## Smart Grid Energy Management Staff Exchange



# D3.1 Guidelines for integrated design towards smart / zero buildings and smart grids. Report on the design phase

Marie Skłodowska-Curie Actions (MSCA) Research and Innovation Staff Exchange (RISE) H2020-MSCA-RISE-2014



1



## **Revision History**

Revision date	Previous revision date	Summary of Changes	Changes marked
26/9/16	-	First issue	
30/9/16		Final	

## Approvals

This document requires the following approvals:

Name	Partner	Date	Approval (y/n)
Prof. Denia Kolokotsa (Project Coordinator)	TUC	30/9/2016	У
Prof. Mattheos Santamouris	UOA	30/9/2016	У
Prof. Diofantos Hadjimitsis	CUT	30/9/2016	У
Prof. Costas Papanicolas	Cyl	30/9/2016	У
Prof. Maria Kolokotroni	UBRUN	30/9/2016	У
Dr. Cristina Cristalli	AEA	30/9/2016	У
Fabio Montagnino	IDEA	30/9/2016	У
Dr. Nerijus Kruopis	EGM	30/9/2016	У
Federica Fuligni	EXERGY	30/9/2016	У
Dr. Siew Eang	NUS	30/9/2016	У

#### Distribution

This document has been distributed to:

Name	Partner	Date
Prof. Denia Kolokotsa	TUC	26/9/2016
(Project Coordinator)		
Prof. Kostas Kalaitzakis	TUC	26/9/2016
Kostas Gobakis	TUC	26/9/2016
Nikos Kampelis	TUC	26/9/2016









Vagias Vagias	TUC	26/9/2016
Aggeliki Mavrigiannaki	TUC	26/9/2016
Prof. Mattheos Santamouris	UOA	26/9/2016
Theoni Karlesi	UOA	26/9/2016
Prof. Margarita N.	UOA	26/9/2016
Assimakopoulos		
Dr. Niki Gaitani	UOA	26/9/2016
Vassilis Lontorfos	UOA	26/9/2016
Georgios Kyriakodis	UOA	26/9/2016
Ioannis Kousis	UOA	26/9/2016
Prof. Diofantos Hatzimitsis	CUT	26/9/2016
Chrysso Chatzinikola	CUT	26/9/2016
Prof. Costas Papanicolas	Cyl	26/9/2016
Dr. Nicolas Jarraud	Cyl	26/9/2016
Alex Lupion Romero	Cyl	26/9/2016
Marios Demetriades	Cyl	26/9/2016
Marina Kyprianou	Cyl	26/9/2016
Andri Pyrgou	Cyl	26/9/2016
Prof. Maria Kolokotroni	UBRUN	26/9/2016
Prof. Tatiana Kalganova	UBRUN	26/9/2016
Thiago Santos	UBRUN	26/9/2016
Dr. Cristina Cristalli	AEA	26/9/2016
Riccardo Paci	AEA	26/9/2016
Dr. Laura Standardi	AEA	26/9/2016
Gino Romiti	AEA	26/9/2016
Daniela Isidori	AEA	26/9/2016
Francesco Carducci	AEA	26/9/2016
Dr. Nerijus Kruopis	EGM	26/9/2016
Karolis Koreiva	EGM	26/9/2016
Gabija Silienė	EGM	26/9/2016
Fabio Montagnino	IDEA	26/9/2016









Filippo Paredes	IDEA	26/9/2016
Luca Venezia	IDEA	26/9/2016
Pietro Muratore	IDEA	26/9/2016
Federica Fuligni	EXERGY	26/9/2016
Fernando Centeno	EXERGY	26/9/2016
Gozde Unkaya	EXERGY	26/9/2016
Felipe Maya	EXERGY	26/9/2016
Sreenivaasa Pamidi	EXERGY	26/9/2016
Kassim Caratella	EXERGY	26/9/2016
Monica Osorio	EXERGY	26/9/2016
Dr. Siew Eang	NUS	26/9/2016









## **Table of Contents**

Table of Contents	1
List of Figures	3
1. Summary	7
2. Introduction	
3. Methodology	16
4. Integrated design in smart and zero energy build	dings 18
4.1 ID process principles and guidelines	
4.2 Scope of services	
4.3 Remuneration models	
4.4 Application of evaluation tools	
4.5 Sustainability certification	
4.6 Consultancy and Quality assurance	
4.7 Measurement of design quality criteria	
4.8 Defining Client's objectives	
4.8.1 Capital cost reduction	
4.8.2 Delivery risk reduction	
4.9 Defining Tenant's objectives	
4.9.1 Operational cost reduction	
4.9.2 Building Unsuitability Risk reduction	
5. Research activities in the Smart GEMS Project	
5.1 Best practice examples-site visits	
5.1.1 A.N. 101102218 and Associates Architects Office	
5.1.2 APIVITA Commercial & Industrial S.A	
5.1.3 Stavios Marchos Poundation Cultural Center	
5.1.4 Kaleids Ollice Park	
5.2 Case buildings assessments	
5.2.1 1 Introduction	
5.2.1.1 Introduction of approach	
5.2.1.2 Innovation of SUMMA building	
5.2.1.4 Geometry	
5.2.1.4 Geometry	
5.2.1.6 Operational conditions	
5.2.1.7 Installed systems	78
5 2 1 8 Energy cost	82
5.2.1.9 Energy savings calculation methodology	83
5.2.1.10 Direct monitoring methodology	
5.2.1.12 Conclusions	
5.2.2 KITE lab	89
5.2.2.1 Introduction	
5.2.2.2 Objectives	
5.2.2.3 Methodology	
5.2.2.4 Data collection, description of the site and	building







	5.2.2.5 The Micro-grid	93
	5.2.2.6 Design of the building envelope	95
	5.2.2.7 Design of the openings, doors and windows	99
	5.2.2.8 Surface matching	102
	5.2.2.9 Design of the Photovoltaic roof installation	102
	5.2.2.10 Kite Lab final 3D model	105
	5.2.2.11 Distinction of thermal zones	107
	5.2.2.12 Materials and construction	109
	5.2.2.13 Importing weather file	116
	5.2.2.14 Internal loads	117
	5.2.2.15 Conclusions and innovativeness of approach	119
	5.2.3 AEA building	120
	5.2.3.1 Introduction	120
	5.2.3.2 Methodology	121
	5.2.3.3 Data collection, analysis and processing	122
	5.2.3.4 Building 3D design using Open Studio SketchUp Plugin	122
	5.2.3.5 Division of the building structure in terms of the thermal zo	ones
		125
	5.2.3.6 Surface matching	126
	5.2.3.7 Open studio - Import of the physical and thermal characte	ristics
	of building structural elements (walls, ceilings, floors, openings)	127
	5.2.3.8 Innovativeness	134
	5.2.3.9 Conclusions	135
	5.2.4 Library building	135
	5.2.4.1 Introduction	135
	5.2.4.2 The solar cooling plant for the UOA Science Library	137
	5.2.4.3 Location and description of the building	137
	5.2.4.4 HVAC system of the building	140
	5.2.4.5 Proposed Linear Frenel Reflector technology	141
	5.2.5 NUS building	144
		144
	5.2.5.2 Description of the NUS building	145
	5.2.5.3 Measurement equipment	146
-	5.2.5.4 Results Σφαλμα! Δεν εχει οριστει σελιοσοε	ικτης.
1.	Conclusions	149
٥. ٥	. Reieleilues	132
<b>J</b> .	0 1 Appendix 1 Summe Ruilding	160
	9.1 AILIER 1-SUITINA DUIUTY	100
	3.2  Annox  2  AEA building	109
	9.5 ATTEX 5-AEA DUILUING	198





2

## List of Figures

Figure 1: The methodological approach of smart technologies	13
Figure 2: The methodology of implemented work	17
Figure 3: Synthesis of ID process	20
Figure 4: Early design phases impact on performance, costs and disruption.	
(www.integrateddesign.eu)	21
Figure 5: Traditional Vs. Integrated Planning	22
Figure 6: Overview of the ID process	24
Figure 7: Timeframe of ID related tasks (www.integrateddesign.eu)	27
Figure 8: The 3-level-model for ID-related remuneration of design works.	
(www.integrateddesign.eu)	28
Figure 9: Sustainability aspects for high performance buildings	33
Figure 10: The interplay of Green Building benefits for developers, owners	
and tenants (WGBC 2013)	42
Figure 11 Location of Tompazis Office Building (red) and city center (blue)	45
Figure 12 a. The block of buildings that includes the Tombazis building (left)	)
	45
Figure 13 Artificial pool, sculpture, and entrance of the Tombazis building	46
Figure 14: Interior spaces	47
Figure 15 a. Natural and b. artificial lighting	48
Figure 16: Location of APIVITA Building (red) and city center (blue)	50
Figure 17: APIVITA interior space	51
Figure 18: Plantation in the area of APIVITA building	53
Figure 19: Location of the SNFCC (in blue)	55
Figure 20: The Stavros Niarchos Foundation Cultural Center and Park $^{\odot}$	
Yiorgis Yerolymbos	55
Figure 21: The design of the Library and Opera	56
Figure 22: The Library building (left) and the Opera building (right) of the	
SNFCC © Yiorgis Yerolymbos	56
Figure 23: The Esplanade of SNFCC © Yiorgis Yerolymbos	57
Figure 24: Works during the installation of the PV system at the roof © Yiorg	jis
Yerolymbos	57
Figure 25 Location of Karelas Office Park (left) b. The green roottop of the	
building (right)	59
Figure 26: Façade movable shading devices	59
Figure 27: Building atrium for natural day-lighting (left), Atrium façade bambo	00
shading devices (right)	60
Figure 28: Root garden	61
Figure 29: Central Solar Thermal System	61 74
Figure 30 Satellite image of the selected building.	71
Figure 31: Loccioni s Micro grid connection	72
Figure 32: CAD drawing for Ground Floor of SUMIMA building.	75 75
Figure 33: CAD drawing for First Floor of SUMMA building.	15
Figure 34. Ground Floor (A), 1° Floor (B) separation in different thermal	70
2011es. Figure 25: Different research luminaire turge met in Summe huilding	70
Figure 35: Different recessed iuminaire types met in Summa building	19





Figure 36: Sample of electrical equipment template used in the simulation Figure 37: Water to water Heat Pump in the storey of ground floor Figure 38: FCX fan placed in the ceilings of Summa building	81 82 82
Figure 39: Site Outdoor Air Dry Bulb Temperature profile for the examined period ideally set to 2002	86
Figure 40: Site Direct Solar Radiation Rate per area (red) and Site Diffuse	00
Solar Radiation Rate per area (blue) for the examined period ideally set to 2002	86
Figure 41: Different types of Smart Meters implemented in Summa and Micr	0
grid Figure 42: Energy data remote access provided by Myl eaf Portal	88 88
Figure 54 Location of KITE lab	92
Figure 55: View from the SS76 highway	93
Figure 56: View from the SS76 highway	94
Figure 57: CAD drawing of the basement floor	95
Figure 58: CAD drawing of the second floor	96
Figure 59: CAD drawing of the root	97
Figure 60. The filled roofton components	97
Figure 62. The tilted rooftop 3D design	98
Figure 63: The aligned openings. Salas and Corridor	99
Figure 64: Opaque view of the complete model, contour based on materials	
Figure 65: Transparent view of the complete model, contour based on	00
materials1	00
Figure 66: Example of external CAD drawing for the design of openings1	01
Figure 67: Example of CAD drawing for the design of internal openings 1	01
Figure 60. The fully surface matched building	02
Figure 70: The PVs covering part of the rooftop	04
Figure 71: Technical Specifications of the PV installation	04
Figure 72: The type of PVs installed1	05
Figure 73: South-east view of the building1	05
Figure 74: North-east view of the building1	06
Figure 75: North-west view of the building1	06
Figure /6: I op view of the building1	07
Figure 77: Distinction in thermal zones	07
Figure 76. Desement merinal zones in 2nd floor 1	00
Figure 80: Open studio categorization of building levels and thermal zones 1	09
Figure 81: Schematics used for the materials and building elements	00
construction1	10
Figure 82: Open studio materials tab 1	11
Figure 83: Different type of walls 1	13
Figure 84: Opaque and non-opaque elements1	14
Figure 85: Final form of constructions sets.	15
Figure 86: Contour based on materials-construction	15
Figure or. Elements integration of weather data files	10



4

Figure 90: Schematics of lights (blue-yellow) installed in each space....... 118 Figure 92: Annual consumption of Loccioni's buildings for 2014 ...... 121 Figure 93: Top view of the first floor of AEA Building ...... 122 Figure 97: Back side view of two storey AEA Building ...... 124 Figure 99: Top view of the second floor of AEA Building ...... 124 Figure 100: East side view of two storey AEA Building......124 Figure 105: Southeast view of AEA Building divided into thermal zones ..... 126 Figure 106: Northwest view of AEA Building divided into thermal zones ..... 126 Figure 113: Space types in Open Studio Mode (Green: offices, Yellow: Industrial Use, Red: kitchen, White: Reception and corridors, Black: meeting rooms, Orange: W.C and stairs)......133 Figure 116: Location of the Library of Science inside the UoA Campus ..... 137 Figure 119: 3D rendering of 8 modules of LFR Solar field installed on a roof of a building......142 Figure 120: Possible positioning of 45 LFR modules as a shadowing cover of a parking area inside the UoA Campus, on the west side of Library of Figure 121: Width and Length of the LFR Solar, built as a covered parking Figure 122: Floor plan of the location of the executive office and the sensor Figure 123: Floor plan of the location of the computer room and the sensor Figure 124: Floor plan of the location of the lecture theatre and the sensor Figure 125: Total energy (excluding lighting) for the three rooms  $\Sigma \phi \alpha \lambda \mu \alpha! \Delta \epsilon v$ έχει οριστεί σελιδοδείκτης.



Figure 126: Total lighting energy for the three rooms ......  $\Sigma \phi \dot{\alpha} \lambda \mu \alpha! \Delta \epsilon v \dot{\epsilon} \chi \epsilon i$ opiotεί σελιδοδείκτης.

Figure 127: Temperature and RH box plots of the three rooms  $..\Sigma\varphi\dot{\alpha}\lambda\mu\alpha!\Delta\epsilon v$  $\dot{\epsilon}\chi\epsilon i opiot\epsilon i \sigma\epsilon\lambda i\delta o\delta\epsilon i\kappa the three rooms ...\Sigma\varphi\dot{\alpha}\lambda\mu\alpha!\Delta\epsilon v$ 

Figure 128: CO<sub>2</sub> concentrations in the three rooms  $\Sigma \phi \alpha \lambda \mu \alpha! \Delta \epsilon v \epsilon \chi \epsilon i o \rho i \sigma \tau \epsilon i \sigma \epsilon \lambda i \delta \sigma \delta \epsilon i \kappa \tau \eta \varsigma$ .

Figure 129: Temperature and RH in the Lecture Theatre from the three different sensors ......Σφάλμα! Δεν έχει οριστεί σελιδοδείκτης. Figure 130: CO<sub>2</sub> concentrations in the Lecture Theatre from the three different sensors ......Σφάλμα! Δεν έχει οριστεί σελιδοδείκτης. Figure 131: Lecture Theatre: one day with high occupancy Σφάλμα! Δεν έχει οριστεί σελιδοδείκτης.

## **List of Tables**

Table 1: Seconded researchers and activities presented in Deliverable 3.18
Table 2: Overview of the measurability criteria of ID
Table 3: The buildings under study for IED and NZEB concepts
Table 4: Area and volume of each floor of SUMMA building
Table 5: Orientation and size of building's windows and doors
Table 6: Thermophysical characteristics of the building envelope      77
Table 7: Construction Template information for the baseline condition
Table 8: Openings Template information for the baseline condition.      77
Table 9: Activity Template information for the baseline condition
Table 10: Lighting Template information for the baseline condition.      79
Table 11: Lighting power of each zone. 80
Table 12: Dominant electrical devices used in the building. 81
Table 13: Maximum tolerances for the BEM and CV statistical indexes.      83
Table 14: Information regarding equipment 118
Table 15: Physical and thermal values of expanded polystyrene      128
Table 16: Measurement units of the physical and thermal values used 128
Table 17: List of the main features in terms of air flow rate [m <sup>3</sup> /h] and thermal
power [kW] provided by the 7 distribution sub-system of HVAC system used
to size the solar thermal power and absorption chillers system
Table 18: Main geometrical features of the LFR solar field
Table 19: Technical specifications of the sensors



6

exergy 📆 NUS

## 1. Summary

The present work focuses on smart and zero energy building's analysis on the design phase and aims to provide guidelines for integrated design procedures towards smart/zero buildings and smart grids.

This is a mandatory requirement based on the fact that by 31 December 2020, all new buildings shall be nearly zero-energy consumption buildings. New buildings occupied and owned by public authorities shall comply with the same criteria by 31 December 2018.

ZEBs are buildings that work in synergy with the grid, avoiding putting additional stress on the power infrastructure. Achieving a ZEB includes apart from minimizing the required energy through efficient measures and covering the minimized energy needs by adopting renewable sources, a series of optimised and well balanced operations between consumption and production coupled with successful grid integration.

To this end research work has been implemented and skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. Table 1 presents the list of persons involved in the deliverable.

Since buildings are major consumers in smart grids, the integrated design task assists to develop a collaborative method for designing buildings for smart grids. The IED process is an innovative approach able to support and manage the growing complexity of the building market sector. Requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.



Researchers	Sending	Organisation of	Research Field
	Organisation	Destination	
Theoni Karlessi	UoA	IDEA	ID/Site Visits/Library building
			assessment
Luca Venezia	IDEA	UoA	Site Visits /Library building
			assessment
Pietro Muratore	IDEA	UoA	Site Visits /Library building
			assessment
Laura Standardi	AEA-Loccioni	UoA	Site Visits /Library building
	Group		assessment
Georgios-	UoA	AEA-Loccioni Group	Summa 3D modelling
Evrystheas			assessment
Kyriakodis			
Ioannis Kousis	UoA	AEA-Loccioni Group	AEA 3D modelling
			assessment
Vassilis Lontorfos	UoA	AEA-Loccioni Group	KITE Summa 3D modelling
			assessment
Margarita-Niki	UoA	NUS	NUS building occupancy
Assimakopoulos			patterns

Table 1: Seconded researchers and activities presented in Deliverable 3.1

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For this reason, the introduction of a design team is compulsory for the design of NZEBs. In this context the building design phase is of particular importance. IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined, to identify pros and cons of alternative variants of design concepts and to allow decision makers to decide based on transparent facts. The choices are no longer taken from a single profession, but from a work team through a participatory process; choosing from a wide range of possibilities to identify the best solution, taking into account the quantitative aspects (high energy performance efficiency and high indoor comfort), economic (cost/benefit), functional, aesthetical aspects and energy efficiency parameters to be achieved. Only if IED is applied from the very beginning of the design phase we can assume that a cost-effective



solution for NZEB can be identified, because only at the early design phases changes of the general design concept can be implemented at low cost. Therefore, the application of IED is part of the best way towards the intended NZEB at low cost.

The work in this Deliverable is structured in 3 levels:

• Level 1: Integrated Design procedure and decision making protocols Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. It is emphasised that the creative problem solving process runs parallel in time with the process of monitoring the compliance with project targets, which have been defined in the design basis. The ID steps represent concrete tasks that to a certain extent go beyond conventional design processes. This means that an adaptation of the scope of services is required. Client's and Tenant's requirements are presented including capital cost, delivery risk, operational cost and minimization of building unsuitability risk. The objectives of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.

#### Level 2: Assessment of best practice examples through site visits

Within the frame of the secondments hosted in the University of Athens site visits at best practice example NZEB buildings which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.

The activities included sites visits, meeting with the building responsible and assessment of the performance of 4 best practice buildings in Greece:

- A.N. Tombazis and Associates Architects Office Building
- Apivita Commercial & Industrial S.A.
- Stavros Niarchos Foundation Cultural Center
- Karelas Office Park



The buildings have adopted the ID procedures from the early stages of design until the final completion and operation. Throughout the secondment activities the applied smart technologies have been investigated in relation with the integration to smart grids.

#### Level 3: Assessment of selected case buildings

Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented.

The buildings that are analysed are:

- SUMMA building, Ancona, Italy
- KITE lab, Ancona, Italy
- AEA building, Ancona, Italy
- Library building, University of Athens, Greece
- NUS building, Singapore

The purpose of CFD analysis is enumerated analytically below:

1) Accurate assessment of occupancy; thermal comfort is essential for successful building design.

2) Assessment of Comfort as it can vary considerably for different thermal zones depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.

3) Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.



4) The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.

5) It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

Innovativeness of the approach of the present work is multiple and can be defined as follows:

- > Analysis of Integrated Design methodology vs conventional procedures
- Application of detailed white box models based on physical knowledge of the system and thermal balance equations vs black box and grey box models that use only measured input/output data and statistical estimation method as well as a priori knowledge on the system. White box models were also used because of the accuracy, the calculation speed and it's usage for optimization and control.
- Evaluation and application of innovative solutions and systems as the High Concentrating solar thermal system for combined thermal and electrical production to drive a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs.



## 2. Introduction

As the EU energy industry is clearly moving towards a new era of reliability, availability, and efficiency that will contribute to the improvement of Europe's economic and environmental sustainability, smart technologies provide the opportunity for new applications with far-reaching interdisciplinary impacts: providing the capacity to safely integrate more renewable energy sources (RES), smart grids and distributed generators into the network; delivering power more efficiently and reliably through demand response and comprehensive control and monitoring capabilities in order to achieve zero energy targets. The integration of smart technologies requires a holistic approach that takes into account all aspects of sustainability.

The methodological approach is based on a cycle expansion of three phases (Fig.1): 1. The users/consumers aspects, focusing on smart and zero energy buildings analysis, 2. The smart grids penetration at community and city level, offering the technological platform for fast moving towards sustainable communities by exploiting the ICT and energy systems development in the maximum degree 3. Development of smart applications and smart grids optimised operation.



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 1: The methodological approach of smart technologies

The main objective of WP3 is the design of common projects concerning smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings. This describes the first phase which is also the core of the cycle approach. The methodological approach is designed to enhance the researchers' competitiveness and promote the ideas sharing from research to market and vice versa. The researchers from the academic and the industrial sector, through their secondments perform specific tasks to further enhance skills and collaboration. The smart buildings and integration in smart grids work package is focusing on the a) smart buildings' design phase b) smart buildings' operational phase and c) zero energy buildings and integration with smart grids.

Phase 1 starts from the users'/consumers' aspects by focusing on smart and zero energy buildings' analysis [1]. This is a mandatory requirement based on the fact that by 31 December 2020, all new buildings shall be nearly zeroenergy consumption buildings. New buildings occupied and owned by public authorities shall comply with the same criteria by 31 December 2018[2], [3]. This is the core of the cycle approach.



ZEBs are buildings that work in synergy with the grid, avoiding putting additional stress on the power infrastructure [4]. Achieving a ZEB includes apart from minimizing the required energy through efficient measures and covering the minimized energy needs by adopting renewable sources, a series of optimised and well balanced operations between consumption and production coupled with successful grid integration [5].

This Deliverable focuses on the design phase and aims to provide guidelines for integrated design towards smart/zero buildings and smart grids.

To this end skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. Since buildings are major consumers in smart grids, the integrated design task assists to develop a collaborative method for designing buildings for smart grids. The integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For the demand side concept of a building the best possible heating or ventilation system should be applied. Activating of thermal mass for example requires the interaction between the structural designer and HVAC engineers. Alternative energy systems have to fit to the concept design and the building energy systems. For this reason, the introduction of a design team is compulsory for the design of NZEBs. In this context the building design phase is of particular importance. IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined targets, to identify the effectiveness of alternative choices and methods of design concepts and to allow decision makers to implement the appropriate solutions based on transparent and solid methodologies. Only if IED is applied from the very beginning of the design phase it is highly probable that a cost-



effective solution towards NZEB can be identified, because only at the early design phases any deviation from the general design concept can be implemented at low cost. Therefore, the application of IED constitutes the best way towards the intended NZEB at low cost. Experience from several demonstration projects and best practice exmples shows that IED leads to highly energy efficient solutions at least cost over the life cycle of the building, because the integration of all required expertise already in the early design phase brings forward the most approprite and thus cost-efficient solutions [6].



## 3. Methodology

In order to provide a holistic approach the following methodology was implemented:

- Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. Client's and Tenant's requirements are presented including capital cost, delivery risk, operational cost and building unsuitability risk reduction. The objectives of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.
- Within the frame of the secondments hosted in the University of Athens site visit at <u>best practice example NZEB buildings</u> which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.
- Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented. The purpose of CFD analysis is enumerated analytically below:
  - 1. Accurate assessment of occupancy; thermal comfort is essential for successful building design.



- 2. Assessment of Comfort as it can vary considerably for different thermal zones depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.
- 3. Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.
- The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.
- 5. It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.



Figure 2: The methodology of implemented work



## 4. Integrated design in smart and zero energy buildings

Directive 2010/31/EU (EPBD recast) Article 9 requires that "Member States shall ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings; and after 31 December 2018, new buildings occupied and owned by public authorities are nearly zero- energy buildings". Member States shall furthermore "draw up national plans for increasing the number of nearly zero-energy buildings" and "following the leading example of the public sector, develop policies and take measures such as the setting of targets in order to stimulate the transformation of buildings that are refurbished into nearly zero-energy buildings".

A nearly zero-energy building is defined in Article 2 of the EPBD recast as "a building that has a very high energy performance. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby". The specific EPBD Concerted Action activities around "Towards 2020 - Nearly zero-energy buildings" will support the Member States by the exchange of experiences with already existing high performance buildings(ranging from low energy buildings to passive houses, zero-energy and zero-emission buildings, and even to energy surplus houses). The discussion topics include the most common building and service system solutions, calculation methods, promotional means, available subsidies and other incentives, supporting documents (e.g. guidelines), etc., as well as study tours to interact with experts at national administrations and visits to relevant sites.

There are different national applications of the definition of nearly zero-energy buildings: in some countries NZEBs concept is well established and they act as best practises exaples providing valuable experience to other that are at a level of development oth this concept.. Through such information exchange, Member States participants are mutually supported in the development of the national plans for increasing the number of nearly zero-energy buildings. To achieve a suitable definition, related facts , findings and experiences need to be seen in



a broader societal context and need to be transferred into a well defined standard, taking into account financial, legal, technical and environmental aspects. Analysing the implications identified above, it becomes obvious that most of them interact or require the consideration of a holistic approach [7]. Consequently, the principles for an nZEB definition should based on the same

broad perspective, addressing the present and future challenges and benefits. Hence, a proper and feasible nZEB definition should integrate the following characteristics [8]:

- To be clear in its aims and terms, to avoid misunderstandings and implementation failures.
- > To be technically and financially feasible.
- To be sufficiently flexible and adaptable to local climate conditions, building traditions etc., without compromising the overall aim.
- > To build on the existing low-energy standards and practices.
- > To allow and encourage open competition between different technologies.
- To be ambitious in terms of energy and environmental conditions considering innovativeness and technology development.
- To be elaborated based on the agreement of the main stakeholders involved (politicians, designers, industry, owners, investors, users etc.).
- To be inspiring and to enforce faster adoption acting also as example for other projects

Within this context, one main objective is the design of common projects concerning smart buildings in an interdisciplinary nature in order to accelerate the process towards zero energy buildings through integrated design. Figure 3 presents a synthesis of the Integrated Design process taking into account climate parameters, building design strategies, systems integration and use/operation [9].



#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design

phase



Figure 3: Synthesis of ID process

#### 4.1 ID process principles and guidelines

Integrated design is an approach that considers the design process and the physical solutions as a whole system, which provides optimized buildings throughout the lifecycle. Firstly, for the purpose of reaching high sustainability performance, the project should be developed and discussed by an integrated, multidisciplinary team.

ID emphasizes a decision process rooted in well based choices with regard to the project goals, and on systematic evaluation of design proposals in every stage of the development. This approach for building design is paralleling the principles of environmental management referred in the international ISO 14001 standards. Here, the identification, definition and prioritization of goals, as well as the development of an evaluation plan with milestones, are central and critical issues.



of the integrated approach emphasizes that the very early phases need more attention because well informed decisions here will pay off in the following stages of the design process and eventually in the lifecycle of the building (Figure 4) [6]. The IED approach is an effective way to realize nZEBs because it involves different specialties to interact on energy performance issues in the early stages of the design process. The Figure 4 shows the difference between a traditional approach (grey area) and an IED process (orange area). With the integrated design process the design phase requires more effort than the construction and documentation phase. At the same time, the cost's curve trend changes with the decision making time phase, in the IED approach it is high during the design phases (blue line) while in a traditional approach (green line) it is high during the construction and operation phase due to project changes [6], [10].



