45	8 to 85	27
A4	5 to 45	-12˚C DP & 8% RH to 90% RH	24	3050	5/20	5 to 45	8 to 90	27

Table 2-2 ASHRAE 2011 Equipment Environmental Specifications, for both Recommended and Allowable ranges. (source: ASHRAE)

2.5 DATA CENTRE INTERFACES

When looking at the energies in relation to the data centre it is a good start to consider the data centre being a black box, as shown in Figure 2-4. There is energy coming in, this is usually electricity but can also be other means of energy, for instance fuel (for the generator), cooling water or air, sunlight, or other means of energy. The energy can be stored in the data centre or underneath it (for instance aquifers in the ground), but will eventually coming out in the form of heat and ICT performance.

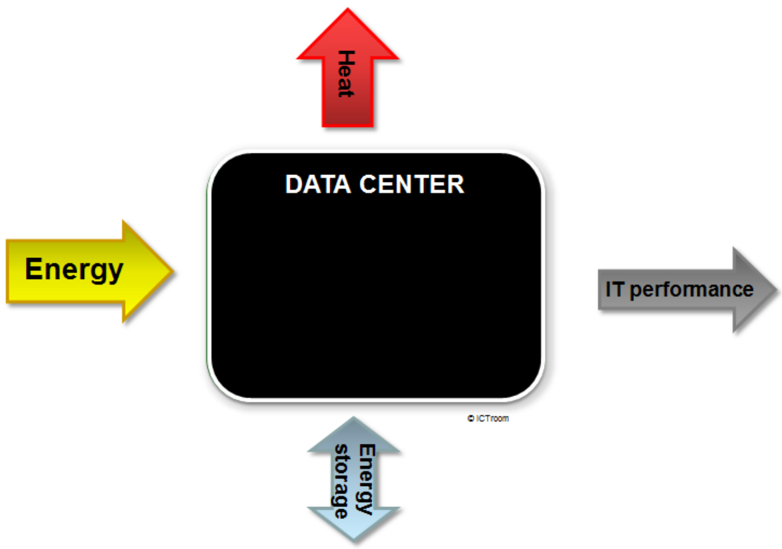

Figure 2-4 Basic Black Box Energy model for a data centre (Source: ICTroom)

Zooming in into the data centre black box we can distinguish the ICT load and the various facility installations needed to let the ICT load function. Also the software running on the ICT equipment can be considered part of the system. In Figure 2-5 some examples are indicated to provide a greener system, and where and how energy efficiency and effectiveness can be achieved. This diagram presents a clear view of the data centre system and helps to clearly pinpoint and distinguish the items that can be improved. Note that there are more possibilities that are given as examples in the figure).

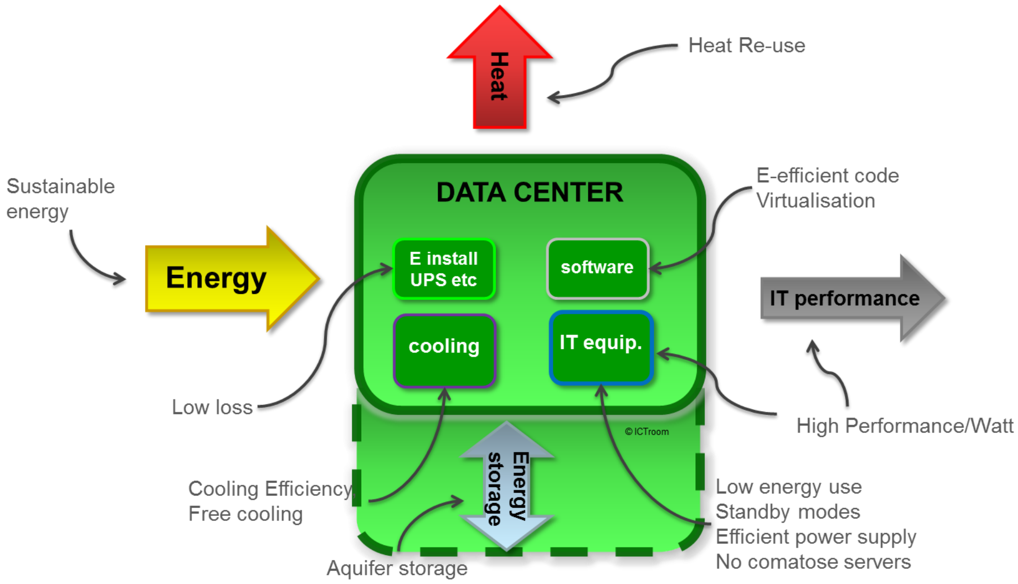

Figure 2-5 Energy model for a data centre indicating examples of sustainable and energy optimisations (Source: ICTroom)

A common energy efficiency performance indicator, Power Usage Effectiveness (PUE), although currently wide spread and easy to use, only touches part of the energy flows in the data centre system. This is clearly shown In Figure 2-6. It is obvious that other performance indicators are also needed, as is also part of the FP7 call.

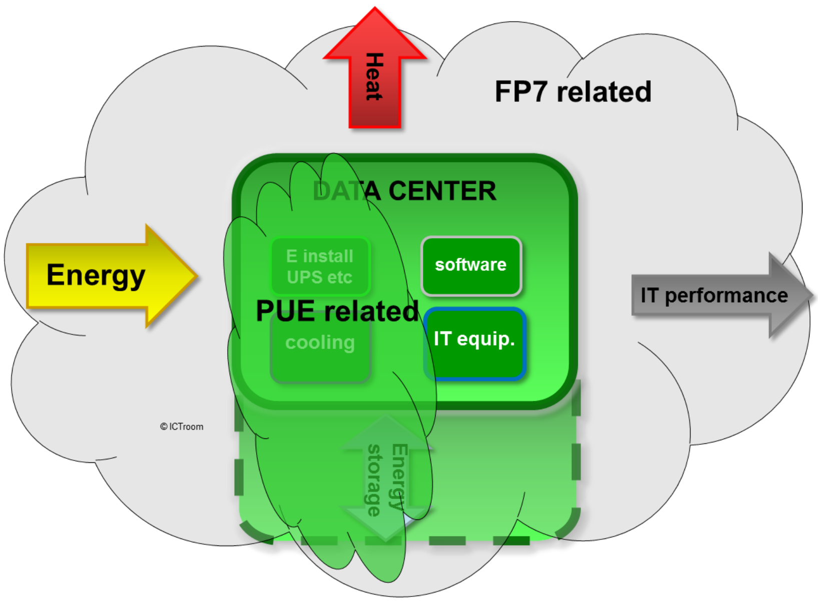

Figure 2-6 Energy model for a data centre indicating the covering of key performance indicator PUE as well as the coverage of the FP7 ICT call. (Source: ICTroom)

2.6 KEY PERFORMANCE INDICATORS

As mentioned, the current most commonly used KPI is PUE [8] [9] [10]. However items like renewable energies and heat re-use are not implemented in this indicator. Therefore other KPIs are necessary [2]. In the document as developed by the Smart City Cluster Collaboration group ("Identify existing metrics and methodologies") [17], an extensive inventory of available KPIs for data centres is documented as listed below.