Figure 4: Early design phases impact on performance, costs and disruption. (<u>www.integrateddesign.eu</u>)

Well informed planning at the beginning of te project can allow buildings to reach high energy performance and reduced operating costs at minor extra capital cost. Considering the whole life cycle of a building, the running costs are higher than construction and refurbishment costs; thus, it becomes obvious that



a short-sighted approach to squeeze the first design phase regarding resources should be avoided. Experience from building projects applying ID shows that the investment costs may be about 5 % higher, but the annual running costs will be reduced by as much as 40-90 %. The process of ID emphasizes that the performance of buildings should be assessed in a lifecycle perspective, both regarding costs (LCC) and environmental performance (LCA). Figure 5 indicates the cost effectiveness of Integrated Planning vs Traditional Planning through the lifecycle of the building.



Figure 5: Traditional Vs. Integrated Planning

Six steps can be identified for a successful Integrated Design implementation [6], [10]:

- Project development: discussion of the project ambitions and challenge initial client presumptions, initiating ID process and preferably make partnering contracts.
- Design basis: selection of a multi-disciplinary design team, including an ID facilitator, motivated for close operation, analysis of the boundary conditions. Also define objectives and specify the project ambitions, preferably as functional goals.



- Iterative problem solving: facilitate close cooperation between the architect, engineers and relevant experts through workshops, seminarsetc. Use of both creative and analytical techniques in the design process. Discussion and evaluation of the multiple concepts and finalise optimised design.
- 4. On track monitoring: Use goals/ targets as means of measuring success of design proposals, make a Quality Control Plan, evaluate the design and document the achievements at critical points/milestones.
- 5. *Delivery:* Ensure that the goals are properly defined and communicated in the tender documents and building contracts, motivate and educate construction workers and apply appropriate quality tests, facilitate soft landing. Make a user manual for operation and maintenance of the building.
- 6. *In use:* Facilitate commissioning and check that the technical systems etc. are working as assumed, monitor the building performance over time regarding e.g. energy consumption, user satisfaction etc.

The procedure is depicted in Figure 6. The figure emphasises that the creative problem solving process (2) runs parallel in time with the process of monitoring (3) the compliance with project targets, which have been defined in the design basis (1). The ID steps represent concrete tasks in a circular iterative way rather than a linear approach. That to a certain extent goes beyond conventional design processes. This means that an adaptation of the scope of services is required.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 6: Overview of the ID process

#### Benefits

Integrated Design processes result in higher energy and environmental performance: all related building aspects are addressed through open multidisciplinary discussions and design decisions in early project phases, where knowledge and experiences are exchanged to provide th most effective solutions.

It also contributes to the reduction of CO<sub>2</sub> emissions as optimized design is prioritized combined with advanced technical systems and control mechanisms.

Indoor climate is significantly improved: the building and technical systems work together in a logical symbiosis in order to achieve sufficient indoor air quality, temperature control and daylight access/ solar protection.

Running costs and maintenance of the building are reduced: efficient technical systems are more cost effective, both in terms of initial investment costs for manufacturing and installation and in terms of running costs and maintenance. An important benefit is the reduction of risks and construction defects as improved planning leads to less building faults. This results to significant financial savings. Early involvement of users and inclusion of their requirements in the design process may improve the overall performance of the building in the operation phase, as well as increase user satisfaction. A high performance



building increase the attractiveness and can yield higher rental costs which can be compensated for by a lower energy bill thus the sales value of the building will increase. A green image enhances also the building profile and benefits the building owner or tenant organization.

#### ➤ Barriers

Despite the important benefits there are certain barriers that need to be addressed as:

1) Conventional thinking: The building sector is considered to be rather slow and reluctant in accepting and adopting new ways of working. ID calls for decision processes and design methods that challenge familiar habits, and require high communication skills. Professionals on both sides of the table must practice in collaboration, and maybe adjust their working habits.

2) ID doesn't seem a cost-effective approach: Developers traditionally pay more attention to construction costs than lifecycle costs (LCC). However, when energy consumption and maintenance is included in the calculations, it usually supports investments in planning for high performance and robust solutions.

3) Time constraints in initial design phase often press engineers and developers to underestimate the value of thoroughly and integrated planning, and propose high speed and inappropriate solutions when analysing the boundary conditions of a building. It can be challenging to convince the developer that the initial phase is crucial, and that giving time for design iterations often pay off in better concepts and later phases.

4) As the ID process requires close and constant collaboration between stakeholders who may have diverging goals, conflicts could be accentuated. It is therefore crucial that the team members do not insist on strict and definite demands within their fields of expertise, but rather endeavour to work with a holistic approach.

The inclusion of a "design process facilitator" should be considered, in order to organize the process, especially in cases where the architect and client lack knowledge of collaborative working or where the project has particularly challenging performance goals. It is highly recommended that he/she should



be assigned and contracted separately to the client in order to guarantee effective coordination and management of the ID process and to avoid the resolve of issues of private interest. Supervision and on-track monitoring throughout the design process should be performed by a facilitator or other person with the authority and experience to challenge both the design team and the client. This facilitator should also be responsible for reporting to the client any variations against the project goals originally defined. A process facilitator such as a BREEAM or LEED Accredited Professional (AP) may be the right option in cases where environmental goals are pursued through an environmental assessment scheme.

## 4.2 Scope of services

One basic element of ID, which is not common in conventional design processes, is the requirement of comprehensive evaluation of the multiple concepts and technical solutions prior of taking definite decisions. This requirement implies that design work needs to be applied in several projects because a comprehensive evaluation can only be implemented if the concepts and technical solutions in question are available in a sufficiently advanced design.

A principal characteristic of ID is an up-stream shift of work load from detailed design and construction documentation towards the phase of concept design. This characteristic has also an impact on the scope of services. The importance relies not only in the certain tasks that will be implemented, but also at the timeframe of implementation. Dynamic thermal simulations, estimation of indoor conditions and daylight calculations have became a standard tool for the design of complex buildings over the last years. Very often these procedures are applied too late in the process acting not as evaluation of the process but mainly aim at proving that the selected design variants work. From an ID perspective these instruments need to be used as decision-supporting tools for filtering out the most suitable variants. This purpose can only be achieved if they are applied already very early in the design process and if they include the comparative analysis of a broader range of design variants; the same accounts



for life cycle cost assessment (LCCA). Considered from an ID perspective an estimation of the future costs, which are usually calculated rather late during the detailed design phase, is not adequate. Instead, ID uses LCCA to compare different design variants from an economic point of view and this kind of comparison is only useful if its results can be fully taken into account without causing larger disruptions in the design process as a whole. Thus it is concluded that thhe LCCA needs to be applied at the very beginning of the design process. Figure 7 depicts the series of the most important typical ID related tasks in the design phases and when they should be implemented or at least initiated. The accurate timing of tasks is crucial in order to fully claim for the benefits of ID [11].



Figure 7: Timeframe of ID related tasks (www.integrateddesign.eu)

## 4.3 Remuneration models

The impact of ID on the remuneration of design services can be divided into four aspects:



- Qualitative aspects resulting from the fact, that quality targets (e.g. energy performance, sustainability targets etc.) are the usual targets of ID processes;
- Quantitative aspects arising from extra tasks which are not part of a conventional design process;
- Time-related aspects reflecting the fact that ID is shifting design efforts towards the early design phases;
- Structural aspects considering that ID introduces an ID facilitator as additional stakeholder. The first two elements are reflected in a generic approach for an ID-related remuneration model for design works, which we call 3-level-model because it states that remuneration for design works committed to ID consists of three different elements (Figure 8).



Figure 8: The 3-level-model for ID-related remuneration of design works. (www.integrateddesign.eu)

#### Level 1- Basic remuneration

The basic remuneration is in accordance with the standard remuneration for conventional design processes. From country to country – but also from client to client – this "standard remuneration approach" shows considerable



differences. In principle three different approaches are possible and may be blended in different ways:

- Remuneration based on a certain percentage of construction cost;
- Time-dependent remuneration (e.g. for force account works, which are added later to a running contract);
- All-inclusive price which is fixed before the design works start.

#### Level 2- Extra remuneration for extra tasks

This level of remuneration reflects the additional tasks which are not necessarily implemented in a conventional design process, but which are required for ID. If the basic remuneration is not sufficient to cover these tasks they need to be disbursed separately. This might be accomplished either by granting an extra percentage of the construction cost or by foreseeing additional time-dependent actions or fixed remunerations for the accomplishment of specific tasks.

#### Level 3- Performance related remuneration

The third level of remuneration reflects the ambition of ID to contribute to the improvement of design quality. With respect to remuneration this ambitious goal could be supported by introducing an incentive for the designer to address the quality target defined at the beginning of the design process. The way of measuring the design quality is the main challenge of this process. Despite the difficulty of these aspects, a limited share of performance-oriented remuneration seems to be feasible, since several quality criteria and performance indicators can be checked by well-established verification methods and partly also by neutral verification bodies (e.g. sustainability certificate at the design stage). The performance-related part of remuneration tries to enforce the ID procedures and strengthen the attention of design processes on quality aspects - such as energy performance, user comfort and a broad range of other sustainability criteria – contrary to the linear ordinary process and the the omnipresent focus on compliance with construction costs. The three-level-model, as presented above, is seen as generic approach which needs to be adapted to national requirements such as fee structure for



architects and engineers, which are settled by respective professional bodies in many countries. Existing legislation needs also to be taken into account. In addition, the approach has to be modified for different organisational models of design and construction works – such as separate contracts for different design tasks; general planner approach; general contractor approach. Altogether, it has to be underlined that ID is not necessarily more expensive than conventional design, even if the three-level-model might imply this. The focus on early design phases will have a clear cost-cutting impact later on. It can be assumed that this impact exceeds the extra-cost of the early design phases.

Typically, there are several additional services arising from the ID process related to the identification of the design basis conditions, the application of evaluation tools, the sustainability verification, consultancy and quality assurance issues.

## 4.4 Application of evaluation tools

The appropriate application of evaluation tools requires an analysis of the design basis conditions identifying the aspects that should be considered:

- Identification of the client's sustainability policy and requirements: This can be done by considering sustainable design schemes (Passivhaus certification scheme, BREEAM, LEED, DGNB, ITACA etc.);
- Evaluation of the local climate and analysis of the prevailing meteorological conditions during summer/winter and day/night). Investigation of the preconditions influencing building orientation, surrounding buildings, obstacles, sun angle, shading, micro-climate, daylight availability, outdoor air quality, noise sources, acoustic intensity etc.;
- Determination of relevant boundary conditions for building concept regarding thermal, visual and acoustic comfort, indoor air quality, operational and embodied energy etc.;
- Integration of (preferably on-site) renewable energy sources: Location, availability of natural resources, climate, studies on the feasibility of integrated geothermal systems.



The following evaluation tools may be part of iterative problem solving and/or part of on track monitoring. They are aimed at supporting the design team in filtering out the optimal design variant by checking to which degree different variants fulfil the defined project goals and targets.

**1. Dynamic Thermal Simulation** of a building or reference zones in order to assess annual indoor temperature and humidity ranges as well as hourly heating, cooling and power loads for building operation: Assessment of different design alternatives, solutions and scenarios, building forms and functions;

- Energy performance calculations: Demand and supply, energy required for heating, cooling, humidification, dehumidification, ventilation, pumping, artificial lighting, electric equipment;

- Indoor conditions assessment: thermal comfort estimation based on calculation tools

- Determination of shaded facades: sun study, optimisation of shading device;

- Project-related climate studies: Insolation, total available solar energy and average temperatures, Mollier-Chart (temperature-humidity), wind rose

2. Calculation of benchmarks referring to ecology aspects of the construction (different kinds of material related indices many of which are now defined only on a national or regional basis): Thermal and optical characteristics of materials such as solar reflectance and infrared emmitance, Index of global warming potential, index of photochemical ozone creation potential, index of acidification potential and others;

**3 Life-cycle cost assessment:** Economic evaluation of different variants to identify cost optimal solutions over the life-cycle of the building (as complementary information to construction cost);

## 4.5 Sustainability certification

If the sustainability policy for the project has been set on the basis of sustainability certification schemes (e.g. BREEAM, LEED, DGNB, ITACA), its



achievement has to be checked at certain check-points by assessing the fulfilment of single criteria. Depending on the sustainability certification scheme selected, this refers to criteria in the following fields:

- Management: Project brief and design, LCC, commissioning and handover
- Location and Transportation: accessibility, land protection and facilities
- <u>Sustainable sites</u>: construction activity pollution protection, environmental site assessment, heat island reduction, tenant design and construction guidelines
- ◆ <u>Water Efficiency:</u> water use reduction, water use metering
- <u>Energy and atmosphere</u>: reduction of energy use and carbon emissions, energy efficient equipment, advanced energy monitoring, demand response
- Materials and resources: life cycle impacts, material efficiency, waste management, recycling
- <u>Health and well-being</u>: visual comfort, indoor air quality, thermal comfort, acoustics, safety and security
- ✤ Innovation

These schemes foresee an accredited person in charge of the assessment. Besides an informal check by the design team, most sustainability certification schemes offer the possibility to conduct a formal pre-check by issuing design certificates at different stages of the design process. Figure 9 presents all aspects of sustainability for high performance NZEB buildings.




Figure 9: Sustainability aspects for high performance buildings

# 4.6 Consultancy and Quality assurance

Consultancy regarding an optimized building design and overall performance refers e.g. to building envelope, thermal quality, facade openings, solar radiation with respect to the local climate conditions and focuses on the detailed design phase.

- Thermal bridges calculation: Minimization of condensation risks, minimization of thermal losses;

- Ventilation and Air tightness: Critical points.

The procedure includes the verification of the results achieved with regard to the quality criteria set for the project (sustainability policy, user comfort etc.) through:

- I. Measurements: Blower door test, thermography etc.
- II. User survey coupled to comfort monitoring;
- III. Indoor quality monitoring of installation and setting of technical systems;
- IV. Energy monitoring: Energy data analysis aiming at the detection of shortcomings in building operation;

Other actions within this framework are:

1. Work sessions with the design team for general interdisciplinary issues and guidelines;



2. Work sessions to develop the specific targets of energy performance and environmental concepts for design issues, such as

- a. Heating, cooling, humidification, dehumidification andventilation
- b. Daylight and solar control;
- c. Indoor climate control;
- d. Energy supply strategy (e.g. co-generation, solar heating and cooling, PV, etc.):
- e. Energy monitoring concept: smart meters and systems
- f. Use of materials
- g. Water saving
- h. Outdoor environment and landscape

### 4.7 Measurement of design quality criteria

In the context of remuneration the quantifiable performance criteria that can be applied, are:

- <u>Criteria for energy performance</u>: Different benchmarking at each level of the ID process can be applied as a measure of the energy performance E.g. net heat demand, net cooling demand, final energy demand, primary energy demand, etc. The performance level requires adjustments and clarifications, as well as the verification methodology (e.g. a standardised calculation methodology such as a building simulation).
- 2. <u>Criteria for environmental quality</u>: Sustainability criteria are reflected by sustainability certificates. Thus, sustainability certificates may also be used to define and measure quality. The quality target "LEED Gold" can be measured by applying for a design certificate for LEED; Since the sustainability certificates include a wider range of different topics and criteria as described in paragraph 4.5, the client might wish to select specific focus areas within the frame of sustainability certificates. The achievement of the (sub-) targets defined for these focus areas (such as ecological materials or recyclability) can be measured by applying the verificate.



3. <u>Criteria for life-cycle cost</u>: The usual criterion for economic performance and evaluation in the construction sector is compliance with target values on construction cost. From an ID point of view the construction cost target could or should be complemented by a life-cycle cost analysis. In principle, both values are measurable, although in practice a very clear -definition of the verification methodology is necessary.

The aspect of measurability of the performance criteria for design quality – as described above – is closely linked to the timeframe of measuring the performance of the design team. Obviously, that there is no best solution, but each point in time has advantages and disadvantages in regard to the measurability of design quality so an optimum method can be selected. Table 2 provides a short overview of criteria.

Timeline	Measurability	Advantages	Disadvantages				
Technical Republic Republic University of Crete		Brunel University London	EA exergy 🐺 NUS				

Table 2: Overview of the measurability criteria of ID

645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

after concept design	verification only	design quality	several quality criteria
respectively after	through	(compliance	are
detailed design	calculated quality	with design targets)	not measurable at this
	criteria	depends	stage
		prevailingly on the	
		design	
		team	
after construction	several quality criteria	more quality criteria are	increasing influence
documentation	are already closer to	measurable than in the	of suppliers on the
	reality	earlier	quality by submission
		design stages	of tender materials
after construction	some quality criteria	clearer and more distinct	execution of
implementation	can	picture of the final quality	construction
	be measured directly	of	work introduces an
	already	the project compared to	additional impact on
		the	quality
		predefined quality	
		targets	
after a certain	operation-related	selected quality criteria	besides design
period	quality	can	quality, also
of operation	criteria can be	undergo a reality-check	quality of execution of
	directly	(e.g.	construction work and
	measured	energy consumption,	operational quality
		comfort parameters etc.)	have an important
		,	impact on the overall
			result

The assessment of quality of design work is a complex challenge that offers no simple or obvious solution. Although in theory it is possible to measure certain design-related quality aspects at different points in time, using performance indicators etc, there is hardly any experience of integrating performance aspects into the designer's remuneration.

On the other hand, ID puts forward quality targets and therefore a reflection of this aspect in the remuneration of the designer would be a logical step. Therefore performance-related remuneration elements are proposed to become part of the generic approach for an ID-related remuneration model. Taking the complexity of the topic into account, it is clear that performance related elements are not suitable to become a major part of the designers'



remuneration, but they may serve as extra incentives for performing work better than standard. Bearing in mind this limitation, we think that performance-related parts of remuneration for designers are feasible.

# 4.8 Defining Client's objectives

There are no obligatory requirements referring to the ID process so each Client can choose to approach the aims of Integrated (Energy) Design in a way that best suits their priorities. However, a typical framework could be adopted, highlighting both the iterative procedure and the additional methods available. Key to ID as stated before is the appointment of a core design team from the start of the project that are instructed to work collaboratively and openly to satisfy the Client's objectives and ensure an environmental and energy efficient building operation. Clients should therefore ensure that the core team are appointed at the initial stage of the project.

All information related with the site's environmental factors should be gathered by, or for, the design team, and presented in an easily understood format to all parties. Clients should therefore ensure that appropriate surveys, data collection and reports are both budgeted for in the initial development appraisals and commissioned as early as possible. Inevitably, the Client expectations for the site (especially if the land/building has already been acquired or there is a potential Tenant) are the basis of the procedure. This step determines the brief and gives the design team the opportunity to review elements that may be restricting the optimum design or cost outcome. To this end, an open forum meeting or workshop involving all the design team with the initial Client brief circulated in advance with an invitation to feedback at the meeting is essential. Clients should ensure that time and budget is allowed for this stage, and where a future Tenant is known, he could be involved in the process. The second part of this step is to translate the agreed brief into clear targets for the design team to deliver through the design stage, construction and with the completed project. Where possible, these clear targets should be contractually embedded. An obvious difference between ID and traditional design development is that, for concept designs, the design team should be



required to present several alternative proposals in an iterative way. This helps the reduction of the risk of a single solution becoming overestimated whilst ensuring different approaches are explored. It is important for the effectiveness of the process that Clients ensure the engagement of any known Tenants, and that the design team's appointments reflects the requirements, and moderate time and costs, for undertaking this approach. The series of meetings and workshops, together with a requirement for multiple early concept designs that are assessed both creatively and analytically are the tangible differences of an ID approach versus conventional approaches. The final workshop session for the design team and client should select the optimum design solutions addressing the client's requirements. It should be ensured that the core team presents all the information needed for this meeting, and that any known Tenants or building end-users are present to input into the final selection of the scheme to be developed. Upon the selection of the final design, an updated version of the Client's brief and targets must be generated to accurately represent what is intended to be delivered: Where Tenants are present such updates may also be required to any Agreement to Lease. This updated Brief and associated goals can be used to form contractual obligations, incentive payments or delivery metrics for both the design team and contractor defining the financial aspects of the project. The client objectives should directly feed in to the development outline and detailed specifications and the specific targets reflected in these documents. As a successful project implementation scheme, ID is reliant on communicating the critical issues, notably the client brief and targets, through the whole construction team delivering the building work. This should include embedding the ID goals into all relevant and contractual documentation, but also plans to communicate them to all involved stakeholders. Another aspect that could be taken into consideration is site training in relevant skills. ID is also efficient on communicating the presumptions and optimum usage methods to the end users of the project as well. In this regard, Building User Manuals, "Soft Landing" contracts and early engagement with the building management personal are important.



#### 4.8.1 Capital cost reduction

Adopting an ID approach to design can be an effective measure to reduce the overall capital cost of the project. However, this overall cost reduction is realised in a later phase of the project, and inevitably the initial stages of design work will result in slightly higher costs due to the extra work effort at the early design phases whilst the core design team develop the optimised scheme design. The slight increase in core design team costs are offset through the improved design delivered through the IED process. Typically, an IED approach will add 0.2% to the project costs before planning, but deliver 3% cost saving on the overall capital spend. Cost reductions are realised through a more coordinated and rationalised design that is better understood by the core team, with potential for notably better interaction between architectural envelope and internal services often yielding some of the largest savings. The process of ID can also operate with the adoption of Building Information Modelling (BIM). BIM is a coordinated set of data about the design (often, but not necessarily in 3D) which is developed by the whole design team, and as such fits with the collaborative approach of ID.

#### 4.8.2 Delivery risk reduction

The collaborative design approach embodied within ID reduces the risk inherent in building design and construction processes through better coordination at early stages in the design development, and a better understanding of the underlying design principles by all key parties through improved communication and collaborative working. This risk reduction is complex to quantify, even through the trial ID projects, since it would require identical "non-ID" projects to be coupled for comparative analysis. However, the risk reduction encounters the reduction of problems and deviations which could otherwise result in an increase in project construction budget as well as those which could occur delays to the project implementation.



# 4.9 Defining Tenant's objectives

Construction projects are frequently formed based on anticipated future space requirements identified by companies; such companies then enter in to Agreements to Lease (pre-lets) with developers who, as experienced construction Clients, then design and construct buildings in order to accommodate the company's requirements. At the completion of the building, the company then occupies the space created at previously determined rental rates. Typically, the building asset would also usually be sold by the developer (if not already) to an investment portfolio to other stakeholders. As this remains a proven delivery mechanism, however it does contain a fundamental dysfunction between the future Tenant's requirements and the developer (Client's) motivations and initial targets; the Tenant will typically be driving for low maintenance & operational costs and insist in solutions fitted to their needs, whereas the Client will be proposing low capital construction costs and 'standardised' solutions acceptable to a wide number of tenants. However this proposal might neglect the specific needs of the project. The usual approach to address this issue is through the specifications and requirements embedded in the Agreement to Lease, and for larger schemes a degree of ongoing monitoring through the design development by an appointed team. Many of these specifications will include the principles of collaborative work even though, such references are not adequately or clearly defined in the contract. The ID process provides a clearer mechanism for ensuring the Tenant's requirements which are also highly considered throughout the design process. This also requires the use of ID by Clients as part of Agreements to Lease which provides an improved outcome for the Tenant.

#### 4.9.1 Operational cost reduction

The ID approach is fundamentally intended to assist design teams to ensure that schemes are designed to satisfy the defined objectives whilst using the minimum building operational energy. This is achieved through the creation of multiple design concept and assessing their energy performance. The engagement with this process, foresees that the Tenant is able to directly steer



the developer Client and retained design team towards lower operational cost buildings. It is acknowledged that the developer Client will incur marginally increased design costs for this process, which in result will finally be passed on through future rental to the Tenant. This slight increase in core design team costs is typically more than offset in the construction process through the savings of the proper construction solutions, coordination and efficiency. The adoption of ID can therefore be considered, at worst, as "Cost neutral" for a developer Client. Tenants should therefore resist any developer Clients that attempt to add cost for a requirement to use an ID approach.

#### 4.9.2 Building Unsuitability Risk reduction

The ID approach provides a collaborative design scheme starting with a detailed analysis and refinement of the developer objectives, which for the Tenant is likely to be directly or indirectly derived from the intended specifications in the Agreement to Lease. This provides an initial opportunity to refine the original briefing document and allows the Tenant to gain the benefit of the design teams' construction experience to review, and challenge, their requirements in order to provide the optimum solution. This interactive process provides benefits both for the Tenant by allowing the opportunity to improve the initial specification and plan based on the design team's experience (but not the obligation), as well as ensuring the design team have a thorough understanding of the Tenant's needs in a more explicit way than can be achieved through a written and approved document. Consequently, the ID approach can provide an effective scheme which tailored to the tenant's and client's needs by a combination of the requirements being better quantified and better understood by the whole design team. Figure 10 summarizes the various benefits of a green buildings for developers, owners and tenants.



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



**Figure 10:** The interplay of Green Building benefits for developers, owners and tenants (WGBC 2013)



# 5. Research activities in the Smart GEMS Project

During the secondments in the framework of the Smart GEMS Project several buildings were addressed in this activity in order to:

• Identify and discuss best practices in good designing;

• Analyse the energy needs and simulate improvements from the industrial point of view in order to identify and propose possible improvement related to cost and energy savings in existing buildings.

Implemented research activities can be divided in two categories:

#### Assessment of best practice examples through site visits

These activities were performed during the secondments that were hosted in the University of Athens and included sites visits, meeting with the building managers and assessment of the performance of 4 best practice buildings in Greece:

- > A.N. Tombazis and Associates Architects Office Building
- > Apivita Commercial & Industrial S.A.
- > Stavros Niarchos Foundation Cultural Center
- > Karelas Office Park

The buildings have adopted the ID procedures from the early stages of design until the final completion and operation. Throughout the secondment activities the applied smart technologies have been investigated in relation with the integration to smart grids.

#### <u>Case buildings assessments</u>

Case building were fully assessed during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data. To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the



appropriate tool. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort, an Internal CFD analysis for each thermal zone separately is implemented. The buildings that were analysed were:

- > SUMMA building, Italy
- > KITE lab, Italy
- AEA building, Italy
- > Library building, Greece

#### 5.1 Best practice examples-site visits

#### 5.1.1 A.N. Tombazis and Associates Architects Office Building

The building is located at Polydrosso, Halandri (Figure 11). It is a residential area, on the northern part of Athens, with relatively low traffic. The presented building is the office building of the architectural group A.N. Tombazis and Associates Architects– Meletitiki Ltd. This is one of three office buildings, which are designed as one complex around a common courtyard. Apart from the architectural practice "MELETITIKI – Alexandros N. Tombazis and Associates Architects" Ltd., the complex houses a contracting company and different engineering companies (Figure 12). One of the main issues was saving energy and enhancing comfort and architectural quality. The building was constructed during 1990-1995 and the design as well as the construction was a leading example in the field of sustainability and integrated design in Greece.

The building is located in a residential area in the municipality of Maroussi Athens. The block consists of three office buildings from which the east building is the A.N. Tombazis and Associates Office Building.





Figure 11 Location of Tompazis Office Building (red) and city center (blue)



Figure 12 a. The block of buildings that includes the Tombazis building (left)b. Entrance of Tompazis building (right)

The total building area is  $1100 \text{ m}^2$ . The design is developed in three levels, and basement with parking area. The two long sides of the Office Building are facing east and west. For reasons of bioclimatic design, the building is narrow and long, approximately 8 x 35 m. Thus all workspaces are adequately supplied with daylight through side windows. As many as possible of the mature olive trees that existed on the site have been saved or transplanted. An important feature of the landscaping is the pond, a sculpture by G. Zongolopoulos and the wooden decks that lead to the entrances of the buildings (Figure 13).





**Figure 13** Artificial pool, sculpture, and entrance of the Tombazis building. The interior of the building is one open space developed on three split level decks interconnected at two points by two open steel stairs with wooden treads that have been designed in such a way, so as to provide minimum visual obstruction and can be seen as bridges. Metal trusses support the concrete slabs of the different levels of the building. In order to combine the structural and mechanical depth and increase the perception of openness of the interior space, metal trusses support the concrete slabs of the different levels of the building. (Figure 14).





Figure 14: Interior spaces

The local environmental conditions are the following:

- Microclimate: Suburban
- Average ambient temperature: January 10°C, July 26.5°C
- Global irradiation: 1581 kWh/m<sup>2</sup>
- Sunshine hours: 2818 h

The present office building is an interesting example of a well-designed building from architectural and energy point of view. The shape and the orientation, as well as, the interior planning of the building (it is an open space) give the possibility to exploit the local climate for energy conservation and daylighting purposes. The installation of a BEMS gives the possibility to control all the systems (such as ceiling fans, night ventilation fans, etc.) installed in the building as well as to monitor energy consumption. The building is also equipped with 7 split and 2 single package air-to-air heat pumps for cooling and heating purposes (back-up system). Rainwater is collected and used for irrigation and flushing of the double mode toilets.

The shape of the building and the location of the workstations, near the windows, allow an efficient use of the daylight. The building gets daylight from both sides by windows and from the roof by way of clerestories. Also, these clerestories are equipped with reflective curtains in order to distribute the daylight "deeper" in the building.



- The building including most of the basement is naturally lit by means of sill to ceiling windows that area provided on both long east and west facing facades and clerestories above the two stair wells.
- The east- and west-facing windows are provided with exterior fabric awnings positioned at approximately 15 cm from the wall, which provide both shading and glare control.

The south-facing clerestory is provided with a light shelf on the south side. Ceiling recessed downlights and task lighting compose the artificial lighting system. Artificial lighting is used only in case natural lighting is not adequate. The control of the artificial lighting system is manual on/off (Figure 15 b.) Another important element of building is the shading devices. They are exterior blinds for the windows and interior blinds for the skylights. The material is white plastic cloth, and its height can be adjusted, through a rotation mechanism. On the last level of the building, skylights are constructed, in the middle of the ceiling. They are covered with panels of cloth, which hang from the roof (Figure 15 a.)



Figure 15 a. Natural and b. artificial lighting

Special attention has been paid to a combination of natural ventilation and passive cooling with mechanical ventilation. A central unit controls the system. In this region, the heating and cooling loads of an office-building normally cause high electricity demand. The following extra measures are taken:



- Natural cooling is achieved by evaporative cooling due to the presence of vegetation and water pond, by solar protection of the building shell and by cross ventilation.
- Ventilation and cooling is achieved by cross-ventilation, when appropriate and by automatically controlled ceiling fans, which extend the comfort range from 25°C to 29°C. When temperatures exceeds 29°C a zoned all-air heat pump back-up air-conditioning system turns on.
- Cooling is further enhanced by radiation by the mechanical night ventilation provided by two extraction fans on the roof, which by way of the lower night time exterior temperatures provide a temperature drop of about 3°C the next day.
- The thermal mass of the building is very high.

The exterior of the building is clad with fair-faced cement bricks and has increased 10cm insulation. The U-values of the ground floor, roof and external walls are  $1.41 \text{ W/m}^2\text{K}$ ,  $0.45 \text{ W/m}^2\text{K}$ , and  $0.40 \text{ W/m}^2\text{K}$  respectively.

Acoustics have been given special attention due to their importance in the large open interior space. Metal acoustic panels are suspended from the concrete decks of the different levels in an open configuration that allows for movement of air between the panels and ceiling.

Measurements for a full year (April 1996-March 1997) show the following results: The overall consumption (heating, cooling, lighting, night and day ventilation and equipment) is 90.1 kWh/m<sup>2</sup>. The total consumption for heating is 35.7 kWh/m<sup>2</sup> and 4.7 kWh/m<sup>2</sup> for cooling. The energy consumption for lighting is 3.1kWh/m<sup>2</sup> which on average represents 3.5% of the total energy consumed. A large amount of energy 24.7kW/m<sup>2</sup> is consumed for PC's. As the building is properly designed to reduce the energy consumption for cooling, this parameter represents only the 5% of the total energy consumption. Additionally, the energy consumption for the artificial lighting system is also low (4%), a proof of the right natural lighting design of the building. This is about 10 times cheaper to run this building than another of this type in Greece: in fact, office buildings have a total annual consumption (for heating and cooling) from 50 to 240



kWh/m<sup>2</sup>/year, while the Tombazis office building consumption for heating and cooling is 41.4 kWh/m<sup>2</sup>/year.

The energy used for heating, cooling and electricity was obtained from meter readings for 9 different points in the building and from energy bills. The *total yearly energy consumption* for the monitoring period (May 2008-May 2009) was 79.7 kWh/m<sup>2</sup> (corrected for hours of use) with a breakdown as follows: i) heating 29.2 kWh/m<sup>2</sup>, ii) cooling 18.8 kWh/m<sup>2</sup> iii) lighting 2.7 kWh/m<sup>2</sup> iv) ventilation 1.2 kWh/m<sup>2</sup> v) PCs 15.5 kWh/m<sup>2</sup> vi) other 12.3 kWh/m<sup>2</sup>. Regarding lighting, the national average is about 30-40% of the overall building consumption, while in such a building is up to 3.5%. The total construction cost was about 1,000,000  $\in$ .

#### 5.1.2 APIVITA Commercial & Industrial S.A.

The new APIVITA building is in tune with the company's philosophy and values, symbolizing sustainability, innovation and a unique way of connecting the workplace with the natural environment. It is located in the Industrial Park of Markopoulo, Attica, Greece, in an area that was once an olive grove; this is an example of a building of NZEB principles in design phase (Figure 16).



Figure 16: Location of APIVITA Building (red) and city center (blue)



In terms of architectural design, the building simulates a beehive, which brings together all the company's activities, such as offices, training, museum, laboratories, cosmetics production, honey packaging, bee pollen and royal jelly, personnel dining hall, SPA and events. The building covers a total surface of  $6,830 \text{ m}^2$  in five levels, two underground and three aboveground, in an area of  $6,170 \text{ m}^2$  (Figure 17).



Figure 17: APIVITA interior space

The key feature of the central atrium is an olive tree, the symbol of serenity, protection and fertility. It is known that APIVITA combines the ancient Greek tradition with the rich Greek flora, focusing on the life of the bee, and creates natural, ecological, effective and holistic cosmetics. It draws inspiration from the beehive, and therefore the society of the bee. The beehive and the society of the bee lead to the main features are cooperativeness, dedication to a common goal, respect to one another and to the environment, the attempt to achieve high qualitative goals.

As a natural outcome of these elements, the beehive worked as an archetype for the construction of the new facilities, in terms of togetherness, allocation and use of the space and mainly functionality, having as a dominating criteria the comfortable, human living of the employees.



As an extension of the factory, right opposite, there is the space of interactive contact with the Greek biodiversity, a miniature of the sources of inspiration of the company: the olive trees, the working society of the bees and a labyrinth made from lavenders and rosemaries, which invite us to forget for a while our daily concerns, to recharge our energy levels and understand the uniqueness of the principles of the company.

The construction of the building was based on the following criteria:

- Simplicity, aesthetics and functionality
- Natural lighting and ventilation
- Respect to natural resources and local biodiversity
- Bioclimatic Design
- Reduction of ecological footprint
- Thermal and visual comfort
- Recyclable, natural and ecological Greek building materials.

To manage the natural sources the following technologies are used:

- a system for geothermal energy exploitation
- photovoltaics
- a rainwater tank, where water from the building and from the environment are gathered, to be used for watering.
- biological waste cleaning and disposal of the water for watering
- green roofs on the first and second floor
- large plantations in the surrounding space, with aromatic, pharmaceutical Greek plants and herbs, fruitful trees and species of the local flora with about 200 species and 5000 plants in their gardens located also on the roofs and balconies, so that the microclimate serves the biodiversity (Figure 18).

The building is mainly made of glass and the energy needs are in charge of geothermal energy system and PV production. Additionally, rain water from the building and from the environment is collected, filtered with a double-pass osmosis treatment and then used for watering.



Natural light infiltrate the building and in winter the solar radiation heats the air; on the contrary, in summer it helps the air ventilation due to proper openings at the top and the bottom. Moreover, interior plants improve air quality.



Figure 18: Plantation in the area of APIVITA building

The offices are situated on the first and the second floor of the building, in a rectangular space with clean geometric lines. The ground floor hosts the two main production lines, namely cosmetics and honey packaging. The first floor underground hosts the packaging department, as well as the accompanying storage rooms. In the same floor we can also find the restaurant. The storage rooms for the packaging materials and the engine rooms are situated on the second floor underground.

The main goal of the architectural design was to shield the building from external environmental factors.

The shaded patio in the entrance area and the four glazing storeys allow natural light to infiltrate the building. Thus, during the winter, the solar radiation entering the building from the southern wall heats the air. During the summer, it acts as a ventilation hopper due to the proper openings at the top and the bottom that facilitate the air movement. The interior planting acts as a natural air purifier and maximizes the energy benefits by cooling the air.

All building materials are certified with ISO, and most of them are ecologicalnatural and recyclable, the spaces were constructed according to FDA standards (production, packaging, weighing, sampling) and for the lighting of the offices and all internal spaces there are lights of low consumption, while for the outside spaces they are LED.



On the surrounding space there was an attempt to maintain the local flora of the area so the herbs planted outside the building are endemic, aromatic, Hippocratic plants and herbs; olive trees that existed there before were planted back and the planting was enriched with fruitful Greek and endemic trees. Further to the green roof on the first floor, a botanical garden was created with Greek aromatic, pharmaceutical and Hippocratic plants and herbs, which are used by the company at the production of its products.

**About the ID process:** The design process of the building adopted from the very early stages the company's philosophy of sustainability, simplicity and functionality. All stakeholders were involved in the project from the early stages and formed a partnership. The project team worked together adopting a holistic approach towards all major aspects: energy, environmental, comfort, economic.

#### 5.1.3 Stavros Niarchos Foundation Cultural Center

The Stravros Niarchos Foundation Cultural Center (SNFCC) is located in Faliro in Greece (Figure 19). The SNFCC has been designed by Renzo Piano and it comprises three main parts: the National Library of Greece, the Greek National Opera and the Stravros Niarchos Park of 170,000 m2 aiming to restore the site's lost connections with the city and the sea (Figure 20). The construction of the SNFCC has created about 1,500 jobs and, approximately, about 160 million € of annual throughout the Greek economy as a The SFNCC park and the roof of the Opera include Mediterranean flora: this will increase enormously in the area and new ecological systems will be introduced. The large site's green surface will cause a decrease in carbon emissions and an improvement in the air quality.

Sustainability is one of the SNFCC's fundamental values. The creation of an environmentally friendly and sustainable infrastructure for the buildings and the Park is an important goal in the design and construction of the Stavros Niarchos Foundation Cultural Center. Through environmentally innovative designs and practices, the project aims to earn at least Gold and ideally Platinum LEED



certification, the first such designation in Greece and the first for a project of this scale in Europe.



Figure 19: Location of the SNFCC (in blue)



Figure 20: The Stavros Niarchos Foundation Cultural Center and Park © Yiorgis Yerolymbos



As one of Athens' earliest seaports in Faliro Bay, Kallithea has always had a strong relationship with the water. To permit the view of the sea from the site, an artificial hill was created at the south (seaward) end of the site. The sloping park culminate in the cultural centre building, giving it spectacular views towards the sea.

Both opera and library are combined in one building, with a public space, known as the Agora, providing access and connections between the two main facilities. The opera wing is composed of two auditoria, one (450 seats) dedicated to traditional operas and ballets, the other (1,400 seats) for more experimental performances. The library is intended not only as a place for learning and preserving culture, but also as a public resource, a space where culture is truly accessible to share and enjoy (Figure 21, 22).



Figure 21: The design of the Library and Opera



Figure 22: The Library building (left) and the Opera building (right) of the SNFCC ©Yiorgis Yerolymbos



The entirely glass-walled library reading room sits on top of the building just underneath the canopy roof. A square horizontal transparent box, it will enjoy 360-degree views of Athens and the sea.

The site's visual and physical connection with water continue in the park with a new canal that will run along a north–south, main pedestrian axis, the Esplanade (Figure 23). The canopy roof provides essential shade and it is covered with 10.000 sq. m of photovoltaic cells, enough to generate 1.5 megawatt of power for the library and opera house (Figure 24). This field of cells should allow the building to be self-sufficient in energy terms during normal opening hours. Wherever possible, natural ventilation will be used.

The visual connection with the water will continue to the park, where it will focus on a channel to the side of the Esplanade, the main pedestrian axis of the site, in the north-south direction.



Figure 23: The Esplanade of SNFCC © Yiorgis Yerolymbos



Figure 24: Works during the installation of the PV system at the roof  $\ensuremath{\mathbb{C}}$  Yiorgis Yerolymbos



About the ID process: Before the commencement of any procurement or construction activity all technical documents produced by the Contractor (Construction Drawings, Method Statements, Material submittals etc.) are subject to the review and approval of SNFCC specialists. Such a procedure coupled with the everyday general and contractual correspondence necessitates the exchange of enormous amounts of documents within and between the three main participating entities i.e. the (a) Project Designers, (b) Employer and its Representatives and (c) Contractor and its Consultants/ Subcontractors. The overall project design is driven by the highest environmental goals and international standards which are summarized in the following principles: Strict Compliance with the Environmental Impact Study and Environmental Terms approved by Greek Authorities Achievement of Platinum LEED certification Compliance with the highest international environmental standards. The same principles, which have already been applied in the design, are followed in every day construction activities. The key participants in this special task are the SNFCC consultants and auditors, which include LEED specialists, third party environmental inspectors and the Contractor's LEED certified supervisors. Monitoring results are documented by a thorough and systematic record keeping. The status of the environmental conditions on site is constantly audited and evaluated through both periodical and ad hoc meetings recorded in monthly reports.

#### 5.1.4 Karelas Office Park

The Karelas Office Park of 61,574 m<sup>2</sup> is located southeast of Athens following sustainability and innovativeness concepts (Figure 25). The complex has a built area of 30,000 m<sup>2</sup> above ground and 30,000 m<sup>2</sup> underground. The total value of the project was 119 million euros and it was completed in 2012 (Figure 26). Gardens full of Mediterranean flora are spread all over the roof and there is also a path where people can have a walk and relax enjoying the plants and the view (Figure 25, 28). The building was the first in Greece that was certified with a LEED GOLD certificate.





Figure 25 Location of Karelas Office Park (left) b. The green rooftop of the building (right)



Figure 26: Façade movable shading devices

The company aim is to achieving reductions in energy consumption whilst simultaneously satisfying the thermal comfort needs of its users. The main entrance has glass ceiling that enables natural lighting and walls are covered by bamboo steaks (Figure 27).

The measures implemented within the business network including the following:

- Free Cooling techniques from the very beginning of the Network construction.
- High Efficiency Rectifiers in Network BTS with high load.
- Modernization of the Network Telecom Equipment.
- Hybrid Systems with batteries and GNs.
- Use of renewable sources of Energy (Wind Turbines, Photovoltaic Systems).



- Data Centers operation according to EU Code of Conduct.
- Solar vacuum tubes in the main Warehouse premises in Avlona.
- Roof Garden in the Karelas Office Park.
- Building Energy Upgrade resulting in improved comfort conditions whilst achieving significant energy saving accomplished in the biggest Call-Center Building.
- Building Management Systems in Office Buildings and Data Centers.
- Smart metering and tele-management systems.
- Energy model predicting the CO<sub>2</sub> footprint.
- Recycling of used material (paper, etc.)
- Special treatment of waste that contaminate the environment (e.g. electronic equipment, lead batteries, etc.)
- Monitoring of materials used and waste generated
- Corporate Responsibility Report with targets and measurements.

Following the presentations, the project participants were taken on a tour of the Karelas Office Park where some its implemented energy saving measures were presented. The technologies demonstrated included the following (as seen in the pictures). Figure 29 presents the central solar thermal system of the building for hot water needs.



Figure 27: Building atrium for natural day-lighting (left), Atrium façade bamboo shading devices (right)





Figure 28: Roof garden



Figure 29: Central Solar Thermal System



# 5.2 Case buildings assessments

Table 3 summarizes basic information and Integrated Design concepts for the buildings under investigation

Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
		Via Fiume, 16,	External Walls	119.4MWh (2014	Approximately 100 implemented smart meters
SUMMA	Offices &	60030 Angeli di	(Summa): Cladding,	before the	recording the energy consumption of the
	Warehouse	Rosora,	Insulation (Polystyrene),	implementation of	building and also the produced energy by the
		Ancona, Italy	Plasterboard	the Heat Pump	PV systems.
		4005	(U <sub>v</sub> =0.452 W/m <sup>2</sup> K)	and without	Renewable energy production by the installed
		1985	External Walls (TM):	regarding energy	PV systems on the roof of the building. The
		constructed	Cladding, Plasterboard	coming from the	results show a cumulative energy production of
			(U <sub>v</sub> =1.365 W/m <sup>2</sup> K)	micro grid, also	34.525kWh.
			Internal Walls: -	few of the	• Reduced CO <sub>2</sub> emissions throw RE production.
			(U <sub>v</sub> =1.674 W/m <sup>2</sup> K)	recorded values	Connection with the micro grid and the thermal
			Roof: Acciaio, fiberglass	are reconstructed	storage establishing energy efficiency.
			(hardboard), concrete	and missing data	
			(U <sub>v</sub> not provided)	of December	<ul> <li>Although half of the building (Summa) is well</li> </ul>
				2014)	insulated (U <sub>v</sub> =0.452 W/m <sup>2</sup> K), the remaining part

 Table 3: The buildings under study for IED and NZEB concepts



Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
			Windows/Doors: Double	In comparison	(TM warehouse) has poor thermal performance
			glazed	with the recorded	(U <sub>v</sub> =1.365 W/m <sup>2</sup> K)
			(U <sub>v</sub> =2.510 W/m²K / U <sub>w</sub>	energy data of	Sliding doors cause a poor value in air tightness,
			=2.347 W/m <sup>2</sup> K / U <sub>g</sub>	2015 and 2016	resulting in an infiltration rate of 1,63 ac/h
			=2.763 W/m <sup>2</sup> K)	the energy	
			Industrial Door:	consumption of	
			(U <sub>v</sub> =3.509 W/m <sup>2</sup> K /	the building is at	
			U <sub>g</sub> =5.468 W/m <sup>2</sup> K /	least one order of	
			U <sub>w</sub> =3.309 W/m <sup>2</sup> K)	magnitude	
				reduced.	
					The Kite Lab building is a newly constructed
KITE Lab	Offices,	Via Fiume, 16 –	Combination of different	Data provided	building that meets the most of the necessary
	Laboratories	Angeli di	types of uses. Typical	from April 2016	directives to follow the IED procedures. First of all
	and Test	Rosora (AN),	rectangular construction,	and forth.	the cell of the building is constructed to meet the
	rooms	built at 2015	constructions are still in	Consumption for	demands of a NZEB building. Furthermore all of
			progress in the 6 <sup>th</sup> test	April to August	the specifications of the materials, components and
			room of the building.	2016 is 132 MWh	HVAC systems are described in various
			Improved insulation,	or 37.6 kWh/m <sup>2</sup>	documents. The building is self-sustainable by
			highly efficient HVAC		means of renewable energy consumption in some
			systems installed,		extent. The connection with the micro-grid ensures
			connected with the micro-		that all energy produced by the hydro plants and
			grid and the thermal		the various PV systems is distributed throughout











Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
			storage. Installation of		the network. The Thermal storage ensures that the
			highly efficient PV panels.		excessive energy is saved and distributed in less
					productive parts and times. Each of the HVAC
					systems installed is highly efficient strengthening
					the general efficiency of the grid. All components
					are well documented. The building is yet until today
					modified and optimized. Smart metering ensures
					that each component is monitored and recorded for
					further analysis. With the use of the 3d modeling of
					the building further analysis and optimization of the
					buildings systems can be conducted.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
AEA	Offices,	Via Flume n. 16	The scope of the	558,747 kWh (for	The choice and/or the combination of the above
	Laboratories,	– 60030 Angeli	optimization procedure is	2014)	measures would be made, provided that these are
	production	di Rosora (An),	to suggest measures		the economical/technical solutions. This would be
	line	2002	which will result in the		the result of the optimization process taking into
			best energy performance,		account not only the investment/installation costs
			taking also into account		but also the variable running costs. The scope after
			the bulding's		all is to ensure that the AEA Building would be an
			incorporation in Loccioni's		nZED Building meeting the IED standards.
			micro grid.		
			• Use of innovative		
			materials for the		
			construction		
			• Replacement of the		
			systems for heating,		
			cooling and hot water		
			with the best available		
			technologies		
			(geothermal heat		
			pumps, district		
			heating/cooling systems,		

645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
			absorption/adsorption		
			chillers, hybrid boilers).		
			Installation of PV		
			systems with improved		
			collectors.		
			<ul> <li>Thermal/Chemical</li> </ul>		
			storage		



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Building	Туре	Location and	Main characteristics	Energy	Concepts of IED
		Year of		consumption	
		construction			
Library	Library	University	The Science Library	Thermal power	Enhancing the Integrated Design concept of the
Building	Offices	Campus,	building is composed by 4	[kW] provided by	building there was the definition of the size of a
		Athens, 2009	floor, each one has a	the 7 distribution	CSP (Concentrating Solar Plant) useful to drive an
			useful surface area about	sub-system of	absorption heating and cooling system to cover
			of 1,580 m <sup>2</sup> and a volume	HVAC system	completely the cooling energy needs of a building
			about of 5500 m <sup>3</sup> , built in	used to size the	and partially the heating, working in heating mode
			2009. Overall, the existent	solar thermal	with the integration of the existent HVAC system
			centralized HVAC system	power and	
			provide heating cooling	absorption	
			and ventilation for about	chillers system.	
			of 22,000 m <sup>3</sup> of useful	At peak	
			volume	conditions:	
				heating 405.3	
				kWh	
				Cooling	
				713.7kWh	



#### 5.2.1 SUMMA building

#### 5.2.1.1 Introduction

The aim of the specific report is to present the work at AEA SrI (Loccioni Group) regarding integrated design and NZEB concepts for buildings. Since buildings are major consumers in smart grids, the integrated design task will assist to develop a collaborative method for designing buildings integrated in smart grids. The integrated design process requires multidisciplinary collaboration, including key stakeholders and design professionals, from conception to completion. Decision-making protocols and complementary design principles must be established early in the process in order to satisfy the goals of multiple stakeholders while achieving the overall integration design objectives.

One of the key objectives of this work concerns the development of skills for smart buildings' operation in order to assist the penetration of smart technologies. Specifically, smart controls and advanced monitoring for buildings' design and operational phase are investigated in the main core of AEA buildings; the headquarters. Furthermore optimal operation and testing by using advanced modelling techniques are exercised.

In order to enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus a thermal simulation model has been developed using the appropriate tool. The building that has been selected to be modeled is a 2-storey office building at AEA's property, the oldest building that exists in the area. The building was retrofitted in 2010 and a high number of smart meters where installed for monitoring energy consumption and energy production from the installed photovoltaic panels on the roof. Also, to estimate and establish the best case scenario concerning the energy consumption of the HVAC system as a function of thermal comfort internal CFD analysis is performed for each thermal zone separately. The purpose of CFD analysis is enumerated analytically below:

 Accurate assessment of occupancy; thermal comfort is essential for successful building design.


- 2. Comfort can vary considerably from one side of a room to another depending on factors such as the location of supply diffusers, radiators, computer equipment, etc.
- 3. Detailed evaluation of both HVAC system and air flow (cold/hot air) inside each thermal zone.
- The HVAC system requires more than simply making sure that mechanical heating or cooling system offer sufficient capacity to offset spatial loads.
- 5. It is equally important to determine that the delivery system is providing an adequate distribution of temperature and fresh air throughout the space.

# 5.2.1.2 Innovation of approach

Nowadays, the building sector is the largest consumer of energy in European Union, corresponding to 40% of total energy consumption and 36% of  $CO_2$  emissions. Currently, about 35% of the EU's buildings are over 50 years old. By improving the energy efficiency of buildings, we could reduce total EU energy consumption by 5% to 6% and lower  $CO_2$  emissions by about 5%.

Two main directives have been conducted to describe analytically the actions and plans of each European country. The 2010 Energy Performance of Buildings Directive and the 2012 Energy Efficiency Directive.

Under these legislations:

- All new buildings must be nearly zero energy buildings by 31 December 2020 (public buildings by 31 December 2018)
- EU countries must set minimum energy performance requirements for new buildings, for the major renovation of buildings and for the replacement or retrofit of building elements (heating and cooling systems, roofs, walls, etc.)
- EU countries have to draw up lists of national financial measures to improve the energy efficiency of buildings
- EU countries make energy efficient renovations to at least 3% of buildings owned and occupied by central government
- EU governments should only purchase buildings which are highly energy efficient



- EU countries must draw-up long-term national building renovation strategies which can be included in their National Energy Efficiency Action Plans [12]
   In order to predict the performance of buildings under real conditions, simulation modeling processes have been adapted from engineers, designers and building physicists. Three main methodological branches are considered dominant for building energy related simulation and assessment [13]:
- White box models: Based on physical knowledge of the system and thermal balance equations. These are often obtained through energy simulation software like EnergyPlus, TRNSYS, etc.;
- Black box models use only measured input/output data and statistical estimation method.
- Grey box models: A mix of the first two categories using input/output data as well as some a priori knowledge on the system. A popular grey-box model is the equivalent RC.

In this study a white box model to simulate Loccioni Summa building was developed due to its high accuracy, reasonable calculation speed and reliability for optimization and control.

# 5.2.1.3 Description of SUMMA building

The building is located at Angeli di Rosora (Figure 30), a valley in the middle of Italy's mainland. Angeli di Rosora is a small village of the province of Ancona 40km away from city centre. The area is surrounded by small hills crossed by a river. The microclimate is highly affected by local conditions characterized by moderate winters, humid and hot summers and quite high levels of rainfall. Thus it is classified as a 4A according to ASHRAE climate zones [14].





Figure 30 Satellite image of the selected building.

Summa building, together with the other four buildings of Leaf Community, are connected into the company's micro grid. In 2008 the company launched the "leaf community" project, accepting the challenge of sustainability, carbon footprint minimisation and renewable sources deployment. The company created around its headquarters a double grid installing solar panels on buildings' roofs, river micro-hydro power production units as well as biomass implants. The electric grid is built to have only one connection point with the main electrical grid and an internal medium voltage (MV) distribution system, to which all the sustainable plants and industrial buildings are connected.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 31: Loccioni's Micro grid connection.

The micro grid connection enhances the prospects of energy efficiency for the Leaf Community. The energy produced from the roof of each building may be used for operational purposes and surplus energy is distributed to the micro grid. Surplus energy may be used by other buildings, stored using batteries or forwarded to the national grid.

The impact of the micro grid and the electrical storage has both economic and environmental benefits. On the one hand it is crucial for the company to consume its own produced electricity. In that way, the savings of electrical consumption and additional fees corresponding to Italian economic regulations are established. Also the company is reducing the emissions of GHGs ensuring environmental remediation. Finally, in future, by reducing even more the energy



consumption (especially for cooling) of each building could lead to a more stable path of energy efficiency.

# 5.2.1.4 Geometry

The building consists of two rectangular shaped constructions; a major one which includes the offices and a smaller used as a warehouse. The offices comprise of two floors, the ground floor which is split in 13 thermal zones including:

- ✤ 4 Meeting Rooms
- Communication Room
- Control Room
- Conference Room
- Entrance and Offices
- 2 Bathrooms
- Kitchen
- 2-Storey Rooms

The first floor includes:

- Offices
- Meeting Room
- Library
- Bathroom
- ✤ Wardrobe

The ground floor and the first floor are connected with an internal staircase (Fig. 34c). Figures 32, 33 display the ground plan of the building for both floors. The area and the volume of each floor of the building as well as the area of the occupied roof are presented in Table 4. The orientation and the size of the building's windows and doors are presented in Table 5.



	Area	Volume
	(m²)	(m³)
Ground floor	856.74	4094.6
1st floor	180.5	505.4
Occupied Roof	552.0	
Total	1037.24	4600.0

Table 4: Area and volume of each floor of SUMMA building.

#### Table 5: Orientation and size of building's windows and doors.

Type of				Height	Width
opening	Number	Opening orientation	Floor	(m)	(m)
Window	3	EAST	Ground floor	1.9	1.2
	7	EAST	Ground floor	1.2	0.8
	5	EAST	Ground floor	1.2	1.2
	4	EAST	1st floor	1.3	0.9
	2	EAST	1st floor	1.3	2.0
	11	WEST	Ground floor	0.8	1.0
	11	WEST	Ground floor	2.1	1.0
	8	SOUTH	Ground floor	1.25	2.3
	4	SOUTH	Ground floor	1.25	1.0
	8	SOUTH	1st floor	1.25	2.3
	4	SOUTH	1st floor	1.25	1.0
	8	NORTH	1st floor	1.3	2.3
	10	NORTH	1st floor	1.3	1.0
	1	NORTH	Ground floor	0.9	2.8
	1	NORTH	Ground floor	0.9	0.8
	2	NORTH	Ground floor	1.2	2.0
	11	NORTH	Ground floor	1.2	1.0
Door	2	WEST	Ground floor	2.0	1.0
	1	WEST	Ground floor	4.0	3.4
	1	EAST	Ground floor	4.0	3.4
	1	EAST	Ground floor	2.0	0.9
	1	NORTH	Ground floor	2.4	1.4
	3	NORTH	Ground floor	2.4	1.3







Figure 32: CAD drawing for Ground Floor of SUMMA building.