No	KPI	No	KPI
1	Power Usage Effectiveness (PUE)	41	Green Energy Coefficient (GEC)
2	Corporate Average Data Centre Efficiency (CADE)	42	Energy Reuse Factor (ERF)
3	Data Centre Infrastructure Efficiency (DCIE)	43	Energy Reuse Effectiveness (ERE)
4	Compute Power Efficiency (CPE)	44	Carbon Emission Factor (CEF)
5	Data Centre Energy Productivity (DCeP)	45	Carbon Intensity per Unit of Data (CIUD)
6	Data Centre Utilisation (DCU)	46	Green Power Usage Effectiveness (GPUE)
7	Server Compute Efficiency (ScE)	47	Return of Green Investment (RoGI)
8	Data Centre Compute Efficiency (DCcE)	48	Total Cost of Ownership (TCO)
9	Coefficient of Performance of the Ensemble (COP)	49	Carbon Credit
10	Energy Efficient Ratio (EER)	50	PAR4 *
11	Seasonal Energy Efficient Ratio (SEER)	51	Building Heat Loss
12	Imbalance of Racks Temperature	52	Weighted energy Balance in Data Centres
13	Data Centre Power Density (DCPD)	53	Global KPI of Energy Efficiency
14	Data Centre Density (DCD)	54	Data Centre Performance per Energy (DPPE)
15	Space, Watts, and Performance *	55	Load match and Grid Interaction indicators
16	Useful work *	56	ICT- power usage effectiveness (ICTUE)
17	Data Centre Productivity	57	Total power usage effectiveness (TUE)
18	Transactions per second per Watt (TPS/Watt)	58	Data Centre Fixed to Variable Energy Ratio (DC FVER)
19	Deployed Hardware Utilization Ratio (DH-UR)	59	Partial Power Usage Effectiveness (pPUE)
20	Deployed Hardware Utilization Efficiency (DH-UE)	60	ICT Equipment Energy Utilization (ICTEU)
21	Site Infrastructure Power Overhead Multiplier (SI-POM)	61	ICT Equipment Energy Efficiency (ICTEE)
22	ICT Hardware Power Overhead Multiplier (H-POM)	62	Green Energy Coefficient (GEC)
23	Server Utilization / Hardware Utilization / Network Utilization	63	Energy Consumption KPI (KPIEC)
24	Relative Humidity Difference (RHD)	64	Task Efficiency KPI (KPICTE)
25	HVAC Effectiveness	65	Energy Reuse KPI (KPIREUSE)
26	Rack Cooling Index (RCI)	66	Renewable Energy KPI (KPIREN)
27	Data Centre Cooling System Efficiency (CSE)	67	Global Synthetic KPI (KPIGP)
28	Air Economizer Utilization (AEU)	68	Data Centre Maturity Model (DCMM)
29	Water Economizer Utilization (WEU)	69	Code of Conduct *
30	Airflow Efficiency (AE)	70	Return Temperature Index (RTI)
31	Air management flow indicators	71	Physical Server Reduction Ratio (PSRR)
32	Cooling System Sizing (CSS)	72	Data Centre Measurement, Calculation and Evaluation Methodology (DOLFIN Project) *
33	Total harmonic distortion (THD)*		
34	UPS Load Factor		
35	UPS System Efficiency		
36	UPS Usage		
37	Lighting Density*		
38	Carbon Usage Effectiveness (CUE)		
39	Carbon Emissions Balance		
40	Water Usage Effectiveness (WUE)		

*) These are not explicit data centre indicators

Table 2-3 Inventory of the unworkable number of data centre related KPIs currently available, as accumulated by the Smart City Cluster Collaboration group.

It is clear that the quantity of KPIs as presented above needs to be reduced as this is not a workable situation. Standardisation is needed [1] [4] [8], too many KPIs will impede widely accepted usage of uniform and unambiguous KPIs. Additionally it is important to realise that it takes time for people to adapt and correctly interpret new (values for) KPIs.

A global joint technical commission has been formed (Committee ISO-IEC JTC1 SC 39) which is currently working on a smaller and more focused list of KPIs. The current proposed list (still under development) is given below. It shows a relevant framework in which development of global standardized Data Centre KPIs will take place.

No	KPI description	KPI
1	Power Usage Effectiveness	**PUE**
2	Partial Power Usage Effectiveness	**pPUE**
3	Energy Reuse Effectiveness	**ERE**
4	Renewable Energy Factor	**REF**
5	Cooling Efficiency Ratio / Cooling Performance Ratio	**CER** **CPR**
6	ICT Equipment Energy Utilization	**ICTEU**
7	ICT Equipment Energy Efficiency	**ICTEE**
8	Carbon Usage Effectiveness	**CUE**
9	Water Usage Effectiveness	**WUE**
10	Economic KPI’s	t.b.d.

Table 2-4 Inventory of largely reduced number of data centre related KPIs as is currently being developed (under construction) by the ISO-IEC JTC1 SC 39 committee.

3. URBAN DATA CENTRE SPECIFICATION

3.1 URBAN DATA CENTRE FOCUS

Large data centres such as the ones from Google or Facebook have recently made the headlines claiming they will use a significant share of renewable power due to their particular locations [40][41]. While these data centres can be useful catalysts for technical progress, they have less relevance for the myriad of small and medium-size Urban DCs that provide for a significant share of ICT needs across Europe. The illustration below shows the DC electrical consumption by market segment in U.S., even if it is not possible to mirror the information concerning the U.S. market with the European one, it is still possible to affirm that DC market in western countries is not so different. According to the electricity consumption split it is evident that the Small and Medium Data Centres are the market segments that consume the biggest amount of the total DC power.

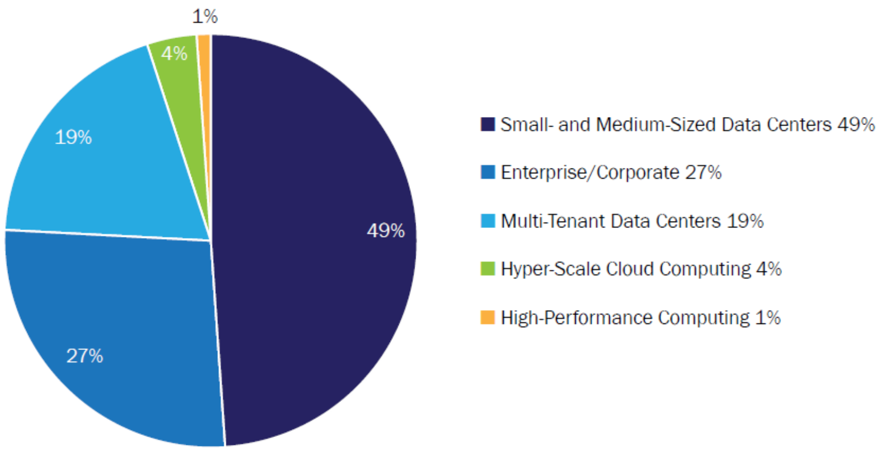

Figure 3-1 Estimated U.S. Data Centre electricity consumption by market segment in 2011[15]

These types of Data Centres are mainly located in the urban environment, therefore it make sense for

GreenDataNet project to focus on Urban DCs located in or close to urban areas. Market analysis has shown that the DC implantation in big cities such as London or Amsterdam is continuously increasing despite the crisis, this is mainly due to the strong corporate presence in the European Capitals and the high quality of the network services offered [33]. Moreover there are some additional reasons to clarify why the Urban DCs are taken as starting point for more sustainable data centres [Annex 1] :

- In general there is less focus on energy efficiency and sustainability
- Monitoring and optimal operation is usually not implemented or not very well
- Located close to potential heat users, so re-use of energy is better feasible
- Less complex, better predictable in relation to energy characteristics
- As less power is consumed, it is easier to use or implement renewable energy sources
- Feasible pilots are available for optimised energy management

There are also some direct drawbacks to mention:

- Due to their scale fewer opportunities for large (and more efficient) facility installations
- Due to their smaller site areas, large PV plants are harder to realise

Very limited data of small data centres is publically available [26]. This might be due to the fact that DC operators of small DCs (if even available) are not taking part in surveys or discussion groups nor are they publishing a lot of information or research data.

3.2 FUNCTIONAL SPECIFICATION

3.2.1 DATA CENTRE OVER-ALL CATEGORIES

When specifying a data centre three main over-all categories can be defined[24]:

Availability

The availability of the data centre is usually expressed in availability tier levels. The Uptime Institutes' Tiers I to Tier IV [5] are the most common rating, with Tier IV representing the highest availability (Uptime Tier topology). It represents a certain level of reliability of the facility infrastructure, of which power and cooling are the most important and direct items. Other well-known availability levels are presented by for instance BICSI [19] and TIA.

Efficiency

The efficiency of the data centre is another category, which in principle is independent of the other two main categories. Currently various efficiency performance indicators are available and are still being developed. The PUE [8] [9] [10] [11], which was presented in paragraph 2.5, only covers part of the efficiency but is currently the most widely used indicator. New standardisation of other indicators is currently on-going [4] [8].

One of the focus items for energy efficiency in Data Centre is cooling as this is usually the major energy user (next to the ICT load itself) [6]. When reaching higher cooling efficiency values, the efficiency of the UPS is the next major contributor. Another focus should be the efficiency of the power supplies of the ICT equipment (although this doesn't show in the PUE).