Figure 33: CAD drawing for First Floor of SUMMA building.



Following the geometry and the openings/doors that exist in the building and taking into account the parameters that play a significant role in propagation and exchange of heat, the whole rectangle building was split into different thermal zones, as shown in Figure 34.



Figure 34: Ground Floor (A), 1<sup>st</sup> Floor (B) separation in different thermal zones. 5.2.1.5 Thermophysical characteristics

The load bearing structure of the office building consists of 3 layers. The outermost layer is of aluminum cladding, the innermost of typical Plasterboard and some of the external walls contain in the middle a standard insulation from polystyrene. The windows have been recently replaced by double glazing windows. The thermophysical characteristics of the building components are presented in Tables 6-8.



#### Table 6: Thermophysical characteristics of the building envelope

Building envelope	
Walls	U value = 0.452 - 1.365 W/m <sup>2</sup> K
Roof	U value = not provided
	SR = not provided
Windows	Uw = 2.347 – 2.401 W/m <sup>2</sup> K
	Ug = 2.763 W/m <sup>2</sup> K
Floor	U value = 1.674 W/m <sup>2</sup> K

#### Table 7: Construction Template information for the baseline condition.

	U-value	Thickness	Materials
Construction	(W/m²*K)	(mm)	(Outer to Inner)
	U value (W/m <sup>2*</sup> K)	Thickness	Materials (Outer to Inner)
Construction		(mm)	
Roof	Not provided	Not provided	Not provided
Internal Walls	Not provided	Not provided	Not provided
			Gypsum plaster(20mm)-outer,
External Walls	0.452	283	cladding(200mm), Insulation
(Summa)			polystyrene(50mm),
			plasterboard(12.5mm), Gypsum
			plaster(5mm)-inner
			Gypsum plaster(20mm)-outer,
External Walls	1.365	237	cladding(200mm),
(TM)			plasterboard(12.5mm), Gypsum
			plaster(5mm)-inner
Floor	1.674	150	concrete(300mm)

#### Table 8: Openings Template information for the baseline condition.

Openings	Glazing Template
Glazing type	Double
Thickness	6 mm
Gas	None
Glazing U - value	2.76 (W/m²*K)
Frame type	Wood/Aluminium
Frame U - value	2.50 (W/m <sup>2*</sup> K)
Shading	Blind with medium reflectivity slats
Doors	Exit/Industrial Door
Material	Glass/Aluminium
Thickness (glass)	10/6 mm
U - value	2.574/3.509 (W/m <sup>2</sup> *K)







# 5.2.1.6 Operational conditions

A major task of the simulation methodology was the identification of the activity and the corresponding schedules of the occupants in active situation. For this purpose several interviews with the person working at the reception area and the communications manager were conducted. Some of the major inputs on activity template are described in Table 9:

Activity	Unit	Scale
Occupancy (Density of people)	$(\text{people}/\text{m}^2)$	0.01-0.2 according to
	(people/in )	thermal zone
Winter Clothing	(clo)	1
Summer Clothing	(clo)	0.5
Metabolic rate	(met)	1.5
Holidays	(days)	0-30
DHW consumption	(L/m <sup>2</sup> -day-person)	0.1
Heating setpoint Temperature	٥C	21(±2)
Target Illuminance	(lux)	500
Cooling setpoint Temperature	٥C	25(±2)
Relative humidification setpoint	%	40
Relative dehumidification setpoint	%	40
Electrical equipment	(W/m²)	·····

## Table 9: Activity Template information for the baseline condition.

# 5.2.1.7 Installed systems

Internal gains resulting from occupancy, lighting and electrical equipment act as a heat source for each thermal zone and affect the environmental parameters. Thus, an integrated assessment of these factors was appropriately completed. In order to prepare the necessary lighting template, the simulation tool requires converting the lighting power according to the form below:

Max Lighting power (W) = Lighting energy ( $W/m^2/100lux$ ) x Zone floor area ( $m^2$ ) x Zone flour area ( $m^2$ ) x Zone ( $m^2$ ) x Zone flour area ( $m^2$ ) x Zone ( $m^2$ ) x Zone ( $m^2$  x Zone ( $m^2$ ) x Zone ( $m^2$  x Zone ( $m^2$ ) x Zone ( $m^$ 

For example the lighting system of the "Communication Room" zone emitting 14W/m<sup>2</sup> is equal to:

Max Lighting power (W) =  $648W/46,93m^2 \approx 13,81W/m^2 \approx 2,76W/m^2-100lux$ 



Also, the lighting energy should be a function of the maximum electrical power input to lighting in a zone, including ballasts, if present. This value is multiplied by a schedule fraction during the simulation to get the lighting energy in a particular time step. The illuminance level of each zone is set at 500lux by the BEM system.

In parallel a template referring to electrical equipment must be imported into the model at the initial stage of the building modelling for the estimation of internal gains (Table 10). Different recessed luminaire types met in Summa building are presented in Fig. 35 while Table 10-11 presents the lighting power of each zone.

Table 10: Lighting Template information for the baseline condition.

Lighting	Lighting Template
Lighting type	Low standard- incandescent
General lighting	0.32-2.76(min-max) (W/m <sup>2</sup> -100 lux)
Visible Fraction	0.18
Radiant Fraction	0.42
Convective Fraction	0.40
Lighting control	Yes



Figure 35: Different recessed luminaire types met in Summa building.



Zone	Lighting Power
1 <sup>st</sup> Floor	[W]
Hall	168
Owners Offices	952
Meeting Room	112
WC	20
Wardrobe	20
Library	20
Ground Floor	[W]
Meeting Room 1	100
Meeting Room 2	216
WC	1080
Meeting Room 3	216
Meeting Room 4	864
Hall	175
Communication Room	648
Conference Room	1350
Entrance & Offices	5259
Kitchen	72
WC	144
Warehouse	792

#### Table 11: Lighting power of each zone.

Electrical equipment has been verified by energy auditing of the building in collaboration with the building manager. The installed devices and the characteristics are depicted in ANNEX 1. In Figure 36 an example of electrical equipment template is presented.



#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 36: Sample of electrical equipment template used in the simulation.

Table 12 presents some of the major energy intensive devices located in the warehouse and others used in the offices.

Electrical Device	Power (kW)
Daikin AKZT437	3.48
LUBE 285060CN	-
MAZAK INTEGREX 200IV	28
MAZAK VTC-300C	11
DART VMC-1000	7.5
NORBLAST	0.14
LEONARD RCL 2.4	18.5
Dyson Airblade	1.6
Xerox Digital Printer/Copier	0.08-1.1(standby-fully operational)

#### Table 12: Dominant electrical devices used in the building.





There is an installed water to water heat pump system which is used both for heating and cooling using electricity from the grid (Power: 213.51 kW/ COP= 5.57) as depicted in Figure 37.



Figure 37: Water to water Heat Pump in the storey of ground floor.

Natural ventilation is used rarely by opening of the windows during recess. Mechanical ventilation is distributed in the building by fans placed in the ceiling (Power: 3.4-24.6kW), (Figure 38).



Figure 38: FCX fan placed in the ceilings of Summa building.

### 5.2.1.8 Energy cost

According to the utility company (ENEL), the cost of the kWh for electricity in 2015 was 0.06750 €/kWh for consumption between 08:00-19:00 in working days and 0.05250€/kWh between 19:00-08:00 in working days, weekends and official holidays.



# 5.2.1.9 Energy savings calculation methodology

This section presents the methodology adopted for the energy savings. More specifically, the methodology corresponds to the ASHRAE Guideline 14-2002 "Measurement of Energy and Demand Savings" and in the International Standard ISO 16346:2013 "Energy performance of buildings – Assessment of overall energy performance" as described in the "Methodology for the calculation of the Energy Savings, LV, July 2014" report.

In order to calculate energy savings a whole building calibrated simulation method was developed based on a multi-zone energy model, dynamic simulation with a 8760 hours weather file, using Design Builder software [15].

The comparison between measured data and the outputs of the model simulation correspond to hourly data. The acceptable tolerances are measured by the statistical indexes of Mean Bias Error (MBE) and Coefficient of Variation of the Root Mean Squared Error (RMSE) defined below:

Hourly mean bias error:

$$MBE = \frac{\sum_{i} (Tmeas - Tsim)i}{\sum_{i} (Tmeas)i}$$

Coefficient of variation of the root mean squared error:

$$CV(MSE) = \frac{(\sum_{i} (Tmeas - Tsim)^2 / (n-1))^{1/2}}{\overline{Tmeas}}$$

The maximum tolerances are presented in the following Table 13:

Table 13: Maximum tolerances for the BEM and CV statistical indexes.

Index	Hourly data	Monthly data
BEM	10%	5%
CV (MSE)	30%	15%

Until the above tolerances are met the model is refined so that an acceptable calibration is achieved. Occupant behaviour, electrical operation schedules,



interior air temperature set-points, airing, opening of interior doors, etc. are estimated using data from sensors, metering, user interviews and in-situ observations. It is important that the values observed in the meters (real values) are comparable to simulation results (estimated values). The calibration process is sensitive, so the "parameters adjustment" is done taking into account all the information referenced above.

# 5.2.1.9.1 Baseline simulation model

As mentioned in the previous section the baseline simulation model has been developed using Design Builder software. The required data which have been entered as inputs in the model consist of four general clusters:

- 1. Climatic Data
- 2. Geometry and Thermophysical properties
- 3. Operational conditions
- 4. Energy systems

Climatic data consist of hourly data that corresponds to the same time period as the energy use data (January 2015 – December 2015) including:

- Outdoor Dry Bulb Temperature [°C]
- Atmospheric Pressure [kPa]
- Outdoor Relative Humidity [%]
- Global Solar Radiation [W/m<sup>2</sup>]
- Diffuse Solar Radiation [W/m<sup>2</sup>]
- Wind speed [m/s] and Wind Direction [degrees]

The aforementioned data have been obtained as described above by the following sources:

- 1. Local weather stations;
- 2. International weather database (Meteonorm);

Energy data was monitored in the exact same period with smart meters as described in section 2 and consist of:

- PV's Energy Production [kWh]
- HVAC system Energy Consumption

The geometric data was obtained by drawings (plans, cross-sections, prospects) and validated by audit on site while the thermophysical properties of



the building envelope components were obtained by National and European reference data according to typology, age, structure and location of the building. The operational conditions were collected by an accurate building inspection and by employments interviews. The conditions include:

- Building operation schedule
- Number of occupants and related activities
- Internal heat sources (appliances, personal computers, artificial lighting);
- Natural and/or mechanical ventilation rates

The energy systems were taken into account to calculate the primary energy consumption in the building. The following aspects were taken into account to define the standard conditions:

1) Indoor climatic conditions (temperature and relative humidity set-points, and the respective set back points)

2) Schedules of the heating and cooling systems

3) Efficiencies of the energy systems including the Coefficient of Performance Index.

# 5.2.1.9.2 Baseline input data

This section describes specifically the input data used for the Baseline simulation as mentioned above.

# Climatic Data

The climatic data were collected from MyLeaf portal for the period January 2015 – December 2015 including:

- Outdoor Dry Bulb Temperature [°C]
- Global Solar Radiation [W/m<sup>2</sup>]
- Diffuse Solar Radiation [W/m<sup>2</sup>]

While EnergyPlus is quite flexible in the format of the data used in simulations, DesignBuilder requires:

• Each line to represent one hour;

• Each file must have exactly 8760 records, one for each hour of the year, starting on Jan 1 and ending Dec 31. The years do not have to be consecutive but should ideally be set to 2002. The climatic data processing was performed with Elements Tool. Figure 39, 40 depicts the hourly values of the data.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 39: Site Outdoor Air Dry Bulb Temperature profile for the examined period ideally set to 2002.



Figure 40: Site Direct Solar Radiation Rate per area (red) and Site Diffuse Solar Radiation Rate per area (blue) for the examined period ideally set to 2002.



# 5.2.1.10 Direct monitoring methodology

Approximately 100 smart metering devices recording energy consumption of Leaf buildings and micro grid infrastructure have been installed and operated. Five different types of sensors are installed in several outputs. And data can be downloaded periodically. In the following sections the monitoring procedure and the instrumentation used is described. The following parameters have been measured:

- Energy use
- Building environmental parameters including thermal comfort conditions
- Meteorological conditions

## **Energy Use**

Smart meters have been installed in several electrical nodes in Summa Building. Types of sensors include (Figure 41); :

- Ducati Mack Smart
- Ducati Smart+
- Schneider PM3250
- Schneider PM710
- Siemens Pac 3200

These are powerful compact power monitoring devices suitable for use in industrial, government and commercial applications where basic metering and energy monitoring is required. The meters may be used as standalone devices monitoring over 50 parameters or as part of an industrial control, building automation or global power monitoring system. Metering and monitoring applications range from simple analog voltage and amplitude meter replacements to stand-alone sub billing or cost allocation installations with multiple tariffs.

Most of them provide open communications and protocols for easy integration into any local or remote monitoring system. Simple configuration of the meters can be done from the front display.

The data is stored in a portal for remote access in which the monitored values can be elaborated in intervals of 10 minutes, hourly, monthly or annually.





Figure 41: Different types of Smart Meters implemented in Summa and Micro grid Figure 42 shows the Energy portal page; where data is extracted for the whole building.

Home Tools System	n Monitor - About	🛓 smartgems
MYLEAF Loccioni Energy dà forma a progetti energetici per il controllo dei flussi, integrando:		LA LEAF COMMUNITY Un laboratorio d'innovazione aperto
Produzione L'Energia è un percorso che supera oggi, Tidea del consumo: riguarda la produzione (sole, acqua, calore della terra, forza del vento, materiali organici), l'accumulo, la sua distribuzione Efficienza Officiarza i flussi significa risparniare, modificando i processi per ridurre gli sprechi e utilizzando tecnologie	Customer Care I dati divertano valore concreto del proprio impegno verso le sostentibiti al timan di esperti Customer Care monitora in tempo reale la performance degli impianti, controllando da remoto funzionalità el efficienza. Comunicazione La misura crea consegventezza e la consegventezza genera attenzione ai comportamenti, my Leaf è i sistema	Entrare nella Community significa condividere gli stessi valon per il futuro, progettare riseme nuove tecnologie per la produzione deregiza on forta illenative, per la induzione dei consumi e per il monitoraggio energetico. Significa diffondere la propria esperienza, convolgere ed educare con focibutto di endere la community un nuovo modo di pensare, di viere e di lavorare improntato su ogni singua responsabilità.
capaci di trastormare renergia in modo pui eticiente. Accumulo L'energia prodotta da fonti rinnovabili è intermittente, discontinua e soggetta ai cici e alle regole della natura. Conservare l'energia diventa la chiave per un presente sostenibile.	per comunicare e conduidere e informazioni con i cienti	
Servizi L'attitudine alla sostenibilità significa consapervilezza del proprio agine. Il team di analisti ed informatici Loccioni Energy raccoglie, gestisce ed elabora i dati misurati © Copyright 2016 Loccioni Group		-

Figure 42: Energy data remote access provided by MyLeaf Portal

# 5.2.1.12 Conclusions

The present study described the development of the thermal simulation model of Summa building, 3D model using Design Builder simulation tool. Model calibration and validation procedures, followed internationally acceptable standards and protocols [17-19], taking into account energy measurements.

The energy consumption diagrams show that energy consumption for cooling is almost twofold than for heating. A revamping of HVAC system is not accepted because of its recent replacement. Thus, passive cooling techniques can be implemented in the building in order to reduce the total energy consumption of the building as well as the cooling loads. Two of most common passive cooling



technologies contain the use of cool and photocatalytic materials and natural night ventilation. The roof of Summa building is exposed in solar radiation during the daytime. Cool roof technology can lead to a reduction in cooling loads for an insulated building up to 35%, according to recent studies, while the heating penalty is up to 4% [20]. Moreover natural night ventilation is a passive cooling technique that is proposed to take advantage of the cold night ambient air to cool down the structure of the building so that it can absorb heat gains in the daytime. This reduces the daytime temperature rise improving indoor thermal comfort conditions and reducing energy consumption for cooling. Recent study has shown that night ventilation can offer energy savings of 7.6% [21]. Furthermore, external insulation can be implemented in the Warehouse in order to mitigate heat conduction exchanges. By decreasing cooling loads renewable energy can be further exploited combined with effective demand response control techniques.

## 5.2.2 KITE lab

### 5.2.2.1 Introduction

In Europe energy consumption of the buildings reaches 40% of total energy as well as 36% of CO<sub>2</sub> emissions. It is essential that new designs and approaches are introduced in order to mitigate these values. A successful mitigation technique on this account is the integrated design towards minimizing energy consumption and CO<sub>2</sub> emissions. It is expected that up to 80% of the operational costs can be saved through integrated design.

Particularly, the increase of nearly zero-energy buildings (NZEB) must be taken into account. National action plans in each member state of the EU encourage the use of integrated design principles specifically towards the renovation and refurbishment of existing structures. Furthermore, the use of low cost efficient energy renewable technologies is encouraged in each of these refurbishments as well. Renewable sources such as a PVs installation is a low cost yet very efficient way to reduce energy operational costs.



In a successful ID approach a wide variety of personnel is required in order to compose a sufficient design. Different designers, engineers, etc. must contribute with their knowledge to the final result.

Certain parameters are greatly affecting the final result of the ID. The thermal mass of a building is one of the most important aspects that must be taken into account. Changes made to the thermal mass of the building must be properly served by parallel changes in the HVAC systems.

Until now a complete IED approach has not been standardized. Different objectives must be met, such as the development of a common tool-kit for the IED of NZEB or the EU-wide promotion and dissemination activities.

In the current section the simulation process of the Kite lab is presented. The optimization and calibration of the cell and construction components are described. A 3D white-box modeling approach is effectively exploited as tool towards estimating the final thermal and energy performance of the building. While the whole process may be time consuming and demands the use of extensive information about the building, the final result is very reliable and accurate.

# 5.2.2.2 Objectives

The objectives of the 3D modelling are briefly described below:

- Optimization of the building following real consumption. Simple ways of interfering with the building form is for example the further use of shades, ensuring the higher energy performance regarding cooling.
- The optimization of the HVAC systems function. Following different strategies for cooling and heating may reduce the high impact of HVAC operation.
- Supplementary, more effective use of systems and controls may result in lower running costs. Better maintenance and revamping of existing systems are proposed.
- Essential for every IED approach is the user aspect. All actions altering the building behavior must always take into account users' requirements and overall comfort (optical, thermal, etc.).



- User engagement is another important issue. Useful conclusions may rise concerning the different patterns and behavior of the users. Following the results of the 3D modeling certain educational approaches should be introduced.
- Higher performance buildings, with lower costs and better control result in general in the increase of their commercial value.
- Finally, the exposure of the building as NZEB with "greener" performance may benefit the building owner or tenant organization.

# 5.2.2.3 Methodology

The main steps of the methodology of the 3D modeling procedure are briefly described below:

- > Data collection, analysis and processing
- > Division of the building structure into various thermal zones
- > Building 3D design using Open Studio SketchUp Plugin
- Surface matching
- PVs installation design
- Importing weather file
- > Importing materials, constructions & composing of construction sets
- Importing opaque and non-opaque elements
- Importing internal loads
- > Compiling proper schedules and schedule sets
- Full space type compilation

# 5.2.2.4 Data collection, description of the site and building

A certain list of information was required for the proper construction of the model. At first the analytical drawings of the building were collected in order to design the building cell, the openings, windows and doors as well as perform the distinction of the thermal zones of the building.

The internal and external walls, doors, windows and other components information were obtained. Certain information about the thermal conductivity and the thickness of each component was used to properly build-in the models'



accuracy. Access was provided to the myLeaf platform to collect data needed for the calibration and evaluation of the model.

The building is situated inside the Loccioni group facilities, located across the SS 76 (Figure 54) and south-west of the AEA lab of the facilities. Google maps have not been updated to include Kite built in 2015.



Figure 43 Location of KITE lab

The lab itself is a two-storey building of minimal industrial design. At Figure 55 the view of the lab is presented as viewed from the SS 76 highway.





Figure 44: View from the SS76 highway

Kite is located near Angeli di Rossora in the Marche province in Italy. The landscape mainly consists of small hills with fields and forest being alternated. In the south-west are the regional national park of Golla della Rossa and Frasassi. In the north-east at 30 km distance is the Ancona city situated on the coast. It is expected that both the mountains at the west as the sea coast at the east affect the microclimate of the region.

# 5.2.2.5 The Micro-grid

The Kite Lab building is part of the micro-grid (Figure 56) of the Loccioni Group. The Micro-grid is at large a self-sustained organism, incorporating the use of renewable energy sources (such as the PVs and the hydro plants) and thermal and electric storage facilities.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



#### Figure 45: View from the SS76 highway

Specifically, a large PVs plant is situated in the company compound including regular cells as well as a concentrative PV installation of great performance. Supplementary, each building in the micro-grid has installed PVs in every rooftop to serve each buildings energy demands.

Part of the micro-grid are also 2 small hydro plants using the nearby river current. Further construction plants of a third one are in progress, increasing the energy production and sustainability of the compound.

Excessive energy production in regular days or during weekends in particular can be stored for later use. This is achieved with the use of a water to water thermal storage solution. Furthermore, electric batteries are used in accordance with the PVs installations.

The micro-grid is connected in paralled with the national grid. Overall, energy demands are served by the micro-grid but the compound is not completely self-sustained especially at winter when clear sky conditions are scarce. At times



like that the PVs production is lowered, thus making necessary the national grid contribution.

Within the smart-grid application the buildings and their correspondent demand response may play a significant part in the energy balance [38]. Therefore the control and better handling of buildings energy behavior are greatly related with the smart-grid behavior in general.

# 5.2.2.6 Design of the building envelope

In order to design the building envelope Autocad (.dwg) files were provided with detailed plans of the building. It was deemed necessary that every different area of the building would be designed separately and the distinction of the thermal zones would be done afterwards. The plan used for the basement floor is shown below (Fig.57).



Figure 46: CAD drawing of the basement floor

From the above drawing the design of the first floor was derived. The separate spaces designed were the entrance with the stairs, the 1<sup>st</sup> and 2<sup>nd</sup> office, the



toilet, the 1<sup>st</sup> and 2<sup>nd</sup> laboratories, the magazzino, the corridor and the 6 sala test rooms along with a small unallocated space between sala 5 and 6. From these spaces the entrance, the corridor and the magazzino were developed until the second floor as they are uniform spaces along the two floors. Next the the 2<sup>nd</sup> floor was developed taking into account the following drawing (Fig.58).





In the second floor, spaces were divided accordingly to the basement floor. The uniformed spaces entrance, corridor and magazzino remained, while the new spaces designed were the 3 technical spaces and the 3<sup>rd</sup> office of the 2<sup>nd</sup> floor. Lastly the roof was designed to fit the plans, taking into consideration the detail of tilted sides of the roof that permit the natural lighting of the building. The design was based in the drawing of Figure 59.



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



#### Figure 48: CAD drawing of the roof

The final result of the building envelope design is presented in the Figure 60.



Figure 49: The final design of the building

Extra care was given to the design of the tilted roof, so to represent the exact lighting conditions of the building. The plans that were used are presented in Figure 61.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 50: The tilted rooftop components

After sketching the exact details of the rooftop was developed as presented in Figure 62.



Figure 51: The tilted rooftop 3D design



## 5.2.2.7 Design of the openings, doors and windows

The construction was completed with the design of the openings, doors and windows. Due to the open software character of the Sketch Up Open Studio plug in, certain specific calibrations must be made [39-40]. It is essential that each opening that corresponds to two tangent spaces must be drawn and be aligned exactly. In Figure 63 the extracted Sala rooms are illustrated with openings aligned in both sides of the Salas and Corridor spaces.



### Figure 52: The aligned openings, Salas and Corridor

The same technique was used in every internal opening of the building to ensure the proper exchange of light and heat mass, while adjusting the proper infiltration rate. The final result can be described by the complete opaque and transparent views of the model (Figures 64, 65).





Figure 53: Opaque view of the complete model, contour based on materials



**Figure 54: Transparent view of the complete model, contour based on materials** The design of each of the openings was made using the Autocad drawings provided. Both external and internal CADs drawings were used such as the ones in Figures 66-67.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 55: Example of external CAD drawing for the design of openings



Figure 56: Example of CAD drawing for the design of internal openings



# 5.2.2.8 Surface matching

One of the most strenuous procedures for the completion of the 3D modeling of the building is the surface matching. Each different wall, roof, floor, opaque and non-opaque openings must be matched with each correspondent neighboring one. Because of the nature of the design of the Sketch Up software described earlier, each separate zone must contain the same characteristics as each neighboring one. For example an interior window between two zones must be designed in the same position for both of them. Without this technique surface matching is not possible.

After successfully designing the different zones, lines in each neighboring zone lines were drawn in every cross section aligning different components to enable the matching of surfaces. All external surfaces do not need surface matching as it is obvious. The building with all surfaces matched (green represents internal surfaces, blue external) is presented in Figure 68.



Figure 57: The fully surface matched building

Surface matching is very important for the proper functioning of the model as it permits the continuous communication between zones. Therefore different phenomena of heat or radiation transfer are calculated correctly.

# 5.2.2.9 Design of the Photovoltaic roof installation

In order to properly design the photovoltaics installation on top of the Kite lab the necessary specifications were provided [41-44]. Firstly the blue-prints



(Figure 69) of the installation was used to define the space covered by the PVs and implement it into the model.



**Figure 58: Design of the photovoltaic installation used for the modelling** The result is presented in Figure 70.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 59: The PVs covering part of the rooftop

In the same pdf file some technical specification (Figure 71) was provided as for example the space covered by the PVs which is approximately half of the available in each tilted rooftop.

CARATTERISTICHE IMPIANTO	
SUPERFICIE UTILE NETTA IMPIANTO	238 m²
POTENZA PANNELLO FOTOVOLTAICO	260 Wp
N° PANNELLI FOTOVOLTAICI	144
POTENZA COMPLESSIVA IMPIANTO	37,44 kWp
STIMA PRODUCIBILITA' ANNUA	42000 kWh
ANGOLO DI AZIMUT (RIFERITO AL SUD)	33° (SUD-OVEST)
ANGOLO DI TILT	28°

COORDINATE GEOGRAFICHE SITO DI INSTALLAZIONE: LATITUDINE 43° 28' 15" (43,47084°) NORD LONGITUDINE 13° 04' 28" (13,07445°) EST ALTITUDINE 124 m s.j.m.

### Figure 60: Technical Specifications of the PV installation

The actual space covered by the PVs cannot be represented in the Sketch up model, but a coverage rate was applied instead. That is the reason why in the model the installation seems to cover all the area available. The specifications of the PVs incline a maximum efficiency of 0.15, which was induced in the model. The model of the PVs is polycrystalline of Solsonica model S610 [45] of 260W power (Figure 72), covering an area of 238m<sup>2</sup>.




Figure 61: The type of PVs installed

## 5.2.2.10 Kite Lab final 3D model

The final result of the sketching is presented in Figures 73-76. Different views of the structure including all the surfaces, the sub-surfaces, the openings and doors are displayed. A shading component was designed at the east of the building to describe the AEA lab that resides next to the Kite one.



Figure 62: South-east view of the building





Figure 63: North-east view of the building



Figure 64: North-west view of the building





Figure 65: Top view of the building

## 5.2.2.11 Distinction of thermal zones

The next step was the integration of the thermal zones into the model. During the design of the building in Sketch Up each space was designed taking into account that it corresponds to a different thermal zone. Normally this is not the case, for example the entrance and the corridor is in fact one unified space which in case are connected with no walls dividing the two spaces. In overall, 16 different thermal zones, regarding the use, the type of the space and the natural distinction with walls and opaque openings were created. The result is presented in Figure 77.



Figure 66: Distinction in thermal zones



Some spaces were unified in one thermal zone as they share similar HVAC activity, as well as similar use and loads. Therefore the 1<sup>st</sup> and 2<sup>nd</sup> office of the basement are unified in one thermal zone, as well as the 1<sup>st</sup> and 2<sup>nd</sup> laboratorio. The final unification was made for the entrance and the corridor which don't have actual borders dividing them as spaces forming one great unified space. The thermal zones of the Basement are described below (Figure 78).



Figure 67: Basement thermal zones

As described before the entrance, the corridor and the magazzino are through to the 2<sup>nd</sup> floor as well. The second floor is presented in Figure 79.



Figure 68: Thermal zones in 2nd floor



The distinction was made using the Open studio platform (Figure 80) that then allows the extraction of the above figures presenting thermal zones with one color each.

paces Properties	Loads	Surfaces Subsurfac	es Interior Partitions	Shading				My Model Library Edit
		Story	Thermal Zone	Space Type	Default Construction Set	Default Schedule Set	Part of Total Floor Area	A Space Types
		Apply to Selected	Apply to Selected	Apply to Selected	Apply to Selected	Apply to Selected		
1st Office		Building Story 1	Thermal Zone 1	189.1-2009 - Office - OpenO				Default Construction Sets
2nd Office		Building Story 1	Thermal Zone 1	189.1-2009 - Office - OpenO	[]]]	[]]]		Default Schedule Sets
3rd Office		Building Story 2	Thermal Zone 13	189.1-2009 - Office - OpenO			Ø	Design Specification Outdo
Corridor		Building Story 1	Thermal Zone 3	[189.1-2009 - Office - OpenO]	([[]]			Air
Empty Space		Building Story 1	Thermal Zone 9	[189.1-2009 - Office - OpenO]	[[]]]	[[]]]		Space Infiltration Effective Leakage Areas
Entrance		Building Story 1	[Thermal Zone 3]	[189.1-2009 - Office - OpenO]				Space Infiltration Design Flow Rates
Laboratorio 1		Building Story 1	Thermal Zone 12	189.1-2009 - Office - OpenO				People Definitions
Laboratorio 2		Building Story 1	Thermal Zone 12	189.1-2009 - Office - OpenO	[]]]	[[]]]		
Locale Technico 1		Building Story 2	Thermal Zone 14	189.1-2009 - Office - OpenO			Ø	
Locale Technico 2		Building Story 2	Thermal Zone 16	[189.1-2009 - Office - OpenO]				Luminaire Definitions
Locale Technico 3		Building Story 2	Thermal Zone 15	[189.1-2009 - Office - OpenO]			M	Electric Equipment Definiti
Magazzino		Building Story 1	Thermal Zone 11	[189.1-2009 - Office - OpenO]				Gas Equipment Definitions
Sala 1		Building Story 1	Thermal Zone 4	189.1-2009 - Office - OpenO			Ø	
					>			Heat Pump Water Heater
🔁 😢 😫							6	Water Use Equipment

Figure 69: Open studio categorization of building levels and thermal zones

### 5.2.2.12 Materials and construction

In order to properly simulate the building environment all of the materials characteristics concerning constructions and structure elements must be imported. First the characteristics of each material used in the building were imported. By using the detailed schematics [46] provided (Fig. 81) the different materials such as thickness, conductivity, density and thermal absorptance were determined.



Desc	rizione della struttura: M	luro este	rno pre	fabbrica	to - con	contropa	irete	Codic	<u>e: M1</u>
Tras	mittanza termica	0,225	W/m²K						
Spe	ssore	363	mm					XA –	
Tem (calo	peratura esterna colo potenza invernale)	-6,0	°C						
Pern	neanza	1,094	10 <sup>-12</sup> kg	/sm²Pa			Ň	XX	
Mas: (con	sa superficiale intonaci)	520	kg/m²						
Mas: (sen	sa superficiale za intonaci)	<u>509</u>	kg/m²					X	
Tras	mittanza periodica	0,010	W/m²K					Ň	
Fatte	ore attenuazione	0,043	-			12 3	456		
Sfas	amento onda termica	-11,8	h						
<u>Strat</u>	tigrafia:								
Ν.	Descrizione st	rato		s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna			-	-	0,130	-	-	-
1	Cartongesso in lastre			12,50	0,250	0,050	900	1,00	10
2	Pannello TP 238 - Lana di vetro			50,00	0,032	1,563	32	1,03	3000
3	C.I.s. armato (2% acciaio)			60,00	2,500	0,024	2400	1,00	130
4	Polistirolo EPS 80			40,00	0,035	1,143	37	1,25	60
5	Polistirolo EPS 80			50,00	0,035	1,429	37	1,25	60
6	C.I.s. armato (2% acciaio)			150,00	2,500	0,060	2400	1,00	130
-	Resistenza superficiale esterna			-	-	0,047	-	-	-

Figure 70: Schematics used for the materials and building elements construction.

After inserting each characteristic the materials tab took the following form (Fig.82):



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

🛡 Kitefi	initosurfacematching3mefeggitihmn	nm3.osm	
File P	references Components & Measu	res Help	
	Constructions Construction Sets	Constructions Materials	
	1/2IN Gypsum	Measure Tags (Optional):	
	1IN Stucco	Standard:	Standard Source:
	8IN Concrete HW	Standards Category:	Standards Identifier:
	Barriera vapore in fogli di polietilene	Composite Framing Material:	Composite Framing Configuration:
	Blocco Leca B20 2f	Composite Framing Depth:	Composite Framing Size:
	C.I.s. armato (2% acciaio) 100cm	Composite Cavity Insulation:	
X	C.I.s. armato (2% acciaio) 150cm	Roughness:	Thickness:
	C.I.s. armato (2% acciaio) 200cm	MediumRough	0.200000 m Density:
0		0.400000 W/m·K Specific Heat:	1300.000000 kg/m <sup>3</sup> Thermal Absorptance:
		1000.000000 J/kg·K Solar Absorptance:	0.990000 Visible Absorptance:
	😌 🥨 🔕 🛛 🛐	0.700000	0.700000

Figure 71: Open studio materials tab

The materials created for walls were:

- Cartogensso in lastre
- > Panello TP 238-Lana di vetro
- > C.I.s. armato (2% acciaio) of different thickness
- Polistirolo EPS 80
- Ultracoustic R
- Intonato di calce e gesso
- Blocco Leca B20 2f
- > Par G3 Touch

Respectively, materials for floors are:

- > Legno di abete flusso perpend. Alle fibre
- Intercarpedine non ventilate Av<500mm2/m</p>
- Plyofoam C-500-XPS
- Barriera vapore in fogli di polietilene
- Tessuto non tessuto
- Ghaia grossa senza argilla (um. 5%)
- Masseto ripartitore in calcestruzzo con rete



- > Polistirene espanso, estruso con pelle
- > Piastrelle in ceramica (piastrelle)
- > C.I.s. di argilla espansa pareti interne a struttura aperta (um 4%)

Equally materials for roofs are described below:

- Impermeabilizzazione con bitumen
- Solaio prefabbricato alveolare Poker –H21
- ➢ EPS 120
- > EPS 80 con grafite

The next step was merging of the materials into walls, floors and roofs. In the constructions tab each element was defined combining the materials (Fig.83):



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



#### Figure 72: Different type of walls

Each of these elements consists of different layers of materials representing the real layout of the constructions. Inserting properly the above values is crucial to the heat flux transfer between thermal zones or the exterior environment.

Furthermore, the opaque and non-opaque elements such as windows, glass doors, doors, etc. were constructed using once again the schematics of each element and inserting the U-factor accordingly (Fig. 84).



645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

	Constructions Construction Sets	Constructions Materials
	^	Name:
	W2-T2	W1-T1
	W3-T3	Measure Tags (Optional):         Standard:       Standard Source:
	W4-Emergency exit	Standards Category:     Standards Identifier:
	W5-T5	Metal Framed Wall
	W6-T6	U-Factor: 1.889000 W/m <sup>2</sup> ·K
	W7-Industrial Door	Solar Heat Gain Coefficient:
X S	W8-Industrial Door Big	Visible Transmittance:
B	W9-Shed	-
	Drag From Library	
	<ul> <li>2 2 3</li> </ul>	

Figure 73: Opaque and non-opaque elements.

Finally, for each different space type constructions sets were composed and linked to each building element. The final form is presented below (Fig. 85).



#### $645677-\mathsf{SMART\,GEMS}-\mathsf{H2020}\text{-}\mathsf{MSCA}\text{-}\mathsf{RISE}\text{-}2014$

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design

phase

🛡 Kitef	initosurfacematching3mefeggitihmmr	n3.osm		
File P	references Components & Measure	s Help		
	Constructions Construction Sets	Constructions Materials		
	Corridor	Name Entrance		
	Empty space	Exterior Surface Construction	ons Floors	Roofs
	Entrance	м2-С2	53 😵	Drag From Library
	Laboratorio 1	Interior Surface Construction	ons	
	Laboratorio 2	Walls	Floors	Ceilings
€) 1]	Locale technico 1	M9-M10	53 🔇	54 🐼
X	Locale technico 2	Ground Contact Surface Co	nstructions	0.:!:
	Locale technico 3	Drag From Library		Drag From Library
	Drag From Library	Exterior Sub Surface Constr	ructions	
		Fixed Windows	Operable Windows	Doors
	3 2 3 5	Drag From Library	Drag From Library	Drag From Library

### Figure 74: Final form of constructions sets.

Contouring the 3D model by construction type results in the following image (Fig.86).



Figure 75: Contour based on materials-construction.



## 5.2.2.13 Importing weather file

In order to properly simulate the thermal and general behavior of the building the proper weather file was created. Using the Elements [47] platform data from the MyLeaf platform was integrated with the corresponding from the nearest national weather station (Figure 87).

atitude [degrees]: 43.62 Long ime Zone: 1 Eleva	.ao jitude (degrees): 13.52 ation [m]: 105								Header Chart
ools: Offset Scale M	Normalize Normalize	By Month				Variables to Hold (	Constant:		
Date/Time	Dry Bulb Temperature [C]	Wet Bulb Temperature [C]	Atmospheric Pressure [kPa]	Relative Humidity	Dew Point Temperature [C]	Global Solar [Wh/m2]	Normal Solar [Wh/m2]	Diffuse Solar [Wh/m2]	Wind Speed [m/s]
2005/01/01 @ 00:00:00	0	-0.16	100.07	97	-0.37	0	0	0	0
2005/01/01 @ 01:00:00	0	-0.21	100.07	96	-0.49	0	0	0	0
2005/01/01 @ 02:00:00	0	-0.32	100.07	94	-0.74	0	0	0	0
2005/01/01 @ 03:00:00	0	-0.48	100.07	91	-1.14	0	0	0	0
2005/01/01 @ 04:00:00	0	-0.43	100.07	92	-1	0	0	0	0
2005/01/01 @ 05:00:00	0	-0.32	100.07	94	-0.74	0	0	0	0
2005/01/01 @ 06:00:00	0	-0.16	100.07	97	-0.37	0	0	0	0
2005/01/01 @ 07:00:00	0	-0.11	100.07	98	-0.24	2	0	2	0
2005/01/01 @ 08:00:00	0	-0.05	100.07	99	-0.12	48.81	16	47	0
2005/01/01 @ 09:00:00	0	-0.05	100.07	99	-0.12	112.51	52	100	0
2005/01/01 @ 10:00:00	0	-0.05	100.07	99	-0.12	169.02	90	139	0
2005/01/01 @ 11:00:00	0	-0.11	100.07	98	-0.24	204.33	115	160	0.8
2005/01/01 @ 12:00:00	0	-0.16	100.07	97	-0.37	209.74	119	163	1.6
2005/01/01 @ 13:00:00	0	-0.16	100.07	97	-0.37	182.14	99	147	2.4
2005/01/01 @ 14:00:00	0	-0.11	100.07	98	-0.24	130.31	63	113	2.4
2005/01/01 @ 15:00:00	0	-0.05	100.07	99	-0.12	67.93	25	64	3.3
2005/01/01@16:00:00	0	-0.05	100.07	99	-0.12	10.02	2	10	3.3
2005/01/01 @ 17:00:00	5.8	5.8	100.07	100	5.82	0	0	0	2.4
2005/01/01 @ 18:00:00	5.4	5.4	100.07	100	5.42	0	0	0	1.6

Figure 76: Elements integration of weather data files

The result was a single weather file containing all the necessary data,

imported to the Open studio platform (Figure 88).

🛡 Kitet	hermalnames2ndfloor.osm*					- 0	×
File F	references Components & Measures Help						
	Ste Weather File & Design Days Life Cycle Costs Utility Bills						
۲	Weather File Change Weather File		Select Ye	ar by:			^
	Name: Loccioni_KiteLab Latitude: 43.62		O Cal	endar Year 2000 🐥			
	Longitude: 13.52 Elevation: 105		First	st Day of Year Sunday			
	Time Zone: 1 Download weather files at <u>www.energyplus.gov</u>		Daylight	Savings Time: off			
6			Start	5		-	
	Measure Tags (Optional):		O De	fine by Date 1/1/2000	Sunday     January	Ŧ	
			Ends				
	ASHRAE Climate Zone		O Del	fine by Day of The Week And Month First	Sunday      January	\$	
	CEC Climate Zone		O De	I/1/2000	2		
x	Design Days Import From DDY						_ [
$\sim$	Design Days	_			_	_	
	Date         Temperature         Humidity         Pressure Wind Precipitation         Solar	Custom					
Ø	Design Day Name All Day Of Month	Month		Day Type	Daylight Saving Time Indica	itor	
	Apply to Selected	Apply to Selected		Apply to Selected			
	⊕ €						3
-	P 🗆 📮 🧕 🕲 🥥 🖬 🚺	🛷 🔼 🛜 💵			<b>∧ ■ </b> (1)) [	ENG 12	:50 µµ /7/2016

Figure 77: Importing the weather file



## 5.2.2.14 Internal loads

In every simulation of this kind it is necessary to fully compose an internal loadsgains profile. In each space and thermal zone apply different kind and level of activity, equipment, lighting and number of personnel was defined.

Regarding the personnel working and moving in each space, as also taking into account the size of the space 4 different types of anthropogenic internal gains (Figure 89) were created:

- Big workload spaces
- Little spaces-Big workload spaces
- Little spaces-Little workload spaces
- Unoccupied rooms

	Loads			
	189.1-2009 - Office - WholeBuilding - Md Office - CZ4-8 People Definition	Name:		
111 () ()	189.1-2009 - Office - WholeBuilding - Sm Office - CZ1-3 People Definition	Number of People:	People per Space Floor Area:	Space Floor Area per Person:
	189.1-2009 - Office - WholeBuilding - Sm Office - CZ4-8 People Definition	Fraction Radiant:	Sensible Heat Fraction:	Carbon Dioxide Generation Rate:
	Big workload spaces	0.300000	autocaiculate	0.000038 L/s·w
	Little-Big workload spaces			
	Little-Little workload spaces			
⊡ X	Unocupied rooms			
<i>(</i> );	Lights Definitions			
5	Luminaire Definitions 🔌 🗸			
	Drag From Library			
	<ul> <li>2</li> <li>2</li> <li>3</li> <li>3</li> </ul>			

Figure 78 Importing internal loads people definitions.

According to each of the above definitions the proper people's activity values were entered. Similarly for lighting detailed schematics of the lights installed in each floor (Fig.90) were used.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 79: Schematics of lights (blue-yellow) installed in each space.

4 categories of different lights definition depending on the size of the space and the amount of lights were used:

- Small space-Small lights
- Small space-Medium lights
- Large space-Medium lights
- Large space-Large lights

Regarding equipment a similar approach was used to import information from different documents and in situ observations. For the equipment of the 2 laboratories and the 3 offices a standard case of 15 and 5 desktop computers along with the correspondent monitors respectively was taken into consideration. For the equipment of the test rooms separate data was provided [48]. Specifically for test room 1, table 14 includes relevant information:

	Aria compressa (P= 6 bar)	Acqua raffreddamento (P=3bar)	Azoto	Aspirazione per i banchi	Potenza elettrica richiesta
Banco					
Sistema		200 lt/min @ 12		1000	Danag 2014M
Iniezione		°C - Delta	10 NI/min @	1000	
Completo	200 Nit/min	Temperatura	6 bar	Nm^3/nr@400	Cniller = 40  KW
Sala test 1		5°C		ra	Camera ciim. = 32 KW

 Table 14: Information regarding equipment

Equivalent data were taken into account for all test rooms except for the 6<sup>th</sup>, which is still under construction.



The Kite Lab building incorporates 3 heat pumps for the heating-cooling demand through the year. All of the heat pumps are water to water so they can be connected with the nearby river and the water thermal storage. 2 of the heat pumps are of type AIRMEC NXP and connected with the air handling unit for heating and cooling demands. The 3<sup>rd</sup> one is of type AIRMEC WRL and is used to serve the conditioning of the offices. All of the heat pumps have winter and summer control modes. As described, certain set points are in use for the winter-summer operation of the building. Specifically, the set point for winter is at 20 °C and for summer is at 25 °C. These set points are used for every space of the building except for test room 6. As constructions are still in progress set points are changed to meet the necessary working conditions.

## 5.2.2.15 Conclusions and innovativeness of approach

Integrated energy design is a modern approach concerning the overall design and construction of a building. While it concerns different phases of the construction and the design of a new building it can be applied also in older ones as part of renovation-refurbishment plans [51].

In the case of KITE building the construction has followed many principles of IED. It is already a NZEB building incorporating increased insulation, natural lighting, advanced HVAC systems and renewable energy sources for covering energy demands as part of a self-sustained micro-grid.

The construction, materials and equipment used suggest a highly energy efficient building. The building is brand new and constructions are still under way, while the smart metering systems are properly calibrated and recording since April of 2016. However, no sufficient data was available for completing and validating the 3D model.

Nevertheless, it is a fact that the work that was completed until now composes a very thorough and detailed image of the actual building, so it can be used in the future with small calibrations and after validation with proper yearly data. Moreover, the basic principle that this research was conducted was to be part of a complete IED. Following the general guidelines of the European Union regarding the further advancement of NZEB or ZEB buildings, approaches such as this can play significant role in the future [52].



As described in previous sections a certain directive for a successful IED is yet to be determined. Although it is a cost effective and very resourceful tool most of the studies suggest preliminary measures, mostly about a new building or a to-be-refurbished one.

In this retrospective the present project contributes to this later case. The Kite Lab building was designed and constructed in order to be part of an already existing micro-grid using the latest technologies strengthening the energy selfsufficient state of it. Nevertheless, further optimization can be made after the finish of the works in order to conserve more energy and lower cost.

Following an IED means that there is comprehensive information regarding the building materials, structural components, HVAC systems, equipment, etc. it is much easier to complete a white box 3D model. As described before, the information that could be exported by such simulations is of great value and accuracy. Therefore, further investigation about the buildings behavior and control can be made.

In conclusion, the above approach can be part of a more complete and successful IED procedure. The knowledge that can be extracted from 3D models of this kind cannot be easily replaced by other means of calculations. Moreover, a set of that kind of simulations regarding other buildings of the micro-grid can be combined for later use.

## 5.2.3 AEA building

## 5.2.3.1 Introduction

The current report presents the modeling process, the validation, the energy performance and optimization of AEA building of Loccioni Company.

Like the Internet, the Smart Grid consists of controls, computers, automation, new technologies, smart buildings and equipment working together, but in this case these technologies will work with the electrical grid to respond digitally to the quickly changing energy demands of the users. Therefore, smart grids create an exceptional opportunity for the support of the development of smart zero energy buildings and communities and offer the step towards the Internet of Things for the Energy and Building Industry





# In Figure 92, the annual consumption of AEA Building for 2014 is depicted.

Figure 80: Annual consumption of Loccioni's buildings for 2014

### 5.2.3.2 Methodology

The main steps of the methodology are briefly described below:

- Data collection, analysis and processing
- Division of the building structure into various thermal zones
- Surface matching
- Building 3D design using Open Studio SketchUp Plugin
- Open studio Import of the physical and thermal characteristics of building structural elements (walls, ceilings, floors, openings).
- Validation
- Energy performance, cost and internal thermal comfort optimization





exergy 🙀 NUS

## 5.2.3.3 Data collection, analysis and processing

The architectural drawings were used for the 3D design of the building envelope and merging the several spaces into thermal zones properly.

Moreover, data concerning the physical and thermal characteristics of the external and internal walls, the roof, the ground floor and the ceiling, alongside with similar information about the external windows characteristics was exploited.

## 5.2.3.4 Building 3D design using Open Studio SketchUp Plugin

In order to implement the 3D design of the AEA building, the dimensions of the different views (north, east, south, west) of each space as provided in AutoCAD drawings were used. First there the opaque elements of the building envelope (walls, roofs, basements) were designed and then the openings (windows, doors) were drawn (Fig.93-97).



Figure 81: Top view of the first floor of AEA Building



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 82: Top view of the second floor of AEA Building



Figure 83: East side view of two storey AEA Building



Figure 84: Front side view of two storey AEA Building

PROSPETTO LATO C - SUD		υŭ
Technical RELENCE REPUBLIC University of Alfond and Rapedistrian Of Crete	ß	INSTITUTE Brunel INSTITUTE Brunel University London 123

### Figure 85: Back side view of two storey AEA Building

The final 3D design of the AEA Building using Open Studio SketchUp Plugin is presented in Figures 98-102:



Figure 86: Top view of the first floor of AEA Building



Figure 87: Top view of the second floor of AEA Building



Figure 88: East side view of two storey AEA Building



Figure 89: West side view of two storey AEA Building



Figure 90: Front side view of two storey AEA Building





Figure 91: Back side view of two storey AEA Building

## 5.2.3.5 Division of the building structure in terms of the thermal zones

The thermal zones are divided in terms of the use, the orientation, the schedule and the construction materials of each space. The use of these criteria was chosen as having a central role in the thermal behavior of the various building zones.



Figure 92: First phase of Leaf Lab 3D modelling

Some spaces were considered one thermal zone for simplicity reasons and in order to avoid having very small thermal zones. This was applied only on spaces that have very similar use, and they are adjacent and/or connected via sliding doors.

In Figures 105-106 the division of AEA building into different thermal zones is presented.





Figure 93: Southeast view of AEA Building divided into thermal zones



Figure 94: Northwest view of AEA Building divided into thermal zones

# 5.2.3.6 Surface matching

One very important step in the modelling process is surface matching. Through this procedure external surfaces in contact with outside air are coloured blue whereas the surfaces common between two spaces are coloured green. This is a vital step for the model to perform correctly (Figures 107-108).



Figure 95: Surface matching for interior of AEA Building





Figure 96: Surface matching for exterior of AEA Building 5.2.3.7 Open studio - Import of the physical and thermal characteristics of building structural elements (walls, ceilings, floors, openings)

Via open studio various data is inserted. This data includes weather conditions, simulation period, construction materials of each building element (wall, ceiling, floor and roof), technical characteristics of the electrical equipment and artificial lighting, lighting schedule, and the schedule of activity and occupancy.

### 5.2.3.7.1 Data on construction of the building envelope

One of the main steps of modelling the building in Open Studio refers to the constructions i.e. walls, ceilings, floors, roofs which consists of several different layers of materials. The technical properties of the materials that form the building structure elements are imported and assigned to the different construction elements. Then construction sets are created and assigned to each construction. A simple example is presented in Figure 109:



#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Gui	delines for integrated	design towards	smart / zero	buildings &	smart grids.	Report on th	e design
			phase				

Constructions Construction Set	Constructions Materials		My Model Library Edit
	∧ Name:		
C I s armato (2%	Cartongesso in lastre 12.50		
acciaio) 300,00			
開田	Measure Tags (Optional):		8IN Concrete HW
Cartongesso in lastre 12,50	Standard:	Standard Source:	
	-		F08 Metal surface
Copertura industriale	· · ·		
prefabbricata 50,00	Standards Category:	Standards Identifier:	E16 Acoustic tile
EOR Matal or stace	•	•	
100 Metal sui face	Composite Framing Material:	Composite Framing Configuration:	G01a 19mm gypsum
	<u></u>	\$	board board
F16 Acoustic tile	Comparts Coming Deaths	Company Stratics Charles	
	Composite Framing Deptn:	Composite Framing Size:	G05 25mm wood
G01a 19mm gypsum board	÷	\$	
	Composite Cavity Insulation:		I01 25mm insulation
G05 25mm wood	A		
			M11 100mm
Ghiaia grossa senza	Roughness:	Thickness:	lightweight concrete
argilla (um. 5%) 200,00	Smooth \$	0.012500 m	MAT-COD5 4 HW
	Conductivity	Dansibr	CONCRETE
Drag From Library	conductivity.	Densey.	
L	0.250000 W/m·K	900.000000 kg/m <sup>3</sup>	Metal Decking
	Specific Heat:	Thermal Absorptance:	
1 😌 🐸 😂	1000.000000 J/kg·K	0.900000	Metal Roofing

### Figure 97: Cartongesso in Lastre physical and thermal values

All data concerning the thickness, conductivity, density, specific heat and thermal absorbance of the different materials were obtained from records such as in tables 15-16 available in Annex 3.

### Table 15: Physical and thermal values of expanded polystyrene

N	Descrizione strato	S	Cond.	R	M.V.	С.Т.	R.V.
2	Polistirene espanso, estruso con	<b>50,0</b>	0,03	1,42	35	1.25	300
	pelle	0	5	9		1/20	

#### Table 16: Measurement units of the physical and thermal values used

S	Spessore	mm
Con d.	Conduttività termica, comprensiva di eventuale maggiorazione	W/mK
R	Resistenza termica	m²K/W
M.V.	Massa volumica	kg/m <sup>3</sup>
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

Next is a list of construction materials used in the building model:

- Expanded Polystyrene
- Expanded Polystyrene 2



- Expanded Polystyrene 3
- Expanded Polystyrene for non-thermal walls
- o Expanded Polystyrene for underground walls
- Attic air gap
- o Attic expanded polystyrene
- o Attic prefabricated
- Attic reinforced concrete
- Attic wooden fiber
- Basement floor concrete
- o Basement floor rock fragments
- o Ceramic tiles
- Fabric layer
- Floor industrial concrete
- Floor industrial expanded polystyrene
- Floor expanded polystyrene
- Fiber wood
- o Fabric layer
- Hollow Cores Slab
- o Net with concrete
- Polyvinyl chloride layer
- Plasterboard sheets
- o Plasterboard sheets for non-thermal spaces
- o Reinforced concrete
- Reinforced concrete 2
- Reinforced concrete 3
- o Reinforced concrete for basement walls
- o Thin concrete
- Vapor barrier for polythene
- Waterproof Bitumen

An equivalent list of materials was also imported for the construction of the glazing and other opaque elements of the building envelope.



# 5.2.3.7.2 Construction Types

As a next step every material was inserted in terms of layers into a specific

construction type. The different construction types are the following:

- Attic ceiling
- **Basement** ceiling 0
- Basement floor
- o Basement walls
- Ceiling
- o External door
- External glass wall
- External wall
- External window
- Floor
- Ground floor
- Ground industrial floor
- Industrial door
- Internal glass wall
- Non thermal external wall
- o Roof
- Roof windows
- Skylight 0

An example of a construction type in Open Studio is presented in Fig.110:



#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 98: External wall construction type example

### 5.2.3.7.3 Construction Sets

The last step in the construction group of fields is the unification of the construction types in specific construction sets, depending on the similarity of materials used in each space. The construction sets created are the following:

- o Basement
- o Floor 1
- Floor 1 meeting room
- o Floor 2
- Floor 2 bridge room
- o Industrial
- o Kitchen
- Non thermal spaces
- Non thermal spaces south WC1
- Non thermal spaces 2<sup>nd</sup> floor
- $\circ$  Reception



exergy 📆 NUS

### $645677-\mathsf{SMART\,GEMS}-\mathsf{H2020}\text{-}\mathsf{MSCA}\text{-}\mathsf{RISE}\text{-}2014$

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

		Materials		
	Floor_1	Name Floor_1		
	Floor_1_meetingRoom	Exterior Surface Construction	Floors	Roofs
	Floor_2	ExternalWall	Drag From Library	Drag From Library
	Floor_2BridgeRoom	Interior Surface Constructio	Dins	Ceilinge
	Industrial	Interior Wall	GroundFloorInd	
	Kitchen			
<b>X</b> 3	NonThermalSpaces	Ground Contact Surface Co Walls	nstructions Floors	Ceilings
	NonThermalSpaceSouthWC1	Drag From Library	Drag From Library	Drag From Library
	NonThermaSpacesl_2ndFloor	Exterior Sub Surface Constr	ructions	
	NonThermaSpacesl_2ndFloor	Exterior Sub Surface Constr Fixed Windows	ructions Operable Windows	Doors
	NonThermaSpacesl_2ndFloor	Exterior Sub Surface Constr Fixed Windows	Operable Windows	Doors ExternalDoor

Figure 99: Floor\_1 Construction Set example

As shown in the example of figure 112 there are different colours for the exterior walls, ceilings and sub surfaces such as windows.