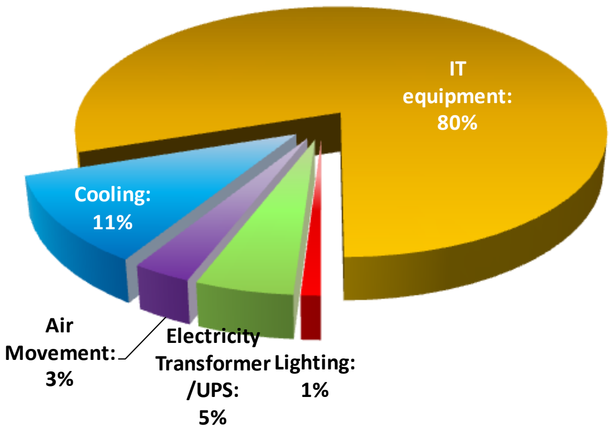

Figure 3-2 Typical pie diagram of annual average energy distribution in a DC at PUE = 1,25. (Source: ICTroom)

It is important to realise that the PUE is an average, annual figure. While the total average annual power of the data centre can be found by multiplying the ICT load by the PUE value, the actual peak power of the data centre can be higher. Due to variations in day-to-day, as well as seasonal related, power usage for cooling and other non-it related energy consumption, the fluctuation of power consumption can be up to +30% to +50% more than the average result of ICT Power *PUE (or even more, depending on the cooling system) see. Fig 3.6

Security

The third independent category is the security of the data centre which is expressed in a variety of standard levels, some standardised, others based on local regulations. The security categories will not be part of this project.

Other

Additional categories can be distinguished, like Scalability, Modularity, and Operational Excellence, but these are not referred to with regards to this project.

3.2.2 DATA CENTRE SIZING PARAMETERS

The process of Data Centre sizing begins with an assessment of the current compute needs of the business, and a comprehensive evaluation of the future business requirement.

Sizing and resilience levels have a strong bearing on the overall build costs, so careful consideration is taken with regard to the current business constraints and the potential impact of under investing on initial build.

In order to design a Data Centre that will be capable of supporting both the current and future requirements, there are some principles to take into account.

Firstly, environmentally controlled estate is expensive [35]: an expansion of physical space can be more expensive than the original build, meanwhile, providing empty floor space may not fit with current budget allocated for DC. For these reasons it becomes evident that the DC design must be focused on space optimization.

In addition, Data Centre must be reliable by definition, which means that it has to have a well maintained and orchestrated ICT Infrastructure. The amount of local storage and network equipment required influences directly the considerations on the amount of space and the number of containing structures (racks) necessary to support the business need. (up to +50%)

To conclude, one constraint that cannot be neglected is the power. As said in paragraph 3.1.1, the total power consumption of a DC comprehends not only the IT power requirements, but also the facility related facility power needs, of whom the cooling represents the greatest part. When specifying the power needs of an ICT room, it is worth to start from the ICT power requirement and add the cooling power that this IT load would need [36]. Depending on the resilience up to twice (n+2) the infrastructure needs to be installed of what can be actually used.

Starting from those considerations it is possible to affirm that when specifying the size of data centres four main parameters are generally practised [23][37]: ICT power, ICT area, ICT connectivity and quantity of racks:

- Total Power (kW) – The maximum required ICT and facility power (max peak).
  Oversizing is required: the used power is in kW, but and the loading of the circuit is in kVA.
- ICT Area (m^2) – The net required data centre floor area.
  Items like service areas, columns and traffic corridors will influence the space that is available for racks.
- ICT Connectivity – The proximity of the Data Centre proposed location to multiple reliable fibre network routes is a must for network intensive data centres

- Quantity of Racks – The size of a rack (600x600 mm up to 1200x800 mm) influences the footprint and thereby the maximum number of racks which can be placed.

The sizing parameters are interlinked with each other: the maximum quantity of racks depends on the available ICT area and a desired average power per rack results in other links. The representation in 3 makes the triangle relations clear.

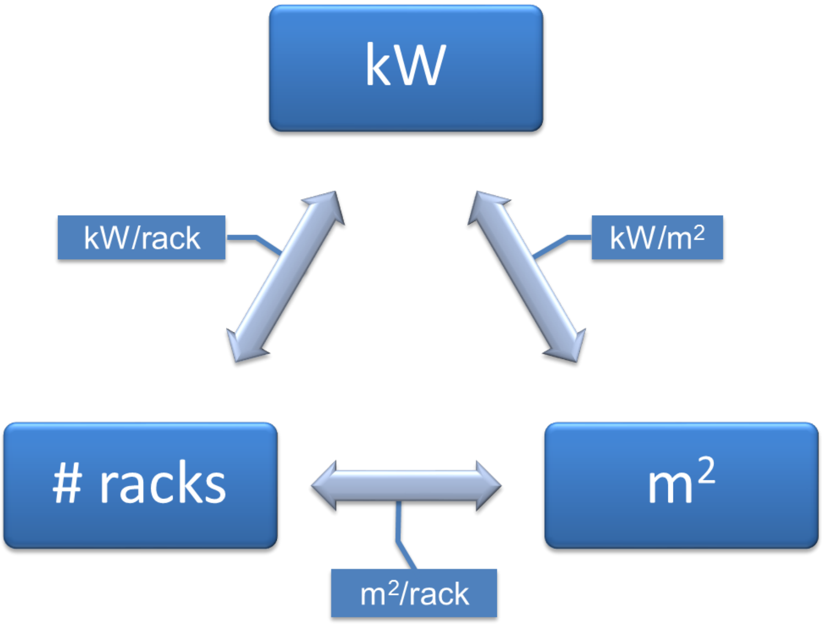

Figure 3-3 Overview and relations of main sizing parameters of a data centre (Source: ICTroom)

To indicate the physical density of a data centre, floor area and quantity of racks are interlinked by the amount of m^2/rack value. This value depends on the actual footprint size of the rack, the density of placements of racks in the datacentre and the "lost" space by traffic & non-utilized space. A typical value is 2,2 to 2,5 m^2/rack in an optimised location.

Analogue to this, the power density of a data centre can also be written as power per ICT area (kW/m^2). Average power densities vary, but typical averages range from 0,5 to 2,5 kW/m^2.

The third relation is between quantity of racks and available ICT power (kW/rack), thus completing the triangle relations). Typical values vary quite a lot but indication ranges are from 2,5 kVA to 10 kVA/rack. Higher values up to 20 or 30 kVA/rack are encountered, but not very common with respect to average power consumption per rack.

Those assumptions are supported by readings performed using the PMSM system developed in task 2.1 by EPFL and Credit Suisse in one of the demonstrator sites of the project. The average reading was of 2.7 kVA/rack, the peak readings up to 18kVA on selected few racks. [34].

The three relations produce an interlinked triangle model in which two relations define the third.

3.2.3 DATA CENTRE LEVELS

GreenDataNet will enable energy monitoring and optimisation of ICT, power, cooling and storage at three levels:

1. Servers and racks;

2. Individual Data Centres;
3. Networks of Data Centres.

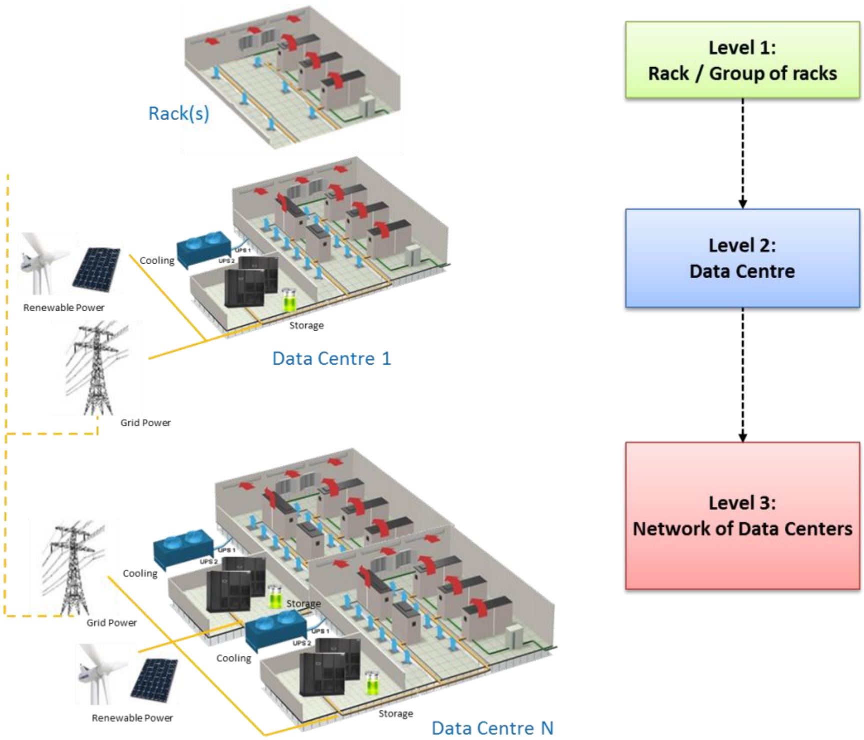

Figure 3-4 Enabling smart energy management at three levels (Source: GreenDataNet)