Figure 100: Exterior of AEA Building construction sets



# 5.2.3.7.4 Space types

After completing the construction sets, space types in terms of similar use and schedule (Figure 113) are created:

- $\circ$  Office
- o Kitchen
- o Industrial
- Meeting rooms
- o Reception
- o Others



**Figure 101: Space types in Open Studio Mode (**Green: offices, Yellow: Industrial Use, Red: kitchen, White: Reception and corridors, Black: meeting rooms, Orange: W.C and stairs) After importing the different schedules, the space types take the form of Fig.114:



#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

	Drop Space Types		General Loads Meas	sure Custom				
	Filter: Load Type Show all loads		\$					
	Space Type Name	All	Rendering Color	Default Construction Set	Default Schedule Set	Design Specification Outdoor Air	Space Infiltration Design Flow Rates	Space Infiltration Effective Leaka Areas
				Apply to Selected	Apply to Selected	Apply to Selected	Apply to Selected	Apply to Selected
	009 - Office - OpenOffice - CZ4-8				189.1-2009 - Office - OpenOl	189.1-2009 - Office - OpenOl	e - OpenOffice - CZ4-8 Infiltration	C1111)
	Kitchen 1			[]]]	ValidationSchedule	[[]]		[[]]
	Office				ValidationSchedule	C1113		CIII3
	Other				ValidationSchedule			C)
	industrial			CIII)	ValidationSchedule	C1113	CIII)	CIII)
	meetingRooms				ValidationSchedule	CIII)		CIII)
1	reception 1			E1113	ValidationSchedule	C11113	(1111)	50000

Figure 102: Space types with validation schedule inserted

## 5.2.3.7.5 Weather files

The next step is to load a weather file of the weather conditions in the

province of Ancona as shown in Fig.115.

	Weather File & Design Days Life Cycle Costs Ublity Bils				
۲	Weather File Change Weather File	Belect Year by:           @ Ceindar Insr         2014           O Pret Day of Year         Structury			
	Name: Ancona				
	Latitude: 43.62 Longitude: 13.52				
語	Elevation: 105				
a.	Time Zone: 1	Daylight Savings Time: off			
-	Download weather rises at www.enercegalas.cov	Charles			
6		Starts			
n.	Measure Tags (Optional):	Ubenne by Day or The Week And Month First + Sunday + Danuary +			
		Define by Date     1/1/2000			
		Ends			
101	ASHRAE Climate Zone 😫	O Define by Day of The Week And Month First			
-	CEC Climate Zone	Define by Date     1/1/2000			
E.					
26	Design Days Import From DDY				
	V Design Days				
	Date Temperature Humidity Pressure Wind Preceptation				
	Design Day Name All				
	Day OF Month Month	Day Type Daylight Saving Time Indicator			
	Apply to Selected Apply to Selected	Apply to Selected			
			~		
	🐥 🕫 🔞		0		

Figure 103: Import a weather file in Open Studio

### 5.2.3.8 Innovativeness

The value of the project that was undertaken and described in this report is to promote a more accurate and state-of-the-art research on specific energy efficiency measures.



# 5.2.3.9 Conclusions

Having followed the previous steps, the model for the energy performance of the AEA building is complete. Nevertheless, in order to ensure that the model is robust and reliable the validation process should take place. Through this process the necessary adjustments would be applied to enhance optimization procedure. The scope of the optimization procedure is to suggest measures which will result in the best energy performance of the AEA Building, taking also into account the building's incorporation in Loccioni's micro grid. To name a few a list is provided:

- Use of materials of the newest technology for the construction of the • building
- Replacement of the systems for heating, cooling and hot water with the best available technologies (geothermal heat pumps, district heating/cooling systems, absorption/adsorption chillers, hybrid boilers).
- Installation of PV or hybrid renewable energy systems state of the art technology.
- Thermal/Chemical storage

The choice and/or the combination of the above measures would be made, provided that these are the cost effective technically feasible solutions. Optimization takes into account the ratio between investment/installation costs and cost savings. The scope after all is to ensure that the AEA Building would be an nZED Building.

# 5.2.4 Library building

## 5.2.4.1 Introduction

The analysis of electrical consumptions of the Library buildings has been conducted within different time frames (days, weeks, months picked during the year); in addition, such an analysis aims to evaluate the impact of innovative solutions as the High Concentrating Photovoltaic systems for combined thermal and electrical production, eventually equipped energy with storage units, or the High Efficiency Solar Cooling, both designed by Idea Srl.



After a first analysis, the installation of a concentrating solar thermal system has been taken into account for driving a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs of a building inside the UoA Campus.

Energy demand for cooling and heating requirements has increased significantly during last years. Global space cooling energy consumption increased by 60% in the period between 2000 and 2010 reaching 4% of global consumption in 2010 [53]. On the other hand heat consumption accounts for more than 50% of the global consumption [54]. Therefore, alternative heating and cooling systems driven by renewable or recovered energy have driven the interest of many researchers. Many researchers [55-58] have carried out experimental and theoretical studies of Solar Heating Cooling (SHC) systems. Work on the use of concentrated energy for polygeneration [59] [60], has drawn significant attention. Absorption heating and cooling systems were studied more than any other systems. These systems have many advantages over other refrigeration systems [61]: Quiet operation, high reliability, long service life, meeting the variable load efficiently, minimum mechanical moving parts, no lubricants needed and no atmosphere-damaging refrigerants. Not many tools are available for accurate dimensioning and evaluating the solar thermal contribution to the total energy requirements. Dynamic simulation tool is used by many researchers [62-64].

Fong et al. [64] made a theoretical comparative study between five different solar cooling systems; Solar electrical compression, solar mechanical, solar absorption, solar adsorption and solid desiccant cooling system. The results show that solar electrical compression alongside solar absorption system have the better performance results. Moreover, the advantages of two-stage systems over other systems are investigated by [65]. It was concluded that the cooling system can work steadily in spite of unsteady solar input, lower generator input and outlet temperature, however, they demand higher temperature heat.

In line with these findings, a solar cooling system has been designed in order to smooth the summer peak of energy demand in one of the case study buildings.



## 5.2.4.2 The solar cooling plant for the UOA Science Library

Initial design defined the size of a CSP (Concentrating Solar Plant) useful to drive an absorption heating and cooling system to cover completely the cooling energy needs of a building and partially the heating, working in heating mode with the integration of the existent HVAC system.

Maximising the summer peak shaving effect of the UoA electrical load was set as a target. The thermal energy provided annually by the CSP, using an hourly steady-state model that simulated the annual solar energy gain was evaluated. In order to estimate the heating and cooling energy that could be supplied by the double-effect absorption chiller system, a monthly average value of thermal COP was used.

## 5.2.4.3 Location and description of the building

The building chosen for this analysis is the Library of Science. It is located at the Eastern side of the University Campus close to Hymettus Mountain (Fig.116).



Figure 104: Location of the Library of Science inside the UoA Campus





Figure 105: Street view of the building

The Science Library building is composed by 4 floors, each of which has a useful surface area about of 1580  $m^2$  and a volume about of 5500  $m^3\!,$  built in 2009. Overall, the existent centralized HVAC system provide heating, cooling and ventilation for about of 22.000 m<sup>3</sup> of useful volume (Fig.117).

The Science Library hosts (Fig. 118):

- Six Studying Rooms with 550 seats; •
- Six Library Rooms;
- Four Group Study Rooms (AOM) of six persons;
- One Computer Room with 24 terminals;
- Seven Rooms with access to the Open Public Access Catalogue (OPAC) of the Athens University Libraries.

		Rooms
1 <sup>st</sup> level	LEVEL 1 BOOK ROOM 1 OPAC BOOK ROOM 2 BOOK ROOM 2 W.C.	Biology books room Geology books room Corridors





Figure 106: List of the rooms divided per floor, with plants



## 5.2.4.4 HVAC system of the building

The existent centralized HVAC system is modular. It is located on the roof of the building inside a technical central and divided in 7 distribution sub-systems which are able to provide the required ventilation and thermal comfort in different parts of the building. In Table 17, the distribution system, the served rooms and the sizing of each sub-system for winter and summer peak conditions are summarized.

Referring to HVAC system it was not possible to obtain measured data in order to evaluate the electrical energy consumption and the thermal load of the building.

With this data being unavailable sizing of the solar thermal system to cover the heating and cooling energy needs of the building was performed on the estimate of fully covering the summer cooling peak demand of energy including the introduction of a hot thermal storage with an extra daily balancing capacity of 30 %.

Table 17: List of the main features in terms of air flow rate [m<sup>3</sup>/h] and thermal power [kW] provided by the 7 distribution sub-system of HVAC system used to size the solar thermal power and absorption chillers system.

HVAC				
Distrbution Sub-	Heating		Cooling	
System				
1	Air supply $(m^3/h)$	14326.3	Air supply (m <sup>3</sup> /h)	13115.8
Biology books				
room - Geology	Total heat of equipment	16.6	$T \rightarrow 11 \rightarrow 0$ $(1 W / 1)$	(1.4
books room -	(kWth)	40.0	Total heat of equipment (kwth)	01.4
Corridors - WC				
2	Air supply $(m^3/h)$	12101.7	Air supply (m <sup>3</sup> /h)	14031.8
Pharmacy books				
room -	Total heat of equipment	10.7	$T \rightarrow 11 \rightarrow 0 \qquad (1 W(1))$	70 5
Mathematics	(kWth)	42.7	Total heat of equipment (KWth)	/0.5
books room				
3	Air supply $(m^3/h)$	10616.2	Air supply (m <sup>3</sup> /h)	19648.0
Chemistry books	T-+-11			
room - Computer	a with	35.3	Total heat of equipment (kWth)	84.2
Science books	(KWth)			





THE CYPRUS INSTITUTE

exerqv
## 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

room - Physics				
books room				
4	Air supply (m <sup>3</sup> /h)	12298.2	Air supply (m <sup>3</sup> /h)	15731.4
Geology study				
room -	Total heat of equipment	( 4 E	$T = t = 1$ h = $t = f = m^2 + m = m + (1 - W/t)$	1144
Mathematics study	(kWth)	04.5	Total heat of equipment (kwm)	114.4
room - Corridors				
5	Air supply $(m^3/h)$	11977.1	Air supply (m <sup>3</sup> /h)	19389.7
Biology study				
room - Computer	Total heat of equipment	59.6	Total boat of acuimment (kW/th)	121.6
Science study	(kWth)	56.0	Total heat of equipment (kwill)	121.0
room				
6	Air supply (m <sup>3</sup> /h)	19745.3	Air supply $(m^3/h)$	21918.6
Pharmacy study	Total best of aquinment			
room - Chemistry	(J-W/th)	84.4	Total heat of equipment (kWth)	133.7
study room	(KW III)			
7	Air supply (m <sup>3</sup> /h)	16820.5	Air supply $(m^3/h)$	21340.0
Physics study	Total heat of aquipment			
room - Computer	(-W(th)	73.2	Total heat of equipment (kWth)	127.9
room	(KW III)			
Total Thermal		-		- <u>.</u>
Power at peak	Heating [kWth]	405.3	Cooling [kWth]	713.7
condiction				
Total Ventilation				
Air Flow rate at	Heating [m <sup>3</sup> /h]	97885.2	Cooling [m <sup>3</sup> /h]	125175.1
peak				

## 5.2.4.5 Proposed Linear Frenel Reflector technology

The proposed solar technology consists in a Linear Fresnel Reflectors composed by 18 mirrors (primary reflective optics) installed by means of glue on a metal frame. At 3.56 m above the mirrors, an absorber tube ASE (Angelantoni Solar Energy) D70 mm in AISI 321, covered by a borosilicate glass (D125mm) and insulated by vacuum, is installed by means of flanges welded on each side of the tube. The length of each LFR module is about of 4 m. The width of each primary mirror is 32 cm, so each module has a primary reflective surface of 21,5 m<sup>2</sup>. Globally the LFR module cover an area of 34 m<sup>2</sup>.



A secondary optic in metal assembled with Alanod Al silvered film of 0,5mm is used to recover the light beams on the upper surface of the absorber tubes. We supposed to use as HTF (Heat Transfer Fluid) a diathermic oil, able to operate at more than 250°C, without pressurization and in safety condition. Figure 119 represents a 3D rendering of 8 modules of LFR Solar field installed on the roof of the building.



Figure 107: 3D rendering of 8 modules of LFR Solar field installed on a roof of a building

In order to cover the summer peak cooling demand of the building, the LFR solar field is composed by 45 modules, divided in three parallel rows in North South configuration, with about 1,004 m<sup>2</sup> of total collecting surface.





Figure 108: Possible positioning of 45 LFR modules as a shadowing cover of a parking area inside the UoA Campus, on the west side of Library of Science.



Figure 109: Width and Length of the LFR Solar, built as a covered parking area

Table 18:	Main geometrical	features of the	LFR solar field
-----------	------------------	-----------------	-----------------

Module Type	LFR1832
Focal Length [m]	3.5
Module Length [m]	4



# 645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Mirror Width [m]	0.31
N. mirrors x module	18
Primary Reflective area [m <sup>2</sup> ]	22.32
Absorber's Diameter [HCEOI 12] [m]	0.066
Optical efficiency	0.6

Rows in parallel configuration	
Number of modules	15
Total collector area [m <sup>2</sup> ]	334.8
Total length [m]	60
Number of rows	3
Total mirror surface of solar power plant [m <sup>2</sup> ]	1004.4

Figure 120 represents the possible positioning of 45 LFR modules as a shadowing cover of a parking area inside the UoA Campus, on the west side of Library of Science and Figure 121 the width and length of the LFR Solar, built as a covered parking area, while in Table 18 the main geometrical features of the LFR solar field are presented.

# 5.2.5 NUS building

# 5.2.5.1 Introduction

The work performed during the secondment at the National University of Singapore of Dr. Margarita Assimakopoulos in the framework of the SMARTGEMS project involves the selection of 3 types of rooms (situated in the NUS campus) with different use and different occupancy patterns of a specific campus building which has a BMS installed in order to assess energy performance and thermal behaviour of the buildings and provide guidelines for achieving zero energy balance.

The work was divided into three tasks:

1. To provide the data collected from the selected areas for overall analysis and to introduce suitable analysis methods. This task requires analysing the



data collected from the different rooms and integrate those sections of analysis in identifying the potential savings they might achieve.

2. To integrate the identification of possible Energy Conservation Opportunities where applicable in order to achieve zero energy concept. This task requires to identify any Energy Conservation Opportunities through the data collected from the rooms under investigation.

3. To collect and analyse data from the tools integrated in the demo buildings. Data collected from the tools will be included in the database and the impact on the energy performance and the thermal behaviour of the demo buildings will be reported.

# 5.2.5.2 Description of the NUS building

The building studied is an institutional building located in Singapore. It contains mainly offices, classrooms and a library space. The offices are open plan, accommodating a large number of staff and researchers each. The library is utilised by students and contains a few permanent staff members. The climate of Singapore is tropical with high temperature and relative humidity throughout the year, so only cooling is required. Windows in air conditioned spaces remain shut at all times during operating hours. The air conditioning system consists of multiple Air Handling Units (AHUs) and Fan Coil Units (FCUs), each serving separate areas. Some of the AHUs and FCUs are of the Single Coil Twin Fan System (SCTF), which decouples the fresh and recirculated air streams until they are mixed immediately prior to reaching the air conditioned zone. The fresh air stream is regulated according to ventilation and indoor air quality requirements, based on readings from CO<sub>2</sub> concentration sensors in the return air grilles, while the recirculated air stream is regulated according to the cooling load, based on readings from temperature sensors. The plant consists of three chillers, of which one is always on standby for extreme load conditions. Each chiller has its own dedicated set of pumps and cooling tower. Architectural plans, material properties, plant specifications and operating conditions were obtained from the building owner in the form of vendor documents, drawings and previous audit findings. Daily energy consumption data for lighting,



equipment and HVAC subsystems and hourly CO<sub>2</sub> concentration data was obtained from the building BEMS. The areas selected were an office, a computer room and a lecture theatre due to their different occupancy patterns. Occupancy per office and for the Lecture Theatre by students were provided by the building administration and by observation.

# 5.2.5.3 Measurement equipment

Measurements were obtained by sensor kits which contained four different types of sensors measuring CO<sub>2</sub> concentration, temperature, relative humidity and illuminance. Table 19 shows the sensors used as well as their technical specifications.

Environmental parameter	Sensor type	Range
Temperature (°C)	Sensirion SHT75	-40 to 123.8 °C
RH (%)	Sensirion SHT75	0 to 100 %
CO <sub>2</sub> (ppm)	K-30, CO2 Meter Inc	0 to 5000 ppm
Illuminance (lux)	ROHM, B17xx	0 to 65.000 lux

Table 19: Technical specifications of the sensors

One sensor is placed in the executive office, two in the computer room and three in the lecture theatre. Greater interest was shown in rooms with frequent fluctuation in occupancy such as the lecture theater and the computer room. Figures 122, 123 and 124 depict the floor plans of the buildings were the rooms under investigation are situated and also show the location of the sensors. Data is available at 1 minute sampling intervals.



645677 — SMART GEMS — H2020-MSCA-RISE-2014 D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



Figure 110: Floor plan of the location of the executive office and the sensor placed



Figure 111: Floor plan of the location of the computer room and the sensor placed





Figure 112: Floor plan of the location of the lecture theatre and the sensor placed

Energy meters have also been installed in the selected rooms and provide data for electrical consumption from lighting, equipment and air-conditioning. In the case of the lecture theatre, the electrical consumption of the FCU is also monitored separately.



# 7. Conclusions

The recast Directive on the energy performance of buildings (EPBD) stipulates that by 2020 all new buildings constructed within the European Union after 2020 should reach nearly zero energy levels. This means that in less than one decade, all new buildings will demonstrate very high energy performance and their reduced or very low energy needs will be significantly covered by renewable energy sources. In parallel, Member States shall draw up national action plans for increasing the number of nearly zero-energy buildings (NZEB). These national action plans shall include policies and measures to stimulate the transformation of existing buildings which are refurbished into nearly zeroenergy buildings. In addition, by 2015 all new buildings and buildings undergoing major renovation should have minimum levels of energy from renewable sources. The implementation of these policy goals requires a major transformation in the building sector during the next few years.

The design of NZEB requires an interdisciplinary approach. Reducing the energy demand in the design phase demands specifications of the different designers and engineers such as architects, building physics or façade designers. For this reason, the introduction of a design team is compulsory for the design of NZEBs.

In order to achieve the high performance goals which constitute not only a requirement but an obligation the building design phase is of particular importance.

To this end the present work focuses on the design phase providing guidelines for integrated design towards smart / zero buildings and smart grids.

IED is a valuable assisting approach to reduce the complexity of the design process, to ensure the implementation of defined, to identify pros and cons of alternative variants of design concepts and to allow decision makers to decide based on transparent facts. Only if IED is applied from the very beginning of the design phase we can assume that a cost-effective solution for NZEB can be identified, because only at the early design phases changes of the general



design concept can be implemented at low cost. Therefore, the application of IED is part of the best way towards the intended NZEB at low cost.

Implementation of research work: Research work has been implemented and skills have been developed through secondments from academia to industry and vice versa in the field of integrated design for buildings. For the production of this Deliverable seven researchers were actively involved according to Table 1.

# > Structure of research work:

In order to provide a holistic approach the following structure was implemented:

- Integrated design concept is analysed providing the principles of ID process and defining decision making protocols. Client's and Tenant's brief is presented including capital cost, delivery risk, operational cost and building unsuitability risk reduction. The scope of services and remuneration models are also investigated. The importance of certification and consultancy aspects is highlighted providing also quality assurance aspects and evaluation of the design quality criteria.
- Within the frame of the secondments hosted in the University of Athens site visit at <u>best practice example NZEB buildings</u> which follow the integrated design concept from the design to the construction and operation, integrating at the same time smart technologies have been carried out. The buildings are documented and their ID characteristics are presented providing also recommendations for smart grid integration.

The activities included sites visits, meeting with the building responsible and assessment of the performance of 4 best practice buildings in Greece:

- A.N. Tombazis and Associates Architects Office Building
- Apivita Commercial & Industrial S.A.
- Stavros Niarchos Foundation Cultural Center
- Karelas Office Park





exergy

 <u>5 Case building were fully assessed</u> during the secondments and the methodology that was developed included the audit and analysis of the building's existing situation, with parameters as Site details and Location, Time, Daylight data and Simulation Weather file data. Except of the above-mentioned, the Layout drawings is described as well as the Activity, Construction, Openings, Lighting, HVAC and Generation data.

The buildings under investigation are

- SUMMA building, Ancona, Italy
- KITE lab, Ancona, Italy
- AEA building, Ancona, Italy
- Library building, University of Athens, Greece
- NUS building, Singapore

To enhance the prospects of building's connection into the smart grid an overall integration design objective is required, thus appropriate simulation models has been developed to estimate and establish the best case scenario concerning the energy consumption.

The correlation of measured and simulated values has also been examined in order to assess the performance and implementation of smart technologies at the buildings.

Fields of innovation related to this work include:

- > Analysis of Integrated Design methodology vs conventional procedures
- Application of detailed white box models based on physical knowledge of the system and thermal balance equations vs black box and grey box models that use only measured input/output data and statistical estimation method as well as a priori knowledge on the system. White box models were also used because of the accuracy, the calculation speed and it's usage for optimization and control.
- Evaluation and application of innovative solutions and High Concentrating solar thermal system for combined thermal and electrical production to drive a double effect absorption chiller system producing heating and cooling to satisfy the thermal needs.



# 8. References

- N. Carlisle and O. Van Geet, "Definition of a ' Zero Net Energy ' Community," NREL, 2009.
- 2. M. Kapsalaki and V. Leal, "Recent progress on net zero energy buildings," Advances in Building Energy Research, vol. 5, no. 1, pp. 129–162, 2011.
- D. Kolokotsa, D. Rovas, E. Kosmatopoulos, and K. Kalaitzakis, "A roadmap towards intelligent net zero- and positive-energy buildings," Solar Energy, vol. 85, no. 12, pp. 3067– 3084,2011.
- D. H. W. Li, L. Yang, and J. C. Lam, "Zero energy buildings and sustainable development implications e A review," *Energy*, vol. 54, pp. 1– 10, 2013.
- 5. N. Carlisle and O. Van Geet, "Definition of a ' Zero Net Energy ' Community," *NREL*, 2009.
- Nordby, A. S. (2013): ID Process Guide. Intelligent Energy Europe -MaTrID project. <u>http://www.integrateddesign.eu</u>.
- T. Karlessi, S. Amann, A.S. Nordby, K. Leutgöb, Adapting the principles of Integrated Design to achieve high performance goals: Nearly Zero Energy Building in the European market, in: 8th International Conference Improving Energy Efficiency in Commercial Buildings (IEECB'14), 2014.
- Thomsen, K.E., Hermelink, A., Schimschar, S., Rose, J., Aggerholm,
   S., O., Boermans, T., Grozinger, J., Offermann, M. (2011): Principles
   For Nearly Zero-energy Buildings, BPIE



- Affirmative Integrated Design Action- AIDA project 2013 http://www.aidaproject.eu/?Ing=gr
- 10. Leutgöb, K. (2012). Annex 1 Description of the Action. Intelligent Energy Europe - MaTrID project. <u>http://www.integrateddesign.eu</u>
- MaTrID Market Transformation Towards Nearly Zero Energy Buildings Through Widespread Use of Integrated Energy Design IEE Project <u>http://www.integrateddesign.eu</u>
- 12. https://ec.europa.eu/energy/en/topics/energy-efficiency/buildings
- S. Royer, S. Thil, T. Talbert, M. Polit, "Black-box modeling of buildings thermal behavior using system identification", Proceedings of the 19th World Congress, 2014
- 14. NSI/ASHRAE/IESNA Standard 90.1-2007 Normative Appendix B
   Building Envelope Climate Criteria.
- 15. Website: <u>http://www.designbuilder.co.uk</u>
- 16. Website: <u>https://energyplus.net/</u>
- 17. <u>https://myleaf2.loccioni.com/beta/Analysis</u>
- International Standard ISO 16346:2013 "Energy performance of buildings – Assessment of overall energy performance
- Ashrae Guideline 14-2002 "Measurement of Energy and Demand Savings"



- 20. CIBSE guide- Chartered Institution of Building Services Engineers, Delta house, London, UK.
- 21. A. Synnefa, M. Saliari, M. Santamouris, "Experimental and numerical assessment of the impact of increased roof reflectance on a school building in Athens", Energy and Buildings,7-15, 2012
- 22. Afroditi Synnefa, Konstantina Vasilakopoulou, Rosa Francesca De Masi, Georgios-Evrystheas Kyriakodis, Vasilis Londorfos, Elena Mastrapostoli, Theoni Karlessi, Mat. Santamouris, "Transformation through renovation: An energy efficient retrofit of an apartment building in Athens", International High- Performance Built Environment Conference, 2016
- 23. Attestato di Qualificazione Energetica Degli Edifici, Ancona, Italy, 2015
- 24. Revisione centrale termofrigorifera-Polo produttivo industriale "AeA S.r.l.", Ancona, Italy, 2015
- 25. Relazione Tecnica, "Impianto Fotovoltaico Stabilimento AEA-SUMMA-Ex TM", Ancona, Italy, 2007
- 26. <u>http://global.aermec.com/it/prodotti/scheda-prodotto/?Code=FCX</u>
- 27. <u>http://planetaklimata.com.ua/instr/Aermec/Aermec\_NXW\_Installation\_</u> <u>manual\_Eng.pdf</u>
- 28. <u>http://www.cnet.com/products/xerox-workcentre-7245-multifunction-</u> printer-color-series/specs/





R THE CYPRUS INSTITUTE Brunel Universi

154

exergy WUS

- 29. <u>http://www.bavada.com/en/dyson-hand-dryers/105-dyson-airblade-db-ab14-hand-dryer.html?gclid=CPK3h5aTk84CFYQcGwod3p8MvA#/35-color-white</u>
- 30. <u>http://www.utemac.it/pallinatrici/norblast--sd-12.php</u>
- 31. http://www.daikinpmc.com/en/catalog/GK245.pdf
- 32. <u>http://www.dcproducts.com.au/documents/Magnaglide\_D-tds.pdf</u>
- 33. Building power demand response methods toward smart grid (Shengwei Wanga, Xue Xuea & Chengchu Yana)
- 34. <u>https://energyplus.net/</u>
- 35. https://www.openstudio.net/
- 36. <u>http://www.sketchup.com/</u>
- 37. Planimetria generale, Impianto fotovoltaico TUV, AEA s.r.l. Via Fiume
   –Angeli di Rosora (AN)
- Blanimetria generale, Impianto fotovoltaico Edificio ATC, AEA s.r.l. –
   Via Fiume Angeli di Rosora (AN)
- Schema planimetrico impianto, Impianto fotovoltaico Edificio ATC, AEA
   s.r.l. –Via Fiume Angeli di Rosora (AN)
- 40. Schema elettrico unfilare, Impianto fotovoltaico Edificio ATC, AEA s.r.l.
   Via Fiume Angeli di Rosora (AN)
- 41. Solsonica S612 SP manual



- 42. Comunicazione di fine lavori parziale e dichiarazione di regolare esecuzione, Autorizzazione S.U.A.O N. 01/2014 permesso di costruire N.2 del 28/07/2014, S.C.I.A. prot. 1793 del 28/04/2015
- 43. <u>http://bigladdersoftware.com/projects/elements</u>
- 44. Specifiche ATC, revision 3,C.Ungaro, " Documento descrittivo delle specifiche di massima dei nuovi laboratori Loccioni Mobility, Lo stabile dei nuovi laboratori viene indicato per brevità con il nome di ATC (Advanced Testing Center)"
- 45. International Standard ISO 16346:2013 " Energy performance of buildings –Assessment of overall energy performance
- 46. Ashrae Guideline 14-2002 " Measurement of Energy and Demand Savings"
- 47. "Market transformation towards nearly zero energy buildings through widespread use of integrated energy design", Theoni Karlessi, Mat Santamouris, Stefan Amann, Klemens Leutgöb 16. European smart cities: The role of zero energy buildings
- 48. Report, "Transition to Sustainable Buildings: Strategies and Opportunities to 2050," OECD/IEA, Paris, 2013.
- 49. Report "Heating without Global Warming: Market Developments and Policy Considerations for Renewable Heat," OECD/IEA, Paris, 2014.
- Kim.D.S, Infante Ferreira.C.A, "Solar refrigeration options a state-ofthe-art review," international journal of refrigeration, vol. 3 I, pp. 3-15, 2008.



- 51. Henning.H.M, "Solar assisted air conditioning of buildings an overview," Applied Thermal Engineering, vol. 27, pp. 1734–1749, 2007.
- 52. Saman, W, Krause, M, Vajen, K,, "Solar Cooling Technologies: Current Status and Recent Developments," in Proceedings of 42nd ANZSES Conference Solar, Perth, Australia, 2004.
- 53. Neuhäeuser, A, Polygeneration using concentrating solar thermal power, Acts of SolarPACES2009
- S. Vasta, A. Frazzica, A. Freni, L. Venezia, A. Buscemi, F. Paredes, F. M. Montagnino, A concentrating – based solar cooling system for agrifood industry, Acts of 5th International Conference Solar Air-Conditioning, Germany, 2013
- Freeman.T. L, Mitchell. J. W and Audit.T. E, "Performance of Combined Solar Heat Pump Systems," Solar Energy, vol. 22, no. 2, pp. 125-135, 1979.
- Quirante.M and Valenzuela.L, "Dimensioning a small-sized PTC solar field for heating and cooling of a hotel in Almería (Spain)," Energy Procedia, vol. 30, pp. 967 – 973, 2012
- Calise.F, Palombo.A, Vanoli.L, "Maximization of primary energy savings of solar heating and cooling systems by transient simulations and computer design of experiments," Applied Energy, vol. 87, p. 524– 540, 2010.
- 58. Mazloumi.M, Naghashzadegan.M and Javaherdeh.K, "Simulation of solar lithium bromide–water absorption cooling system with parabolic



trough collector," Energy Conversion and Management, vol. 49, pp. 2820–2832, 2008

- 59. Fong K.F, Chow T.T, Lee C.K, Lin Z, Chan L.S., "Comparative study of different solar Cooling systems for buildings in subtropical city," Solar Energy, vol. 84, pp. 227–244, 2010.
- Mittal V, Kasana K.S, Thakur N.S, "The study of solar absorption airconditioning systems," Journal of Energy in Southern Africa, vol. 16(4), 2005.



# 9. Annexes

This section includes the hardcopies of the technical characteristics of various elements as provided by the manager of the buildings. More specifically they correspond to the thermophysical characteristics of the building components, such as the external walls and roof, as well as, the specifications of several kind of openings [12-13]. Moreover, the specifications of the electrical equipment used both in warehouse and offices [15-37] are provided, and also the sunpath diagram of the building. All the necessary technical characteristics of the PVs and the Invertors [14], used for the renewable electricity production are provided. Information on Energy data and categorization of internal gains is also provided. Sketchup extractions and CFD temperature contours are depicted.



# 9.1 Annex 1-Summa Building

**Building Components characteristics** 



#### Descrizione della struttura: Parete esterna - isolata

Trasmittanza termica	0,452	W/m <sup>2</sup> K
Spessore	263	mm
Temperatura esterna (calcolo potenza invernale)	-6,0	°C
Permeanza	12,403	10 <sup>-12</sup> kg/sm <sup>2</sup> Pa
Massa superficiale (con intonaci)	293	kg/m <sup>2</sup>
Massa superficiale (senza intonaci)	282	kg/m²
Trasmittanza periodica	0,101	W/m <sup>2</sup> K
Fattore attenuazione	0,224	-
Sfasamento onda termica	-9,5	h

#### Stratigrafia:

Ν.	Descrizione strato	s	Cond.	R	M.V.	С.т.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Cartongesso in lastre	12,50	0,250	0,050	900	1,00	10
2	Polistirene espanso, estruso con pelle	50,00	0,035	1,429	35	1,25	300
3	Tamponamento Italprefabbricati	200,00	0,360	0,556	1400	0,88	5
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

#### Legenda simboli

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m <sup>2</sup> K/W
M.V.	Massa volumica	kg/m <sup>3</sup>
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-

# Technical University of Crete







## Codice: M1

#### Descrizione della struttura: Parete esterna - non isolata

Trasmittanza termica	1,365	W/m <sup>2</sup> K
Spessore	200	mm
Temperatura esterna (calcolo potenza invernale)	-6,0	°C
Permeanza	200,00 0	10 <sup>-12</sup> kg/sm <sup>2</sup> Pa
Massa superficiale (con intonaci)	280	kg/m²
Massa superficiale (senza intonaci)	280	kg/m²
Trasmittanza periodica	0.632	W/m <sup>2</sup> K
Fattore attenuazione	0,463	-
Sfasamento onda termica	-7,4	h

000000	
<b>\$\$\$\$</b> \$	
*****	
6666666	
1939399	
188888	
188889	
666666	
888888	
88888	
<b>33333</b> 3	
*****	
<u>84848488</u> 1	

#### Stratigrafia:

Ν.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale interna	-	-	0,130	-	-	-
1	Tamponamento Italprefabbricati	200,00	0,360	0,556	1400	0,88	5
-	Resistenza superficiale esterna	-	-	0,047	-	-	-

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m <sup>2</sup> K/W
M.V.	Massa volumica	kg/m³
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-







#### Descrizione della struttura: Pavimento industriale

Trasmittanza termica	1,674	W/m <sup>2</sup> K
Trasmittanza controterra	0,252	W/m <sup>2</sup> K
Spessore	650	mm
Temperatura esterna (calcolo potenza invernale)	-6,0	°C
Permeanza	3,960	10 <sup>-12</sup> kg/sm <sup>2</sup> Pa
Massa superficiale (con intonaci)	1390	kg/m²
Massa superficiale (senza intonaci)	1390	kg/m²
Trasmittanza periodica	0,087	W/m <sup>2</sup> K
Fattore attenuazione	0,344	-
Sfasamento onda termica	-15,7	h

#### Codice: P1



#### Stratigrafia:

Ν.	Descrizione strato	s	Cond.	R	M.V.	С.т.	R.V.
-	Resistenza superficiale interna	-	-	0,170	-	-	-
1	Massetto ripartitore in calcestruzzo con rete	150,00	1,490	0,101	2200	0,88	70
2	C.I.s. armato (2% acciaio)	300,00	2,500	0,120	2400	1,00	130
3	Ghiaia grossa senza argilla (um. 5%)	200,00	1,200	0,167	1700	0,84	5
-	Resistenza superficiale esterna	-	-	0,040	-	-	-

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m <sup>2</sup> K/W
M.V.	Massa volumica	kg/m <sup>a</sup>
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-





#### Descrizione della struttura: Copertura a copponi prefabbricati (Ondal)

Codice: S2

Trasmittanza termica	0,436	W/m²K
Spessore	185	mm
Temperatura esterna (calcolo potenza invernale)	-6,0	°C
Permeanza	0,004	10 <sup>-12</sup> kg/sm <sup>2</sup> Pa
Massa superficiale (con intonaci)	287	kg/m²
Massa superficiale (senza intonaci)	287	kg/m²
Trasmittanza periodica	0,201	W/m <sup>2</sup> K
Fattore attenuazione	0,462	-
Sfasamento onda termica	-5,5	h



#### Stratigrafia:

Ν.	Descrizione strato	s	Cond.	R	M.V.	C.T.	R.V.
-	Resistenza superficiale esterna	-	-	0,047	-	-	-
1	Acciaio	5,00	52,000	0,000	7800	0,45	99999999
2	Fibra di vetro - Pannello rigido	80,00	0,038	2,105	100	0,84	1
3	C.I.s. armato (2% acciaio)	100,00	2,500	0,040	2400	1,00	130
-	Resistenza superficiale interna	-	-	0,100	-	-	-

s	Spessore	mm
Cond.	Conduttività termica, comprensiva di eventuali coefficienti correttivi	W/mK
R	Resistenza termica	m <sup>2</sup> K/W
M.V.	Massa volumica	kg/m <sup>3</sup>
C.T.	Capacità termica specifica	kJ/kgK
R.V.	Fattore di resistenza alla diffusione del vapore in capo asciutto	-





#### 6. PRINCIPALI RISULTATI DEI CALCOLI

#### Edificio: Insediamento direzionale produttivo

#### a) Involucro edilizio e ricambi d'aria

Caratteristiche termiche dei componenti opachi dell'involucro edilizio

Cod.	Descrizione	Trasmittanza U [W/m²K]	Trasmittanza media [W/m²K]
<b>S2</b>	Copertura a copponi prefabbricati (Ondal)	0,436	0,436
M1	Parete esterna - isolata	0,452	0,503
M2	Parete esterna - non isolata	1,365	1,395
P1	Pavimento industriale	0,252	0,252

Caratteristiche termiche dei divisori opachi e delle strutture dei locali non climatizzati

	Cod.	Descrizione	Trasmittanza U [W/m²K]	Trasmittanza media [W/m²K]
--	------	-------------	---------------------------	-------------------------------

Caratteristiche di massa superficiale Ms e trasmittanza periodica YIE dei componenti opachi

Cod.	Descrizione	Ms [kg/m²]	YIE [W/m²K]
<mark>S2</mark>	Copertura a copponi prefabbricati (Ondal)	287	0,201
M1	Parete esterna - isolata	282	0,101
M2	Parete esterna - non isolata	280	0,632

#### Caratteristiche termiche dei componenti finestrati

Cod.	Descrizione	Trasmittanza infisso U <sub>w</sub> [W/m²K]	Trasmittanza vetro U <sub>g</sub> [W/m <sup>2</sup> K]
W1	Modulo finestra continua	2,347	2,763
W2	Ingresso nord	2,401	2,763
W3	Finestra singola 100x85	2,372	2,763
W4	Uscita di sicurezza 180x250	2,383	2,763
W5	Uscita di sicurezza 115x250	2,362	2,763
W6	Lucernai	3,285	5,079
W8	Portone industriale	3,309	5,468

Valutazione dell'efficacia dei sistemi schermanti delle superfici vetrate

Gli infissi sono dotati di opportuni sistemi di schermatura solare.

Attenuazione dei ponti termici (provvedimenti e calcoli) Non si è intervenuti sulla struttura dell'edificio.

Numero di ricambi d'aria (media nelle 24 ore) – specificare per le diverse zone

Ν.	Descrizione	Valore di progetto [vol/h]	Valore medio 24 ore [vol/h]
1	Uffici	1,63	1,63
1	Laboratori	0,50	0,50

Portata d'aria di ricambio (solo nei casi di ventilazione meccanica controllata)

Q.tà	Portata G [m <sup>3</sup> /h]	Portata G <sub>R</sub> [m <sup>3</sup> /h]	<b>η</b> τ [%]		
1	6340,0	6340,0	0,5		
1	1406,0	0,0	0,0		





Descrizione della finestra: Mo		Codice: W			
Caratteristiche del serramento					
Tipologia di serramento	Singolo				
Classe di permeabilità	secondo N 2207	lorma			
Trasmittanza termica	U,	2,347	W/m <sup>2</sup> K		
Trasmittanza solo vetro	Ug	2,763	W/m <sup>2</sup> K		
Dati per il calcolo degli apporti s	<u>olari</u>				
Emissività	ε	0,837	-		
Fattore tendaggi (invernale)	f <sub>c inv</sub>	0,80	-		
Fattore tendaggi (estivo)	f <sub>c est</sub>	0,80	-		
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,750	-		
Caratteristiche delle chiusure os	curanti				
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W		
f shut		0,6	-		
Dimensioni del serramento					
Larghezza		800,0	cm		
Altezza		145,0	cm		
Caratteristiche del telaio					
Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup> K		
K distanziale	Kd	0,08	W/mK		
Area totale	A,,	11,600	m <sup>2</sup>		
Area vetro	Ag	9,250	m <sup>2</sup>		
Area telaio	Ar	2,350	m <sup>2</sup>		
Fattore di forma	Fr	0,80	-		
Perimetro vetro	Lp	27,300	m		
Perimetro telaio	L <sub>f</sub>	18,900	m		
Stratigrafia del pacchetto vetr	ato				

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,130
Primo vetro	6,0	1,00	0,006
Intercapedine	-	-	0,173
Secondo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

#### Legenda simboli

- s Spessore
- λ Conduttività termica
- R Resistenza termica

mm W/mK m<sup>2</sup>K/W







Caratteristiche del serramento			
Tipologia di serramento	Singolo		
Classe di permeabilità	Classe 3 secondo Norma UNI EN 12207		
Trasmittanza termica	U,	2,401	W/m <sup>2</sup> K
Trasmittanza solo vetro	U <sub>9</sub>	2,763	W/m <sup>2</sup> K
Dati per il calcolo degli apporti so	olari		
Emissività	ε	0,837	-
Fattore tendaggi (invernale)	f <sub>c inv</sub>	0,80	-
Fattore tendaggi (estivo)	f <sub>c est</sub>	0,80	-
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,750	-
Caratteristiche delle chiusure osc	uranti		
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W
f shut		0,6	-
Dimensioni del serramento			
Larghezza		255,0	cm
Altezza		250,0	cm
Caratteristiche del telaio			
Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup> K
K distanziale	Kd	0,08	W/mK
Area totale	Α,	6,375	m <sup>2</sup>
Area vetro	A	4,715	m <sup>2</sup>
Area telaio	A,	1,660	m <sup>2</sup>
Fattore di forma	Fr	0,74	-
Device attra system	La	22.500	m
Perimetro vetro			

#### Descrizione della finestra: Ingresso nord

Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,130
Primo vetro	6,0	1,00	0,006
Intercapedine	-	-	0,173
Secondo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

#### Legenda simboli

s Spessore

λ Conduttività termica

R Resistenza termica

mm W/mK m²K/W Codice: W2







Descrizione della finestra: Fin	estra singola	a 100x85			Codice: W
Caratteristiche del serramento					
Tipologia di serramento	Singolo				
Classe di permeabilità	Classe 3 s UNI EN 12	econdo N 207	lorma		
Trasmittanza termica	Uw	2,372	W/m <sup>2</sup> K		
Trasmittanza solo vetro	Ug	2,763	W/m <sup>2</sup> K		
Dati per il calcolo degli apporti s	olari				
Emissività	ε	0,837	-		
Fattore tendaggi (invernale)	f <sub>c inv</sub>	0,80	-		
Fattore tendaggi (estivo)	f <sub>c est</sub>	0,80	-		
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,750	-		
Caratteristiche delle chiusure os	curanti				
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W		
f shut		0,6	-		
Dimensioni del serramento					
Larghezza		100,0	cm		
Altezza		85,0	cm		
Caratteristiche del telaio					
Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup> K		
K distanziale	Kd	0,08	W/mK		
Area totale	Α,	0,850	m <sup>2</sup>		
Area vetro	A	0,520	m <sup>2</sup>		
Area telaio	A,	0,330	m <sup>2</sup>		
Fattore di forma	Fr	0,61	-		
Perimetro vetro	L <sub>p</sub>	2,900	m		
Perimetro telaio	L,	3,700	m		
Strationafia del pacebotto unit	ata				

#### Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,130
Primo vetro	6,0	1,00	0,006
Intercapedine	-	-	0,173
Secondo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

- s Spessore
- λ Conduttività termica
- R Resistenza termica







#### Descrizione della finestra: Uscita di sicurezza 180x250

Caratteristiche del serramento					
Tipologia di serramento	Singolo				
Classe di permeabilità	Classe 3 se UNI EN 12	condo N 207	ondo Norma 07		
Trasmittanza termica	U <sub>w</sub>	2,383	W/m <sup>2</sup> K		
Trasmittanza solo vetro	Ug	2,763	W/m <sup>2</sup> K		
Dati per il calcolo degli apporti s	olari				
Emissività	ε	0,837	-		
Fattore tendaggi (invernale)	f <sub>c inv</sub>	1,00	-		
Fattore tendaggi (estivo)	f <sub>c est</sub>	1,00	-		
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,750	-		
Caratteristiche delle chiusure oso	turanti				
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W		
f shut		0,6	-		
Dimensioni del serramento					
Larghezza		180,0	cm		
Altezza		200,0	cm		
Altezza sopraluce		50,0	cm		
Caratteristiche del telaio					
Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup> K		
and the second sec			1.11 12		

Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup> K
K distanziale	Kd	0,08	W/mK
Area totale	Α,	4,500	m <sup>2</sup>
Area vetro	Ag	3,330	m <sup>2</sup>
Area telaio	Ar	1,170	m <sup>2</sup>
Fattore di forma	Fr	0,74	-
Perimetro vetro	La	14,400	m
Perimetro telaio	L,	8,600	m

#### Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-		0,130
Primo vetro	6,0	1,00	0,006
Intercapedine	-	-	0,173
Secondo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

#### Legenda simboli

s Spessore

- λ Conduttività termica
- R Resistenza termica



W/mK

m<sup>2</sup>K/W







#### Descrizione della finestra: Uscita di sicurezza 115x250

Singolo					
Classe 3 secondo Norma UNI EN 12207					
U,	2,362	W/m <sup>2</sup> K			
Ug	2,763	W/m <sup>2</sup> K			
olari					
٤	0,837	-			
f <sub>c inv</sub>	1,00	-			
f <sub>c est</sub>	1,00	-			
9 <sub>gl,n</sub>	0,750	-			
curanti					
	0,16	m <sup>2</sup> K/W			
	0,6	-			
	115,0	cm			
	250,0	cm			
Ur	2,50	W/m <sup>2</sup> K			
Kd	0,08	W/mK			
	Singolo Classe 3 s UNI EN 12 Uw Ug olari fc inv fc est ggl,n curanti	Singolo Classe 3 secondo N UNI EN 12207 U <sub>w</sub> 2,362 U <sub>g</sub> 2,763 olari E 0,837 f <sub>c</sub> inv 1,00 f <sub>c</sub> est 1,00 ggl,n 0,750 curanti 0,16 0,6 115,0 250,0 U <sub>f</sub> 2,50 K <sub>d</sub> 0,08			

Trasmittanza termica del telaio	Ur	2,50	W/m <sup>2</sup>
K distanziale	Kd	0,08	W/mK
Area totale	A <sub>w</sub>	2,875	m <sup>2</sup>
Area vetro	Ao	2,090	m <sup>2</sup>
Area telaio	Ar	0,785	m²
Fattore di forma	Fr	0,73	-
Perimetro vetro	Lo	8,200	m
Perimetro telaio	L,	7,300	m

#### Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,130
Primo vetro	6,0	1,00	0,006
Intercapedine	-	-	0,173
Secondo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

#### Legenda simboli

s	Spessore

- Conduttività termica λ
- R Resistenza termica



mm

W/mK m<sup>2</sup>K/W

Technical University of Crete



## Codice: W5



170

645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Descrizione della finestra: Luc	ernai			Codice: W6
Caratteristiche del serramento	Cincola			
lipologia di serramento	Singolo			
Classe di permeabilità	UNI EN 1	secondo N 2207	lorma	
Trasmittanza termica	U <sub>w</sub>	3,285	W/m <sup>2</sup> K	
Trasmittanza solo vetro	U <sub>9</sub>	5,079	W/m <sup>2</sup> K	
Dati per il calcolo degli apporti s	olari			
Emissività	ε	0,837	-	
Fattore tendaggi (invernale)	f <sub>c inv</sub>	1,00	-	
Fattore tendaggi (estivo)	f <sub>c est</sub>	1,00	-	
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,750	-	
Caratteristiche delle chiusure os	curanti			
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W	
f shut		0,6	-	
Dimensioni del serramento				
Larghezza		520,0	cm	
Altezza		80,0	cm	
Caratteristiche del telaio				
Caracteristiche dei telaio				
Trasmittanza termica del telaio	Ur	2,50	W/m°K	
K distanziale	Kd	0,00	W/mK	
Area totale	Α,,	4,160	m"	
Area vetro	Ag	3,000	m²	
Area telaio	Ar	1,160	m²	
Fattore di forma	Fr	0,72	-	
Perimetro vetro	Lg	11,200	m	
Perimetro telaio	L	12,000	m	

#### Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,100
Primo vetro	10,0	0,20	0,050
Resistenza superficiale esterna	-	-	0,047

s	Spessore	mm
λ	Conduttività termica	W/mK
R	Resistenza termica	m <sup>2</sup> K/W







#### Descrizione della finestra: Portone industriale

Caratteristiche del serramento			
Tipologia di serramento	Singolo		
Classe di permeabilità	Senza clas	sificazio	ne
Trasmittanza termica	U,	3,309	W/m <sup>2</sup> K
Trasmittanza solo vetro	Ug	5,468	W/m <sup>2</sup> K
Dati per il calcolo degli apporti s	olari		
Emissività	ε	0,837	-
Fattore tendaggi (invernale)	f <sub>c inv</sub>	0,00	-
Fattore tendaggi (estivo)	f <sub>c est</sub>	0,00	-
Fattore di trasmittanza solare	9 <sub>gl,n</sub>	0,850	-
Caratteristiche delle chiusure os	curanti		
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W
f shut		0,6	-
Dimensioni del serramento			
Larghezza		200,0	cm
Altezza		200,0	cm
Caratteristiche del telaio			



Trasmittanza termica del telaio	Ur	4,40	W/m <sup>2</sup> K
K distanziale	Kd	0,00	W/mK
Area totale	A,,	4,000	m <sup>2</sup>
Area vetro	A	0,000	m <sup>2</sup>
Area telaio	Ar	4,000	m <sup>2</sup>
Fattore di forma	Fr	0,00	-
Perimetro vetro	Lo	3,600	m
Perimetro telaio	L	8,000	m

#### Stratigrafia del pacchetto vetrato

Descrizione strato	s	λ	R
Resistenza superficiale interna	-	-	0,130
Primo vetro	6,0	1,00	0,006
Resistenza superficiale esterna	-	-	0,047

#### Legenda simboli

s	Spessore				mm
λ	Conduttività termica				W/mK
R	Resistenza termica				m <sup>2</sup> K/W
Caratt	eristiche del modulo				
Trasmi	ittanza termica del modulo	U	3,509	W/m <sup>2</sup> K	

Ponte termico del serramento

Ponte termico associato	<b>Z1</b>	P.T. serra	menti, porte e finestre
Trasmittanza termica lineica	Ψ	0,100	W/mK
Lunghezza perimetrale		8,00	m









# **Electrical equipment characteristics**

#### Caratteristiche tipiche

Test	Melodo	Unità	D 32	D 68	D 100	D 150	D 220
Grado di viscosità ISO	-	-	32	68	100	150	220
Densità @ 15°C	ISO 12185/ ASTM D4052	kg/m³	870	880	890	890	890
Viscosità @ 40°C	ISO 3104/ ASTM D445	mm²/s (cSt)	34	68	100	150	220
Viscosità @ 100°C	ISO 3104/ ASTM D445	mm²/s (cSt)	5,4	8,7	11,1	14,5	19,2
Indice di viscosità	ISO 2909/ ASTM 2270	-	102	99	98	98	98
Punto di scorrimento	ISO 3016/ ASTM D97	°C/°F	-15/5	-12/10	-12/10	-12/10	-9 /15
Punto di infiammabilità, COC	ISO 2592/ ASTM D92	°C/°F	206/403	232/450	232/450	232/450	249/480
Test antiruggine	ISO 7210/ ASTM						
Procedura A (acqua distillata)	Deese	-	Passato	Passato	Passato	Passato	Passato
Procedura B (nebbia salina)	00000						
Corrosione del rame (3 ore @	ISO 2160/ ASTM		1b	16	1b	1b	15
100°C)	D130			10			
Valore di Brugger	DIN 51347	N/mm <sup>2</sup>	-	44	-	-	-
Prova di usura delle 4 sfere (1							
ora, 40 kg, 1800 rpm,	ASTM D2266		0.3	0.3	03	0.3	0.32
75°C/167°F) - Diametro	7.5111 02200		0,5	0,0	0,5	0,5	0,52
impronta							
Prova EP delle 4 sfere -	ASTM D2783	ka	170	180	180	190	200
Carico di saldatura	A31W D2703	∿9	170	100	100	130	200
Stick slip ratio	(Cincinnati Lamb)	-	0,74	0,74	0,74	0,74	0,74
Specifiche Cincinnati Lamb	-	-	P-53	P-47	-	-	P-50

#### Informazioni aggiuntive

Magnaglide D risponde ai requisiti di:

- Cincinati Lamb (Mllacron) P - 47, P - 50 e P - 53 (a seconda del grado di viscosità),

- DIN 51502 - CGLP,

- DIN 51524 Parte II (Luglio 2004) che include il test di filtrazione ISO 13357 1/- 2,
- Adatto come olio idraulico per le attrezzature Muller Weingarten.

#### Stoccaggio

Per evitare il deterioramento del prodotto si consiglia di mantenere gli imballaggi sigillati. Evitare qualsiasi infiltrazione di acqua e preservare dal gelo. Mantenere in un luogo fresco ed asciutto, al riparo dal sole diretto, preferibilmente in ambienti chiusi. Per ulteriori dettagli è consigliabile fare riferimento alla scheda di sicurezza del prodotto.

Castrol, Magnalide e il logo Castrol sono marchi di Castrol Limited, usati sotto licenza

Le indicazioni e le notizie tecniche riportate, derivanti da prove severe di laboratorio o da applicazioni attendibili, come pure ogni altra informazione verbale o scritta, fornita anche su richiesta dell'utente, hanno carattere puramente informativo. Per esse la Società non chiede nè riceve corrispettivo e non impegnano in alcun modo la responsabilità della Società circa riformativa del prodotti alle specifiche applicazioni cui l'utente intende destinarii. Le caratteristiche tipiche riportate rappresentano valori medi indicativi, che non costituiscono specifica.