Level 1

If you start with the smallest energy user, a server or processing unit can be seen as the smallest basic module. Within a rack (or group of racks), several servers can be seen as a cluster of computing or processing power, dedicated to a specific task. In this case, we consider this level 1 of our subdivision. A task in this level could be i.e. the support of a law firm's office network, the provision of the computing power of a bitcoin network or the hosting of a variety of services of a third party service provider.

Energy management at level 1 operation could mean reducing the available processing power induced by lower demand during off-office hours or re-scheduling specific computing tasks to more low cost periods.

Typical for level 1 type of energy management capabilities are the opportunities to optimise towards better suited processing periods or more evenly balanced maximum processing power. An accurate estimation of the expected ICT loads is key in this optimisation.

Level 2

The next level consists of multiple level 1 racks or group of racks within a data centre. The applicable energy management here is determined by interaction of the individual level 1 modules. Within the datacentre, tasks could be moved or rescheduled to optimise the load.

Additionally the energy management is determined by the type of connection to the power grid. If applicable, a supply-demand interaction with the grid allows the power network operator (Distribution System Operator, DSO) to use generator power from the datacentre to balance the energy distributed within the power grid system.

Finally, on the supply side, prediction and monitoring of availability of renewable power (e.g. solar, wind) completes the energy management system.

Level 3

When considering multiple data centres, the next level of energy management could be applied, as this can shift tasks from one data centre to another. Theoretically, processing tasks can be completed at the best suited location at that moment (follow-the-moon or, in this case of solar energy, follow-the-sun principle). It is important to realize that also the shift of tasks requires energy as data has to be transported (reallocated) between locations. Level 3 energy management implies at least a basic implementation of Level 2 and Level 1 energy management in the system.

Energy Management

Translating the black box model as presented in Figure 2-4 Basic Black Box Energy model for a data centre (paragraph 2.5) to an energy model at DC level results in Figure 3-7 below.

On the supply side, there is grid power, renewable power (solar, wind, etc.), non-renewable power (i.e. genset) or stored power. These elements are the actual power sources.

On the demand side the power load is determined by the ICT load. The amount of ICT load translates into the required power for the ICT related processing components (servers, network, and storage)[11][39].

The figure 3-5 below shows the split between the ICT and cooling electrical power consumption of one of the site in which the PMSM system, developed in Task 2.1 of the project, has been installed.

Analysing the yearly trend of the PUE in figure 3-6 it is possible to see that the seasonal variation of the cooling requirement is responsible for the large variations of the monthly PUE of +8,5% and -9,7% , compared to the yearly average value of 1.57[23][36]

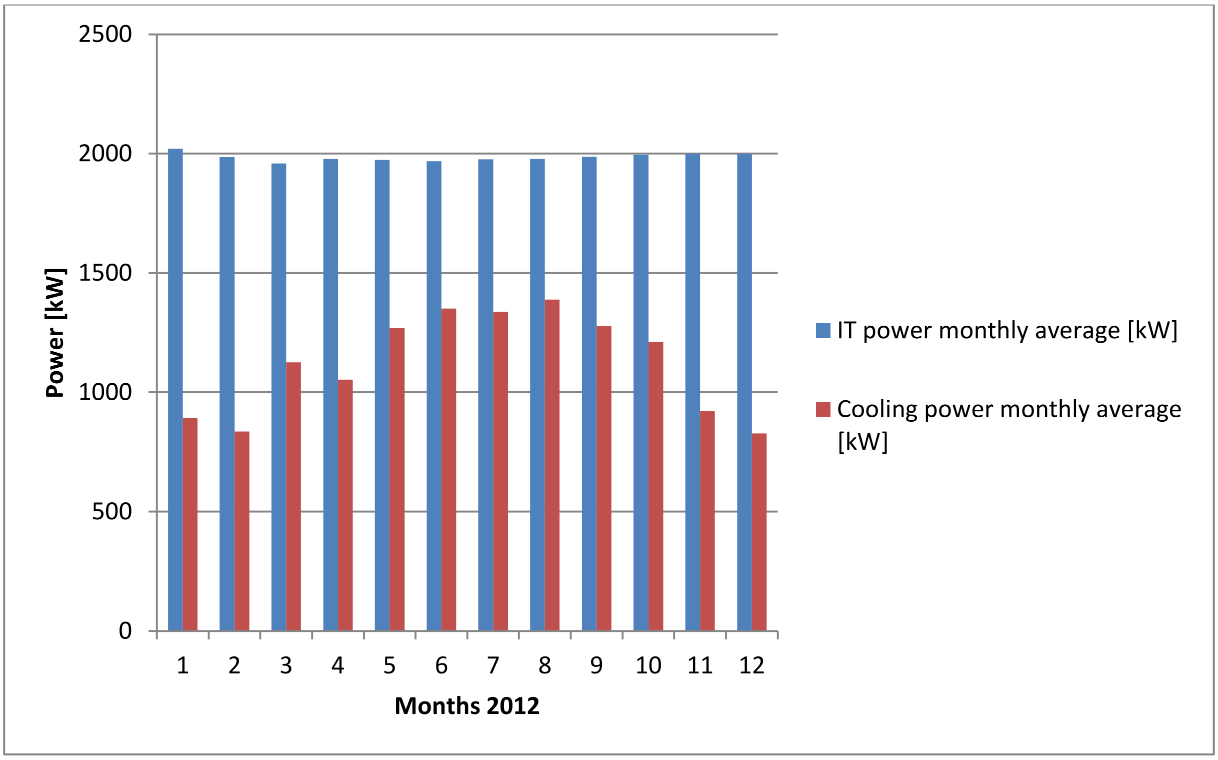

Figure 3-5 ICT and Cooling monthly average load (Source: PMSM, Credit Suisse)[34]

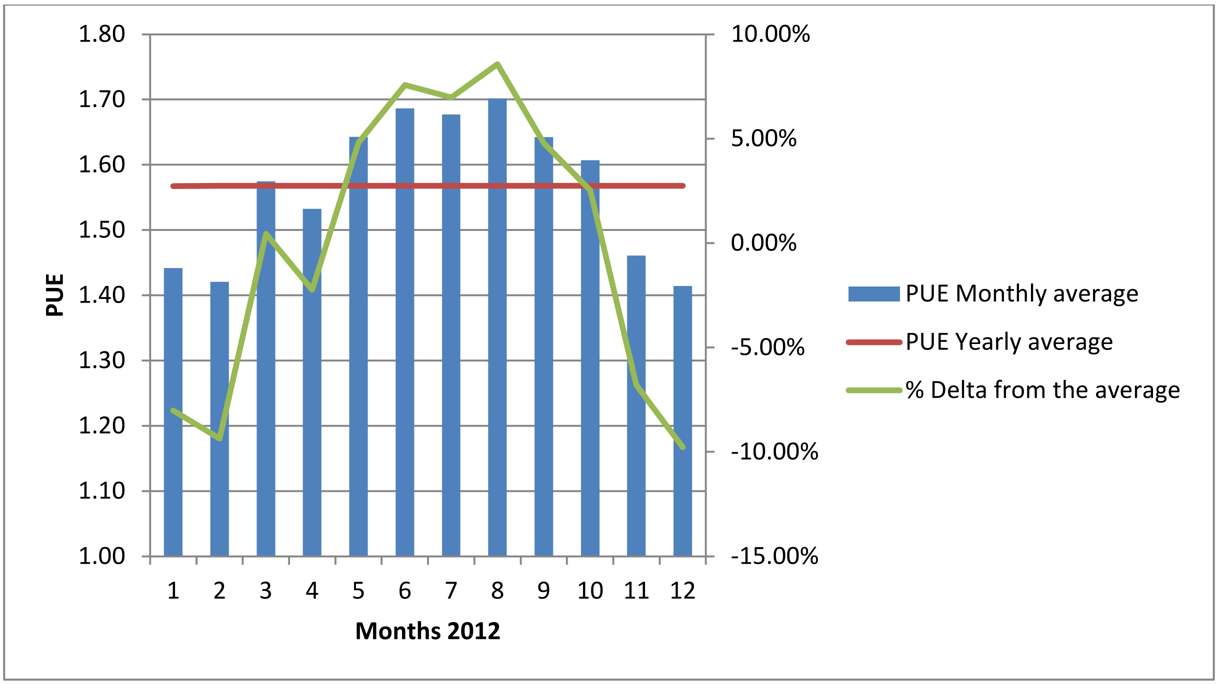

Figure 3-6 Monthly and Yearly PUE of one demonstrator (Source: PMSM, Credit Suisse)[34]

A Smart Energy Management Tool is linked to all elements in this model, and thus capable of collecting all data needed for the Smart Energy Management System (SEMS).

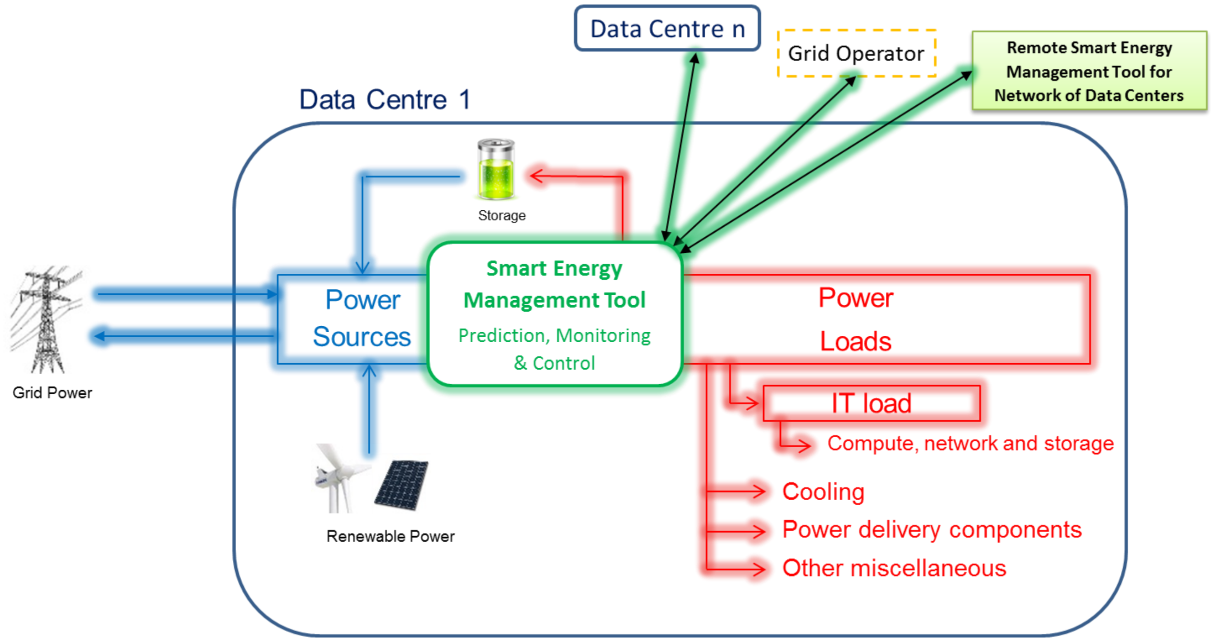

Figure 3-7 GreenDataNet Energy Model at DC level (Source: GreenDataNet/ICTroom)

The role of the Smart Energy Management System (SEMS) within a data centre is to supply the required ICT load by predicting, monitoring and controlling the available power sources in the most efficient way.

On the next aggregation level, the SEMS will act as a Smart Grid node to further optimise energy efficiency between DCs.

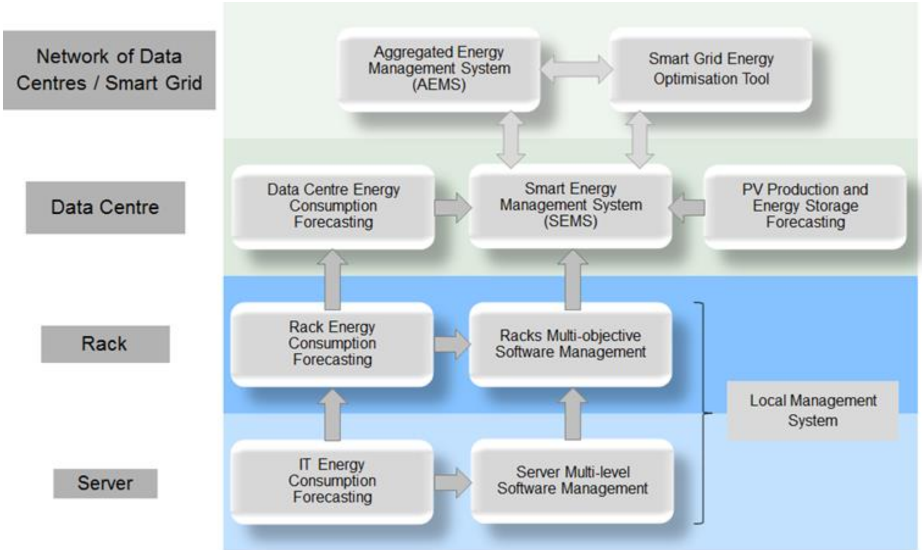

Figure 3-8 GreenDataNet Energy Management architecture (Source: GreenDataNet)

3.2.4 DATA CENTRE LIFE CYCLE

Green Field

The data centre can be categorised by life cycle status. A new data centre (green field) has the advantage that it isn't built yet, so new features can easily be adapted to requirements. Also, a new data centre can be designed from scratch to support maximum energy saving components, systems and tools. A new green field data centre can either be constructed from scratch in a new constructed building or be located in an existing building.

As more energy efficient server systems appear on the market every year, a new data centre has optimal possibilities to implement the latest energy efficiency technologies. Not only at facility level but also at the ICT level; the systems can be matched to maximise state-of-the-art energy saving solutions. For instance using ICT equipment that cope with high air inlet temperatures allows for the use of high cooling water temperatures. This will result in longer periods of free cooling and thus better efficiency.

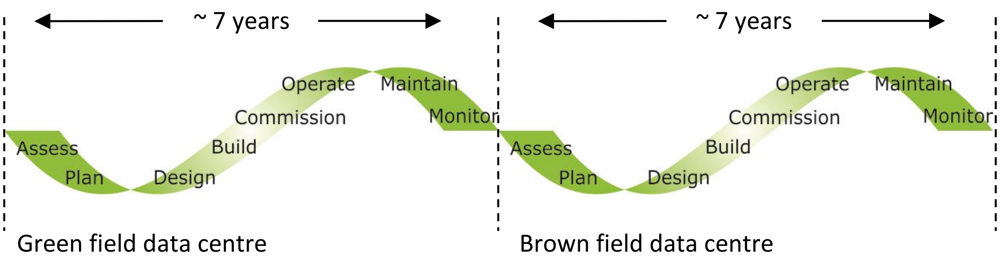

Figure 3-9 View of data centre Life Cycle (Source: ICTroom)

Brown Field

An existing facility is typically in operation between 5 and 10 years (see Figure 3-9). After this period an upgrade or retrofit (brown field data centre) is normally applicable, due to normal wear and tear of systems and end of (technical or economical) life of facility systems.

The moment of upgrade or retrofit provides the best opportunity to make large improvements in efficiency.

An important point of attention in brown field data centres is the fact that they are in 24/7 operation. They normally require expert retrofit implementation where no downtime is allowed.

3.2.5 DATA CENTRE LOCATION

The location of a data centre always has a basic link towards the local availability of power, network connectivity, and business use.

Another link is the geographical location of the data centre which can determine the energy sustainability and efficiency that can be accomplished. Items related to this geographical location are:

- Climate (see also Figure 3-10 indicating free cooling possibilities in Europe)
- Time zone (‘follow the moon’ (free cooling) or ‘follow the sun’ (PV power generation))
- Ground conditions (with respect to underground energy storage)

Finally there is a link to the surroundings of the location that can have an impact on the design of the data centre:

- Rural, industrial or urban area
- Environment (for instance availability of surface water)
- Nearby energy users or energy providers (offices, swimming pool, drinking water pipes)
- Air contamination (airports, seaside, industry)
- Possibilities for local power generation

It should be clear that not every energy efficient system is possible on any location. The GreenDataNet project focusses on the data centres in urban areas.

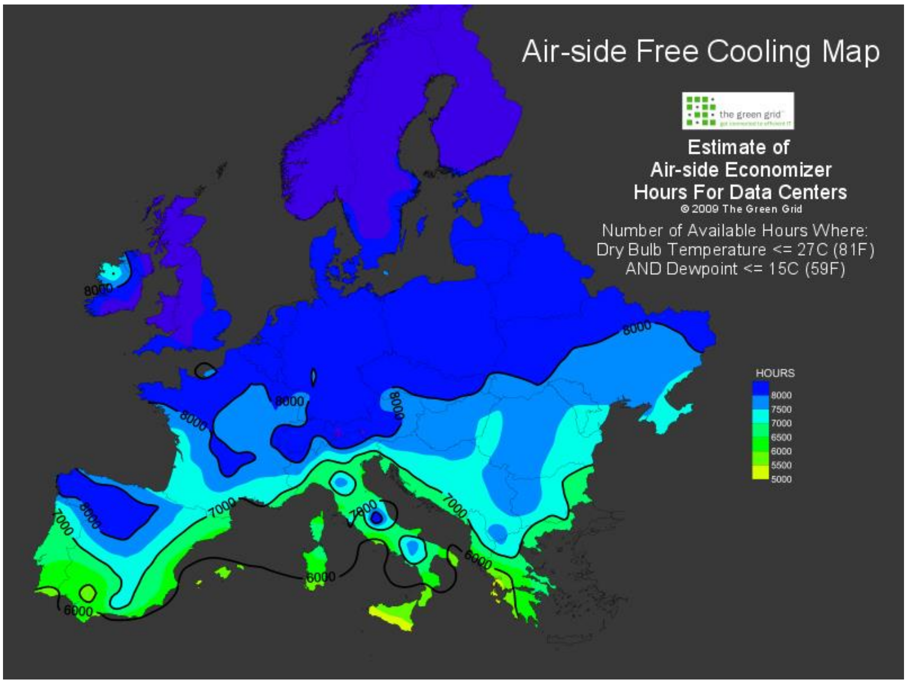

Figure 3-10 Map of Europe indicating free cooling possibilities by presenting hours/year with temperatures below 27°C. (Source: The Green Grid). Within the GreenDataNet a similar map is being developed for PhotoVoltaic power generation possibilities.

3.3 URBAN DATA CENTRE TYPE SPECIFICATION

3.3.1 URBAN DATA CENTRE TYPES

Within GreenDataNet two types of Urban DCs are presented, primarily based on size and type of cooling. As indicated in chapter 3.2.2 the size of a data centre (in kW, m2 or quantity of racks) is the major type indicator. In chapter 3.1 it has been explained that the small and medium Data Centres represent the most power consuming market segment, and that they are mainly located in an urban setting, for these reasons it is worth to focus on small sized DCs to reduce their environmental impact.

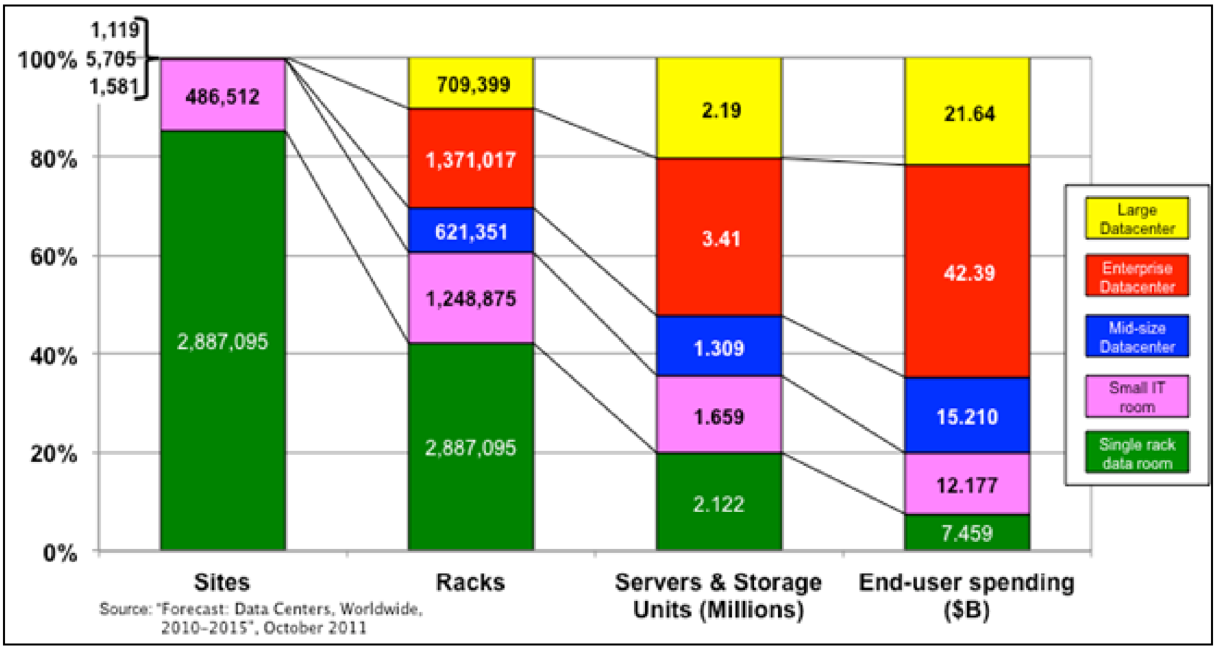

Figure 3-11 Market split according to criteria such as number of sites, number of racks, number of devices, cost of the DC. [38]

DC Type	Nb Rack/Site	Server&Storage Units/Site	Server & Storage Units/Rack	ICT Load(kW)/site (Rack load 2.5kW)
Large	634	1957	3	4893
Enterprise	240	598	2	1494
Mid-size	393	828	2	2070
Small ICT	3	3	1	9
Single rack	1	1	1	2

Table 3-1 Averages characteristics per DC type.

Exact information on DC sizing and especially Urban DC sizing is difficult to obtain as stated in a EU study [13], only few research projects depict mostly a national picture of smaller sized DC's [14] , or are US oriented [15]. This type of study towards the European Datacenter market is currently not available but could be very valuable as a solid basis for next steps.

In order to go beyond those limitations of information, the approach proposed in this document is based on the analysis of the power devices installed in the small and medium Data Centres, particularly the Uninterruptible Power Supply. As there is no detailed information directly related to the small/medium DC market, our assumption will be that the characteristics of the products available in the ICT channel fit the market needs. The offer for this specific market slice is composed by single phase UPSs with a nominal power varying from 500VA to 20kVA and three phase UPSs with a power rage from 10 kVA up to 500kVA [27][28][29][30]. The products considered have a market coverage of about 85% in Europe [31]. In our definition of the Urban Data Centre we take into account whether or not, dedicated cooling equipment is present. Basically, for very small data centres (less than 2 racks), the amount of cooling capacity is easily managed without any dedicated cooling equipment. Keeping this consideration in mind, the smallest range of nominal cooling power available in the market is 5kW [32]. A minimum of 2 racks, 5 kW or 6 m^2 is therefore used as criteria to define the smallest Urban DC. By deeply analysing the UPS offer, it is possible to affirm that according to the ICT load, a DC would be equipped with a single phase or a three phase UPS. This information can be used to define a border between Type I and II of the Urban Data centre, as the smallest three-phase UPS available in the market (according to the analysis that covers the 85% of the European products) is 20 kVA, we will use this information to place the lower limit of the definition of Data Centre of Type II.

At the highest level the “maximum” size is determined by protected ICT load, and the most common largest three-phase UPS ranges from various suppliers for these types of facilities are in the range of 200 to 300 kW each. All larger facilities are subsequently based on multiple (modular) modules of theses sizes.

Hence, due to major size indicators and the UPS upper values, combined with the minimum water cooling values, two types of Urban DC’s are defined which have distinct characteristics.

In the decision table below, the typecasting of Urban Data Centre Type I and Type II is depicted.

Parameter	Range	Typical	Type I	Type II
Quantity of racks	2 – 12 racks	8 racks	X	
	6 – 80 racks	25 racks		X
ICT Area	5 – 30 m^2	20 m^2	X	
	15 – 200 m^2	70 m^2		X
ICT Power	7 – 42 kW	28 kW	X	
	20 – 250 kW	100 kW		X
Cooling	DX		X	X
	Chilled Water			X
Free Cooling				X
Availability	Tier I - II		X	
	Tier II - III		X	X
Best Efficiency (PUE)	1,6 - 2,1	Not available	X	
	1,4 - 1,9	~1,6		X
Short-Break Power				X
Monitoring				X
Close to users			X	X

Table 3-2 Decision Table Urban DC Type I and Type II

Differentiating two data centre types with distinct sizing parameters allows for the next project tasks to base their solution on, while limiting overlapping scenarios.

Limiting the definition to just one specification would result in a broad range of key parameters. This would have limited possible solutions for reaching optimal energy sustainable and efficient solutions.

In chapter 3.2.2 it was stated that key data centre size parameters are power, area and quantity of racks. The following figure depicts the defined ranges of these parameters for the two types of Urban DCs.

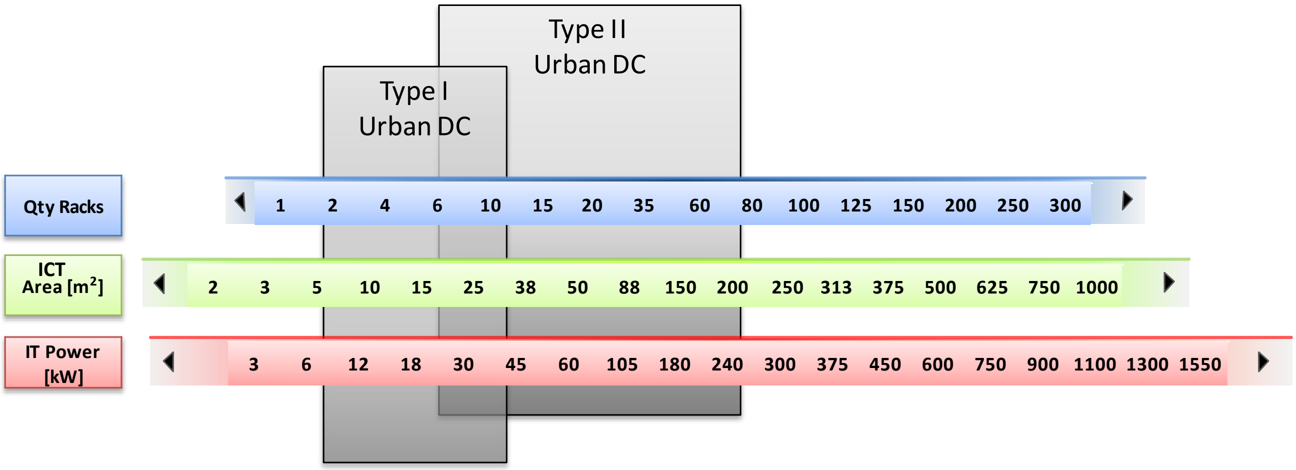

Figure 3-12 Capacity ranges of Type I and Type II Urban Data Centres (Source: ICTroom)

Some remarks:

- The ranges for Type I and Type II UDC are somewhat overlapping to accommodate some flexibility in the designs as used in the next phases of the project.
- The coloured parameter bars can be shifted to some extent, in order to accommodate different correlations between the three parameters.
- Please note that the momentary total required power for a data centre is more than the ICT power which is specified above. The total facility power should account for the worst case scenario and is therefore about 30-50% more than the result of ICT Power *PUE.

With these parameters the sizes and capacities of the Type I and Type II Urban DCs are outlined. In the next paragraphs the types are described in more detail.

3.4 URBAN DATA CENTRE TYPE I (SMALL)

Sizing

Type I Urban DC comprises the smaller facilities. Indicative ranges for the three main sizing parameters of the type I Urban DC can be extracted from Figure 3-1212.

Type I UDC Size parameter	Range	Typical
Quantity of racks	2 – 12 racks	8 racks
ICT Area	5 – 30 m^2	20 m^2
ICT Power	7 – 42 kW	28 kW

Table 3-3 Typical type I Urban DC parameters

Availability

- Typically lower uptime Tier ranges (I – II)
- More N or N+1 topologies than 2N
- Note: Type I Urban DCs don't rule out higher Tier implementations

Efficiency

- Usually Type I Urban DCs are less energy efficient due to the smaller scale of Type I Urban DC installations.
- Using modern efficient installations the PUE shall not exceed 1,3. As the development of data centre KPIs is currently ongoing, no other efficiency KPIs than PUE are specified.

Cooling

- Typically Type I Urban DCs don't have dedicated central cooling systems based on chilled water.
- Usually Type I Urban DCs use either DX cooling, or rely on existing building cooling installations.
- For this reason the cooling system of Type I Urban DCs is seldom provided with free cooling.
- New cooling technologies using direct free air cooling or indirect air-to-air cooling are still minimally applied.
- As in general no dedicated chilled water system for the Urban DC is used, the possibilities for heat re-use are most likely to be limited to air-to-air heat exchangers with heat consumers in or near the facility.

Power

- Typically less complex electrical installation
- Local UPS or even UPS per rack
- Typically either no genset or general genset of the total building emergency power
- Due to lack of backup genset, longer runtimes of UPS battery power are used (10 – 30 minutes)
- Typically more implementations of shut-down software

Business

- The Type I Urban DC is usually applied in SME
- Hardly hosting or housing
- Single user

- No 24/7 personnel

Location

- As the definition is about Urban DCs, the location is set to be within, or nearby a city.
- This means that nearby energy users or energy providers are likely to be available (offices, swimming pools).
- The location will determine the possibility to use on-site power generation and the use of aquifer thermal energy storage.

Building construction

- Typically the Type I Urban DC is located within a non-data centre specific building. Relevant dependencies are the adjacency to outside walls or roofs, building isolation, etc.
- The shape of the building can influence the possibility to position renewable energy sources (high tall building with limited roof space vs large flat warehouse).

Monitoring

- The Type I Urban DCs are generally fitted with limited monitoring and security systems.
- In order to maximise energy efficiency, (extra) adequate monitoring is needed for all energy using systems, as well as for measuring the climate conditions.
- Typically, DC power and cooling parameters are rarely monitored, especially when systems are used in combination with the building power and cooling systems.

3.5 URBAN DATA CENTRE TYPE II (MEDIUM)

Sizing

Type II Urban DC comprises the medium sized facilities. Indicative ranges for the three main sizing parameters of the Type II Urban DC can be extracted from Figure 3-12.

Type II UDC Size parameter	Range	Typical
Quantity of racks	6 – 80 racks	25 racks
ICT Area	15 – 200 m^2	70 m^2
ICT Power	20 – 250 kW	100 kW

Table 3-4 Typical type II Urban DC parameters

Availability

- Typically medium uptime Tier ranges (II – III)
- More N+1 topologies, even some 2N

Efficiency

- Usually Type II Urban DCs have more possibilities for efficient cooling systems, including free cooling systems.
- Using modern efficient installations the PUE shall not exceed 1,3. As the development of data centre KPIs is currently ongoing no other efficiency KPIs than PUE are specified.

Cooling

- Typically cooling of Type II Urban DCs is based on either DX systems or dedicated systems using chilled water cooling.
- When using a chilled water system Type II Urban DCs are capable of using free cooling. This is also the case with water cooled DX systems.
- Using an independent cooling system is preferred (capacity and availability not dependant on shared installations). However, the location of the Type II Urban DC (typically within a non-data centre specific building), may imply the use of shared facility installations.
- Also for Type II Urban DCs new cooling technologies using direct free air cooling or indirect air-to-air cooling are still minimally applied.
- As sometimes chilled water systems are used, the possibilities for heat re-use are not only limited to air-to-air heat exchangers with heat consumers in or near the facility. Using heat pumps and piping creates possibilities to transport the heat towards heat consumers elsewhere.

Power

- Typically more complex electrical installation
- Typically centralised UPS
- Most of the time a dedicated GenSet is available. Alternatively a GenSet as part of the building emergency power is used.
- Usually runtimes of UPS battery power ranging from 5 - 10 minutes
- Typically more use of VM-ware and ICT server management software

Business

- The Type II Urban DC is usually applied in SME, Governmental, NPOs, Corporates
- Rarely hosting or housing
- Usually single user
- 24/7 personnel usually in combination with the main building staff

Location

- As the definition is about Urban DCs, the location is set to be within, or nearby a city.
- This means that nearby energy users or energy providers are likely to be available (offices, swimming pools).
- The location will determine the possibility to use on-site power generation and the use of aquifer thermal energy storage.

Building construction

- The Type II Urban DC is usually located within a non-data centre specific building. Relevant dependencies are the adjacency to outside walls or roofs, building isolation, etc.
- The shape of the building can influence the possibility to position renewable energy sources (high tall building with limited roof space vs large flat warehouse).

Monitoring

- In general the Type II Urban DCs are fitted with better monitoring and security systems than Type I.
- In order to maximise energy efficiency, also for Type II Urban DCs (extra) adequate monitoring is needed for all energy using systems, as well as for measuring the climate conditions.

3.6 OTHER SPECIFICATIONS

Environmental Control

In paragraph 2.4 the ASHRAE thermal envelopes are described. Recommended and Allowed climate ranges were presented. Higher temperature ranges allow for better energy efficiency and/or free cooling or heat re-use capabilities. The maximum temperature ranges are in envelope A3 and A4. Our goal is to find energy savings beyond state of the art solutions but our framework is within a data centre environment, with high availability business demands. Although some manufacturers are preparing specific server models for wider ASHRAE envelopes [16], this is not common practice yet.

For the specification of the Urban DCs it is therefore proposed to increase the design climate conditions from the standard Recommended envelop to the Allowed A2 envelop, taking into account the notes as mentioned in paragraph 2.4. This implies a broader range of temperatures and relative humidity (as shown in Figure 2-3 and specified in Table 3-5).

Classes (a)	Equipment Environmental Specifications							
	Product Operations (b)(c)					Product Power Off (c) (d)		
	Dry-Bulb Temperature (˚C) (e) (g)	Humidity Range, non-Condensing (h) (i)	Maximum Dew Point (˚C)	Maximum Elevation (m)	Maximum Rate of Change(˚C/hr) (f)	Dry-Bulb Temperature (˚C)	Relative Humidity (%)	Maximum Dew Point (˚C)
Recommended (Applies to all A classes; individual data centers can choose to expand this range based upon the analysis described in this document)								
A1 to A4	18 to 27	5.5ºC DP to 60% RH and 15ºC DP						
Allowable								
A1	15 to 32	20% to 80% RH	17	3050	5/20	5 to 45	8 to 80	27
A2	10 to 35	20% to 80% RH	21	3050	5/20	5 to 45	8 to 80	27
A3	5 to 40	-12˚C DP & 8% RH to 85% RH	24	3050	5/20	5 to 45	8 to 85	27
A4	5 to 45	-12˚C DP & 8% RH to 90% RH	24	3050	5/20	5 to 45	8 to 90	27

Table 3-5 Specification A2 of environmental conditions for Urban DC Type I and II (yellow highlighted). (Source: ASHRAE)

- Note that an air inlet temperature of 35°C implies an air outlet temperature of the servers of about 43°C – 50°C! Some aspects of the consequences of using higher temperatures were described in paragraph 2.4.
- Again it is noted that these temperatures don't allow for the UPS batteries to be located in the same room.
- Although in the allowable specifications the humidification range is also extended, climate control is still needed to prevent ESD problems (at low RH) or condensation and corrosion (at high RH).
- Efficient methods should be used to humidify (e.g. ultrasonic or centrifugal systems). Using no humidification at all is not recommended as problems are to be expected in practice.
- Allowable ranges A3 and A4 are not proposed, as the project targets for a generic solution for Urban DCs, and these ranges are not common practice for ICT equipment (yet).

With broader ranges of the climate specifications in mind, lower PUE's come within reach as more energy saving techniques can be applied:

- Less or no cooling
- Less humidification / dehumidification
- More or complete free cooling / outside air cooling
- Higher operating temperatures result in higher waste heat temperatures. This creates better possibilities for heat re-use

It should be mentioned that sometimes it will be difficult to implement these high temperatures. For instance if:

- More parties are involved
- More SLA's are in place
- More critical human factors play a role
- Legacy ICT equipment is used

Energy Sources

The Urban DC design will prefer to make use of renewable energy sources. For this Urban DC specification the renewable power sources are assumed to be located on, or adjacent to the location of the Urban DC. Within GreenDataNet the focus for renewable power sources is on PV power.

Communication and interfacing

With regards to communication two categories can be distinguished: communication between ICT equipment and communication from facility systems.

ICT equipment is capable of communicating at high level, interfacing via TCP/IP. Advanced management and control is possible and fairly standardised. Using VM it is possible to migrate machines (virtual servers) or tasks to other physical locations.

Facility systems on the other hand, are less standardised in communication protocols, control, and data exchange. These systems originate from traditional Building Management Systems with a broad spectrum of protocols is used. In general it can be stated that facility and ICT systems don't share an integrated platform of data exchange. An emerging trend in DCIM systems is the integration of ICT equipment and facility management systems. Although most UPS systems usually also communicate via SNMP, cooling and other facility infra still use more traditional communication via Modbus or BACnet, or even still via potential free contacts.

The communication protocols for this project shall be based on open source and open standards. An example of an industry standard for exchange of data is OPC (Object Linking and Embedding for Process Control (https://opcfoundation.org))

Operational Use

In smaller DCs there is usually less focus on energy efficiency and sustainability. Furthermore monitoring and optimal operation procedures are generally not implemented or not optimised. However, for energy efficiency it is imperative that not only by design but also in the daily operation the DC has to run as efficient and as effective as possible. This implies continuous management, fine tuning and adjustments. It should be obvious that this should be implemented for both the Type I and Type II Urban DCs. In this respect the SEMS will automatically control optimal and efficient balancing of power supply and demand, thus contributing to energy efficiency and sustainability of Urban DCs.

Standards

There is a wide range of standards that can be applied to the design and build of DCs. It is out of the scope of this document to provide in the listing of all these standards.

- A start of a listing (but including national standards), is given in the Dutch Guidelines for Data Centres (NPR 5313) [7].
- The EN 50600, Data centre facilities and infrastructures, is still under development and will provide a data centre specific standard.

4. ANNEXES

4.1 ANNEXE 1

The table below shows the DC market segmentation in U.S.. It is clear that the small and medium sized Data Centres represent a great part of the DC market, both for number of servers installed and electricity consumption [15].

U.S. Data Center Segmentation Energy Use Methodology and Assumptions

Segment	% of stock (based on # of servers)	Average PUE	Average server utilization	Average server age (years)	2011 Electricity Use (MWh)	Server power at average utilization level (SPECpower_ ssj2008) (watts)	DC market segmentation by electricity consumption
Small- to Medium-sized Data Centers	40%	2.0	10%	3	37,500,000	149	49%
Enterprise/ Corporate	30%	1.8	20%	2	20,500,000	120	27%
Multi-tenant Data Centers	22%	1.8	15%	2	14,100,000	113	19%
Hyper-scale Cloud Computing	7%	1.5	40%	1	3,300,000	101	4%
High-performance Computing	1%	1.8	50%	2	1,000,000	169	1%
	100%				**76,400,000**		**100%**