Castrol Industrial, Divisione di BP Italia spa, via A. Checov, 50/2 – 20151 Milano Tel: 02 33446.1 – Fax: 02 33446300 www.castrol.com/ndustrial

Castrol Magnaglide D Pagina 2/2

08 maggio 2012, versione 1/2012







## $645677-\mathsf{SMART\,GEMS}-\mathsf{H2020}\text{-}\mathsf{MSCA}\text{-}\mathsf{RISE}\text{-}2014$

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

0			-	-							1			
	Specifications													
AKZ149	Oil Cooling Unit horsepower (HP)		0.	5				1.2				1.0	5	
AK7220	Model name		AKZ	149			AK	Z329			_	AKZ	139	_
AKZJZJ		ad -B	-с -н	-T**	Diffeent voltage specifications +3	Stan davd -B	-С -Н	-T*	Different unitage specifications =3	Stan daed -B	3 -C	-H	-T*	Conterent voltage repetitionisme 47
AKZ439	Cooling capacity (50/60Hz)" kW		1.3	/1.4			2.	8/3.2				3.8/	4.3	
	Heater kW	-	1		-	-	1		-	-		1		-
	Supply power <sup>1</sup>	3-Phase	AC 200/200-22	OV 50/60Hz	-3	3-Phase	AC 200/200-3	20V 50V50H	*3	3-Phase	EAC 2	200/200-220	IV SOVEOHz	-3
	Circuit voltage	_	_	_		3-Pha	a AC 200	200-2204	50/60Hz	_	-	-		_
	operang circuit	090/0/1	1 204 1 204 1	nanwaa		1 35-007		2/249		_	1.6	NW/R R	٨	_
	Max, power consumption 200V 60Hz 0	0.91kW/	1.32WW4.2	0.918W/3.64	-10	1.4380/	UBA 1.61KW/5	24 1.43kW48	*10		1.8	38kW/6.4	A	-10
	wax, consumption current 220V 60Hz	0.91KW/1	1.43KW/4.2	0.918/8/3.54		1.4380/	USA 1.724W/S	04 1.43kW/46			1.8	38kW/6.1	A	
	Transformer capacity		-		2.6kVA		-		2.6kVA			-		2.6kVA
	Exterior color						lvor	y white						
	Outside dimensions(H×W×D) mm	650+390+	440 950×350×44	810×360×535	950×390×440	775-360	440 1015×350×	40 965×360×53	510754360440	875-360	0x440	1175×380×440	1055-360-635	11754360440
>	Compressor(Totally enclosed DC swing type)		Equivalent	to 0.4kW			Equivaler	t to 0.75k	V		E	quivalent	to 1.1kW	
5	Evaporator						Shell-er	d coil type						
0	Condenser	<u> </u>				_	Cross-f	n coil type			_			
0	Propeller fan Motor		¢250	.54W					¢300	,54W	_			_
8	Oil Motor		10/				0.4	W×4P	244	20.0	-			
	pump Ocean arrest and MPa	<u> </u>	12/	4.4			_	_	247	e	-			
0	Sup Standard	-	Boom	o temperatu	re or mac	bine ter	nerature <sup>14</sup>	(Set to "Bo	om temper	ature: N	Mode	3" by de	(ault)	_
	chroni- Object to be controlled	<u> </u>	Ini	et oil temp	erature or	outlet	il temperat	ure (Set to	Inlet oil te	mperat	ure	by default	0	
10	adjust type Synchronication K			-9.	9~+9.9 a	gainst t	he standar	i temperatu	re(Set at 0	).0 by c	defai	ult)		_
ő	(Selectable) Fixed Object to be controlled				In	let oil te	mperature	or outlet oil	temperatu	re		-		
ğ	type Range °C						5	~50						
C.	Refrigerant control			Compr	essor revo	lutions	by inverter	+ Opening	of electric	expans	sion	valve		
to	Religeant@low religeant R4104/h Filling anount Kg		0.	49				0.72				0.9	8	
ns and -	Protection equipment	A set of ovecurent relia/(moto to pump), eversi-phase potection equipment, restart prevention time, bei non-temperature protection thermostat, high non-temperature protection thermostat, low of-temperature protection thermostat, relief valve to pump, discharge table temperature thermostat, condenser temperature thermostat, ordenser tais disclose, and inventer protection equipment. High-processe setted/~C type only), compresser protection thermostat (~C to central), overhall creation temporate thermostate (~H to central). Overhall central (~H to central), contain termine (~H to central).												
2	Room temperature "C						5	~45						
80	Inlet oil temperature "C						5	~50						
9	range Oil viscosity mm <sup>2</sup> /s						.4~200(8	50 VG2~	32)					
Lo Co	Product external Discharge side						0.5MF	a or less	_					
	pressure was Suction side			and other			-30.7	Pa or less	the Barrier of			And on the late		Part 1 3
	Usable oil	ubicart,	nydiaulic oli oʻri	neral oil(Not u	sable for hyde	ulic oil of	anar prosphale,	water, water-6d - 374	uzile liquid, diuj	p <b>., 1000 p</b> r	tars	, ruel, cutting	iqua, girdin	adinai enci)
	Connecting tube Oil outlet	Bo3/	4 Bc1 1/4		Bc3/4		Bol 1/	4	Rc3/4	-		Bc1 1/4	Ro	3/4
	Oil drain						Bc1/4	(Plugged)						
	Noise value (Value measured at its high in how, value analysisment in measured in marking and the (B)(A)				6	2						65	5	
	Transport vibration performance"				Up down	14.7m	/S <sup>2</sup> ×2.5 h	(7.5~100	Hz sweep	/ 5 mir	ı.)			_
	Ingress protection*						1	P2X						
	Mass kg	51	78	68	87	56	83	73	92	64		91	81	100
	Volded-case circuit breaker(Rated current) A	- 10		-		- 10		-		- 10			-	
	Oil tank(Capacity) L		-	15	-		-	20	-		-		20	-
	by customer*8 Matter/Case circuit by customer*8 breaker(Rated current) A				1	O(Req.	ired for typ	es other the	n –B type	)				

Technical University of Crete





#### 645677 — SMART GEMS — H2020-MSCA-RISE-2014

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

**VENDUTA!** DART VMC 1000 Centro di lavoro verticale Verticale MC1000 DART VMC 1000 Centro di lavoro verticale MODELLO: TAVOLA CAPACITÀ MANDRINO MAGAZZINO UTENSILI Dimensioni tavola Corsa asse x longitudinale Stazioni portautensili Attacco mandrino C.N.C: 1016 mm FANUC 18M Corsa asse y trasversale Velocità di rotazione ANNO: 8000 giri/min. 500 mm Corsa asse z verticale Potenza motore Note: Cambio utensile ad ombrello, luce







 $645677 - \mathsf{SMART\,GEMS} - \mathsf{H2020}\text{-}\mathsf{MSCA}\text{-}\mathsf{RISE}\text{-}2014$ 

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Macchine Utensili	21052 Busto Arsizio (Va)	Cell. 348 71589	93 Into(@crespigianluigi
Cat. CEN	TRO DI LAVORAZION	E VERTIC	ALE
1	ERTIVAL MACHINING	G CENTER	
REMA CONTROL			
Mod.: LEONARD RCL 2.4	Contraction of the local division of the loc		
No. 2704001	2004	L .	
Matr.: 3704001 Anno/ Y	ear: 2004		
Chc: FANUC 211M	the second secon	a de	
bar. Scotti continuous rotary t counterbearing Ø 320mm	able complete		
Chip convceyor, coolant throu bar. Scotti continuous rotary t counterbearing Ø 320mm	able complete		<u> </u>
Chip convceyor, coolant throu bar. Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche	Technical Data		<u> </u>
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola	Technical Data Table Table dimensions	mm	 2600 X 800
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet	Technical Data Table Table dimensions Number table	mm n°	€ 2600 X 800 2 800 X 800
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro	Technical Data Table Table dimensions Number table Working Area	mm n°	€ 2600 X 800 2 800 X 800
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale	Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel	mm n°	€ 2600 X 800 2 800 X 800 2 800 X 800
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse Y trasversale	Technical Data Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vectical Z travel	mm n° mm	€: 2600 X 800 2 800 X 800 2 800 X 800 2400 800 650
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse Y trasversale Corsa asse Z verticale Rapidi X-Y-Z	Technical Data Table Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z	mm n° mm mm mm mm	€ 2600 X 800 2 800 X 800 2 800 X 800 2400 800 650 40
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse Y trasversale Corsa asse Z verticale Rapidi X-Y-Z Mandrino	Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z Spindle	mm n° mm mm mm mm	€ 2600 X 800 2 800 X 800 2 800 X 800 2400 800 650 40
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse Y trasversale Corsa asse Z verticale Rapidi X-Y-Z Mandrino Attacco mandrino	Technical Data Table Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z Spindle Spindle taper	mm n° mm mm mm m/min ISO	€ 2600 X 800 2 800 X 800 2 800 X 800 2400 800 650 40 40
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse X trasversale Corsa asse Z verticale Rapidi X-Y-Z Mandrino Attacco mandrino Veloctà di rotazione	Technical Data Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z Spindle Spindle taper Spindle taper Spindle speed	mm n° mm mm m/min ISO giri/min	€: 2600 × 800 2 800 × 800 2 800 × 800 2400 800 650 40 40 8000
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse X longitudinale Corsa asse Y trasversale Corsa asse Z verticale Rapidi X-Y-Z Mandrino Attacco mandrino Velocità di rotazione Potenza motore	Technical Data Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z Spindle Spindle taper Spindle speed Engine power	mm n° mm mm m/min ISO giri/min Kw	€: 2600 × 800 2 800 × 800 2 800 × 800 2400 800 650 40 40 8000 18,5/22
Chip conveyor, coolant throu bar, Scotti continuous rotary t counterbearing Ø 320mm Caratteristiche tecniche Tavola Dimensioni tavola Numero pallet Capacità di lavoro Corsa asse X longitudinale Corsa asse X longitudinale Corsa asse Y trasversale Corsa asse Z verticale Rapidi X-Y-Z Mandrino Attacco mandrino Velocità di rotazione Potenza motore Magazzino utensili	Technical Data Technical Data Table Table dimensions Number table Working Area Longitudinal X-travel Cross Y-travel Vertical Z-travel Axis rapid X-Y-Z Spindle Spindle taper Spindle taper Spindle speed Engine power Tools magazine	mm n° mm mm m/min ISO giri/min Kw	€ 2600 X 800 2 800 X 800 2 800 X 800 2400 800 650 40 40 8000 18,5/22

Technical University of Crete




# **INTEGREX 200-IV**



### **Machine Specifications**

Specification		Bed Longth -
Capacity	Maximum Machining Diameter	860 mm / 28.000 ir
	Maximum Machining Length	995 mm / 39.170 ir
Main Spindle	Chuck Size	8 ir
	Maximum Speed	5000 rpm
	Motor Output (30 minute rating)	22 kw / 30.8 hp
Miling Spindle	B-Axia Travel	225*
	Magazine Capacity	21
	Maximum Speed	20000 rpm
	Motor Output (20 ED Rating)	6 low/ 8 hp
Feed Axes	Travel (X Axio)	680 mm / 22.83 ir
	Travel (Y Axia)	180 mm / 8.30 in
	Travel (Z Axia)	1045 mm / 41.14 in







×



#### MACHINE DESCRIPTION:

The VERTICAL TRAVELING COLUMN (VTC) 300C Vertical Machining Center features a powerful 40 Taper spindle, full traveling column design and fixed table for machining of extremely long and heavy workpieces. Or with a table center partition the machine work envelop can be transformed into two separate work areas that allow the machine to be in cycle in one work area, while a part is being set up in the other work area. The machine also delivers fast rapid traverse rates to reduce non-out times.

#### MACHINE CHARACTERISTICS:

- Long fixed table design
- Optional table partition available
- Standard 12,000-rpm CAT 40-taper spindle
- 1,181 ipm rapid traverse rate
- 24-tool (48 optional) storage capacity
- Automatio tool ohanger
- Maximum table load of 3,300 lbs.

#### MACHINE SPECIFICATIONS

Specification		Values
Capacity	Table Right/Left	78.740 in / 2000 mm
	Table Longitudinal	30.000 in / 760 mm
Spindle	Spindle Taper	40
	Maximum Speed	12000 rpm
	Motor Output (30 minute rating)	15.0 hp / 11 kw
Magazine	Number of Tools	24
Feed Axes	Travel (X Axis)	65.35 in / 1660 mm
	Travel (Y Axis)	30.00 in / 760 mm
	Travel (Z Axis)	26.00 in / 660 mm





D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase



#### Scheda Prodotto



### Caratteristiche

Compatta

- · Filtro a cartuccia autopulente integrato 10m2 (certificazione BIA)
- Sistema di separazione e recupero graniglia ad alta efficienza
   Dispositivo di sparo in pressione 7 lt
- · Dispositivo di regolazione flusso graniglia
- Dimensioni camera di lavoro LxPxH mm: 1200 x 1000 x 850
- · Dimensioni esterne LxPxH mm: 1590 x 1025 x 1700

#### Accessori opzionali

- · Tavola girevole fissa manuale
- · Componentistica e/o Carpenteria in Acciaio INOX
- Tavola girevole fissa automatica
- Tavola girevole mobile manuale
- · Supporto esterno per Tavola estraibile
- Gruppo buratto
- . Separatore Magnetico
- Rivestimento interno antiusura

La SP12 è una macchina manuale dalle dimensioni contenute, dotata del sistema di sparo in pressione che permette potenze di lavoro e velocità di produzione fino a 3 volte superiori al sistema classico in depressione. La SP12 è perfettamente integrata con il sistema di recupero e di filtrazione delle polveri esauste. Il layout contenuto e pulito la rende collocabile anche negli spazi più ridotti.









Costruzione:	NORBLAST	
Modello:	SD12	
Matricola:	3995	
Anno di costruzione:	2005	
Completa di filtro e cartuccia con sistema automatico di pulizia:	12 mm	
Dimensioni utili di lavoro:	1150 x 950 x h 830 mm	
Pressione di lavoro:	1 ÷ 8 bar	
Carico massimo applicabile:	150 kg	
Motore aspirazione:	0,14 KW	
Aspirazione:	160 m³/h	
Prevalenza:	330 Pa	
Cartuccia filtrante:	10 m²	
Materiale cartuccia filtrante		
poliestere		
Peso:	200 kg	
Dimensioni d'ingombro:	1590 x 1095 x h 1700 mm	







# DYSON AIRBLADE DB AB14 HAND DRYER

50% quieter Acoustically re-engineered to reduce noise. Hygienic. Fast. Costs less to run. 5 years guarantee.

Available in 2 colors: - Grey - White

#### **REFERENCE: AB14-W**

Send to a friend





C Display all pictures

MORE INFO DATA SHEET ACCESSORIES DOWNLOAD
---

Activation	automatic
Material(s)	White ABS polycarbonate
Electrical Specifications	220V - 240V / 50Hz&60Hz / <mark>1600W</mark>
Motor type	Dyson digital motor V4 – brushless DC Motor
RPMs	90,000
Motor watts	1600W
Warranty	5 years parts, 1 year labour guarantee
Air velocity	430 mph
Filtration	Bacteria removal 99.9%
Dimensions	H 661 x W 303 x D 247 mm









#### POWER /

Power Consumption Sleep	80 Watt
Power Consumption Standby	277 Watt
Power Consumption Operational	1012 Watt









### Building's sunpath diagram





### **PV systems and Inverter characteristics**

### 3.5 Parametri modulo fotovoltaico SL-001-182; 182 Wp

(installato su tetto stabilimento AEA, SUMMA-AD)

DATI GENERALI	
Codice	SL-001-182
Marca	SOLYNDRA
Modello	182.Wp
Tipo materiale	Cella Cilindrica in CIGS
CARATTERISTICHE ELETTRICHE IN CONDIZIONI STC	
Potenza di picco [W]	182
Imp [A]	2.46
lsc [A]	2.76
Efficienza [%]	9.26
Vmp [M]	73.9
Voc [V]	96.7
ALTRE CARATTERISTICHE ELETTRICHE Coeff, Termico Voc [%/°C] Coeff, Termico Isc [%/°C]	-0.24 -0.02
Coefficiente di temperatura a (Pmm)	-0.26%/°C
NOCT (°C)	41.7
Vmax [V]	1000.00
CARATTERISTICHE MECCANICHE	
Lunchezza (mm)	1820
Larghezza [mm]	1080
and Alexandra (a. 1974). A set of the set of the state of the state of the set of the set of the set of the set	







## 3.6 Parametri modulo fotovoltaico HS-115 - 115 Wp

(installato su tetto stabilimento SUMMA-ex TM)

	CENEDAL	ı
DAII	GENERAL	J,

Codice	HS 115 - 115 Wp
Marca	HELIOSPHERA
Modello	115 Wp
Tipo materiale	Film Sottile
CARATTERISTICHE ELETTRICHE IN CONDIZIONI STC	

	Potenza di picco [W]	115
	Imp [A]	1.12
j	ISC [A]	142
	Efficienza [%]	8.04
	Vmp M	102.7
	Voc [V]	130

#### ALTRE CARATTERISTICHE ELETTRICHE

Coeff. Termico Voc [%/°C]	-0.37
Coeff. Termico isc [%/°C]	0.05
Coefficiente di temperatura q (Pmco)	-0,32%/°C
NOCT [°C]	그는 이 것 그렇는 책 친물을 가지 않는 것
Vmax [V]	1000.00

#### CARATTERISTICHE MECCANICHE

Lunghezza [mm]	1300
Larghezza (mm)	1100
Spessore [mm]	6.4
Peso [kg]	25
Numero celle	
CERTIFICAZION	
Certificazione IEC EN	61646 Ed 2 0
Certificazione Classe II	NO
Altre certificazioni	IEC 61730
GARANZIË	
Garanzia prodotto	5 anni
Garanzia prestazioni	. 20 anni





# 3.7 Parametri Inverter REFUSOL 016K

(installato per tetto stabilimento AEA, SUMMA-AD)

Marca Modello	REFUSOL 016 K
Tipo fase	Trifase
PARAMETRI ELETTRICI IN INGRESSO	
VMppt min [V]	525
VMppt max [V]	800
Jmax [A]	32
Vmax [M]	1000
Max potenza FV [W]	18.1 kWp
DADAMETRI ELETTRICI IN LISCITA	
Potenze nominale MA	18.5 MM
Tensione nominale M	400 Vac
Efficienza massima (%)	
	$\mathbf{n} = \mathbf{n} + $
Encienza europea [%]	η <sub>EU</sub> = 97.7
Frequenza [Hz]	50/60
Distorsione arm. [%]	< 2.5
CARATTERISTICHE MECCANICHE	
Dimensioni L x H x P [mm]	535 x 601 x 277
Peso [kg]	39
Grado di protezione	IP65
CERTIFICAZIONI	
Certificazione per collegamente alla rete elettrica	
Altre certificazioni	IEC 61643-21
CARANZIE	
Geranzia prodotto	5 anni (data fabbricazione)
Estensione garanzia (+ manutenzione)	Fino a 210 anni
NOTE	anian an dan manana anian selama kata di Mandal Manda anakata akananan 40 Manda ata sebagai se
Note	Inverter SENZA trasformatore;





3.8 Parametri Inverter 25 BT (SIAC)	
(installato per tetto stabilimento SUMMA-ex TM)	
DATI GENERALI	
Marca	SIAC
Modello	25 BT
Tipo fase	Trifase
PARAMETRI ELETTRICI IN INGRESSO	
VMppt min M	<b>330</b>
VMppt max [V]	700
Minax Mina and the second s	780
Max potenza FV [W]	27 kWo
A TEMPERATURE CONTRACTOR AND A CONTRACTOR A	
PARAMETRI ELETTRICI IN USCITA	
Potenza nominale [W]	22.5 KW
Efficienza massima (%)	
Efficienza europea 1%	1 = 94.4
	$\eta_{EV} = 93$
	<b>90</b>
Distorsione arm. [%]	<3
CARATTERISTICHE MECCANICHE	
Dimensioni L x H x P (mm)	550 x 850 x 1055
Peso [kg]	330
Grado di protezione	IP21
CERTIFICATION	
Certificazione par collocomento elle rate elettrice	
Centricazione per collegamente alla rete elettrica	Contorme alla "Guida per le connessioni alla rete elettrica di Enel Distribuzione" Ed. 1.1 - Dicembre 2009
	Appartiene all'elenco dei dispositivi collegabili alla rete BT di
	Enel Distribuzione
Altre certificazioni	DK 5940, CEI 11-20
GARANZIE	
Garanzia prodotto	2 anni (data fabbricazione)
Estensione garanzta (+ manutenzione)	Fino a 5 o 10 anni





187

### CFD internal Temperature Contour





# 9.2 Annex 2-KITE lab

### My Leaf energy Data

		Contatore	Kite Lab	Sala 1	Sala 2	Sala 3	Sala 4	Sala 5	Lab 1	Lab 2	Condizionamento	Fotovoltaico
	Date	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value	Value
	01/09/2015 00:00:00	197,2	0	0	0	0	0	0	0	0	0	8,216666667
Sep 15	01/10/2015 00:00:00	4140,07	0	0	0	0	0	0	0	0	0	5,750097222
Oct 15	01/11/2015 00:00:00	2599,45	0	0	0	0	0	0	0	0	0	3,493884409
Nov 15	01/12/2015 00:00:00	2565,59	0	0	0	0	0	0	0	0	0	3,563319444
Dec 15	01/01/2016 00:00:00	2485,42	0	0	0	0	0	0	0	0	0	3,34061828
Jan 16	01/02/2016 00:00:00	2107,54	0	0	0	0	0	0	0	0	0	2,832715054
Feb 16	01/03/2016 00:00:00	2132,71	0	0	0	0	0	0	0	0	0	3,064238506
Mar 16	01/04/2016 00:00:00	3410,45	0	0	0	0	0	0	0	0	0	4,583938172
April 16	01/05/2016 00:00:00	4609,26	8,546794	0,000549346	0,001178	0,001281	0,000724	0,000896	0,092227	0,00239225	15,80142647	6,40175
May 16	01/06/2016 00:00:00	5447,15	7,064586	0,000521414	0,001081	0,001578	0,00244	0,000849	0,291874	0,001615791	15,60453401	7,321438172
Jun 16	01/07/2016 00:00:00	5254,13	8,87865	0,000554081	0,001101	0,001435	0,001118	0,001109	0,178107	0,001323327	17,95564998	7,297402778
Jul 16	01/08/2016 00:00:00	6052,23	20,68834	0,000813378	0,00151	0,001894	0,00106	0,001417	0,626073	0,000350252	30,23516057	8,134717742
Aug 16	31/08/2016 00:00:00	5729,32	20,16621	0,000688767	0,00138	0,001816	0,000986	0,001205	0,245619	0	32,55349631	7,957388889
	Sum	46533,32	65,34457	0,003126986	0,006251	0,008005	0,006328	0,005475	1,4339	0,005681621	112,1502673	63,74150867
			6153,692	0,395529412	0,848235	0,922622	0,521345	0,644941	66,4038	1,722420168	11377,02706	4609,26
			5256,052	0,387932121	0,804447	1,173766	1,81536	0,631523	217,1546	1,202148687	11609,7733	5447,15
			6392,628	0,398938004	0,79253	1,033547	0,80529	0,79828	128,2369	0,952795797	12928,06799	5254,13
			15392,12	0,605153345	1,123553	1,409249	0,788365	1,054329	465,7981	0,260587563	22494,95947	6052,23
			15003,66	0,512442536	1,026928	1,351049	0,733451	0,896366	182,7403	0	24219,80125	5920,297333
		kwh	48198,15	2,299995417	4,595692	5,890233	4,663811	4,025439	1060,334	4,137952215	82629,62906	27283,06733
Total	131913,7267	kwh										

### Categorization of internal gains

		Peopl	Lights	Equipment	Human	Light	Siz
Space	E (m2)	е	(W)	(W)	Activity	s	е
Entrance	82,3	5	656		В	М	L
1st Office	25,6	6	164		В	S	S
2nd Office	35	7	164		В	S	S
Toilet	26,9	2	200		LL	S	S
Lab 1	94,7	10	648	50	В	М	L
Lab 2	94,7	10	648	50	В	М	L
Sala 1	46,3	2	481	152	LL	М	S
Sala 2	65	3	648	73	LL	М	S
Sala 3	63,3	3	648	35	LL	М	S
Sala 4	46,4	2	481	125	LL	М	S
Sala 5	47,3	2	348	125	LL	М	S
Sala 6	46,3	0	348	150	Ν	М	S
Empty	21,2	0	162		Ν	S	S
3rd Office	81,2	8	574		В	М	S





Magazzin							
0	97	4	560	15	LL	м	L
Corridor	245,5	4	1506		LB	L	L
Technico							
1	392,8	1	1944		LB	L	L
Technico	127,8						
2	2	0	405		Ν	М	L
Technico							
3	66	0	405		Ν	М	L

### Sketchup extractions

































D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

















# 9.3 Annex 3-AEA building

### Characteristics of Walls

Des	crizione della struttura	<u>ı:</u> Parete esi	terna - i	solata				Codic	<u>e:</u> M1
Tra	smittanza termica	0,452	W/m²K						
Spe	essore	263	mm			R	88888	B	
Ten (cal	nperatura esterna Icolo potenza invernale)	-6,0	°C						
Peri	meanza	12,403	10 <sup>-12</sup> kg/	sm²Pa		1 8	88888	8	
Mas (cor	ssa superficiale n intonaci)	293	kg/m²						
Mas (ser	ssa superficiale nza intonaci)	282	kg/m²						
Trat	smittanza periodica	0,101	W/m <sup>2</sup> K					8	
Fatt	tore attenuazione	0.224				12.0	аврал	LI LI	
Sfa	samento onda termica	-9,5	h						
Sfa Stra	samento onda termica	-9,5	h						
Sfat Stra N.	samento onda termica ttigrafia: Descrizione	-9,5 e strato	h	s	Cond.	R	M.V.	С.Т.	R.V.
Sfat Stra N.	samento onda termica ttigrafia: Descrizione Resistenza superficiale inter	-9,5 e strato	h	s -	Cond.	R 0,130	M.V.	с.т.	R.V.
Sfa: Stra N. - 1	samento onda termica ttigrafia: Descrizion Resistenza superficiale inter Cartongesso in lastre	-9,5 e strato	h	s - 12,50	Cond. - 0,250	R 0,130 0,050	M.V. - 900	с.т. 1,00	R.V. - 10
Sfat	samento onda termica ttigrafia: Descrizione Resistenza superficiale inter Cartongesso in lastre Polistirene espanso, estruso	-9,5 e strato ma o con pelle	h	s 12,50 50,00	Cond. - 0,250 0,035	R 0,130 0,050 1,429	M.V. - 900 35	C.T. 1,00 1,25	R.V. 
Sfat Stra N. 1 2 3	samento onda termica ttigrafia: Descrizione Resistenza superficiale inter Cartongesso in lastre Polsistrene espanso, estruso Tamponamento Italprefabbi	-9,5 e strato rna o con pelle ricati	h	s 12,50 50,00 200,00	Cond. - 0,250 0,035 0,360	R 0,130 0,050 1,429 0,556	M.V. 900 35 1400	C.T. 1,00 1,25 0,88	R.V. 10 300 5
Sfat Stra N. - 1 2 3 -	samento onda termica tigrafia:  Resistenza superficiale inter Cartogesso in lastre Polistinene espanso, estruso Tamponamento Italprefable Resistenza superficiale este	-9,5 e strato rna o con pelle ricati rna	h	s - 12,50 50,00 200,00	Cond. - 0,250 0,035 0,360 -	R 0,130 0,050 1,429 0,556 0,047	M.V. 900 35 1400	C.T. 1,00 1,25 0,88	R.V. - - - - - - - -
Sfat	samento onda termica titarafía: Descrizion Resistenza superficiale inter Cartongeso in lastre Polatitene espanso, estruso Tamponamento Italgrefabbi Resistenza superficiale este nda simboli	-9,5 e strato ma o con pelle ricati ma	h	s - 12,50 50,00 200,00 -	Cond. - 0,250 0,035 0,360 -	R 0,130 0,050 1,429 0,556 0,047	M.V. - 900 355 1400 -	C.T. 1,00 1,25 0,88	R.V. 
Sfat Stra N. 1 2 3 -	samento onda termica ttigrafia: Resistenza superficiale inte Politirene espanso, estruso Politirene espanso, estruso Resistenza superficiale este inda simboli Spessore	-9,5 e strato ma o con pelle ricati rna	h	s 12,50 50,00 200,00 -	Cond. - - 0,250 0,035 0,360 -	R 0,130 0,050 1,429 0,556 0,047	M.V. - 900 35 1400 -	C.T. 1,00 1,25 0,88	R.V. - 10 300 5 -
Sfat Stra N. - 1 2 3 - - - - - - - - - - - - - - - - - -	samento onda termica ttigrafía: Descrizion Resistenza superficiale integr Polistiene espanso, estruso Tamponamento Italprefabbi Resistenza superficiale este nda simboli Spesore di. Conduttività termica, co	-9,5 e strato ma o con pelle ricati rna	h	s 12,50 50,00 200,00 -	Cond. 0,250 0,035 0,360 -	R 0,130 0,0550 1,429 0,556 0,047	M.V. - 900 35 1400 - -	C.T. - 1,00 1,25 0,88 -	R.V. - 10 300 5 -
Sfat Stra N. - 1 2 3 - - - - - - - - - - - - - - - - - -	samento onda termica ttigrafia:      Besistenza superficiale inte     Cartongesso in lastre     Polistiene espanso, estruso     Tamponamento Laipenfable     Resistenza superficiale exte     da simboli     Spessore     d. Conduttività termica, termica,     resistenza termica	-9,5 e strato rna o con pelle ricati rna comprensiva di	h	s 12,50 50,00 200,00 -	Cond. 0,250 0,355 0,360 -	R 0,130 0,050 1,429 0,556 0,047	M.V. 900 35 1400 - W/m m <sup>2</sup> K,	C.T. - 1,00 1,25 0,88 -	R.V. - - - - - -
Sfat Stra N. - 1 2 3 - - - - - - - - - - - - - - - - - -	samento onda termica ttigrafía: Resistenza superficile inter Politirene espanso, estruso Tamponamento Italprefabbr Resistenza superficiale este nda simboll Spesore d. Conduttività termica, o Resistenza termica Massa volumica	-9,5 e estrato o con pelle ricati rma	h	s 12,50 50,00 200,00 -	Cond. - 0,250 0,035 0,360 -	R 0,130 0,050 1,429 0,556 0,047	M.V. 900 35 1400 - W/m m <sup>2</sup> K, kg/n	C.T. 1,00 1,25 0,88	R.V. - 10 300 5 -
Sfat Stra N. - 1 2 3 - - - - - - - - - - - - - - - - - -	samento onda termica ttigrafia:      Cartongeso in lastre Polistiene espanse, estruso ramponamento talpendable Resistenza superficiale este spessore d. Conduttività termica , nel Resistenza termica , Massa volumica . Capacità termica speci	-9,5 e strato nna o con pelle ricati comprensiva di fica	h	s 12,50 50,00 200,00 -	Cond. - 0,250 0,035 0,360 - -	R 0,130 0,050 1,429 0,556 0,047	M.V. - 900 355 1400 - - - - - - - - - - - - - - - - - -	C.T. 1,00 1,25 0,88	R.V. 10 300 5

Desc	crizione della struttura	: Parete es	terna - I	non isola	ita			Codic	<u>e:</u> M2
Tras	smittanza termica	1,365	W/m²K						
Spe	ssore	200	mm			18	8888		
Tem (cale	nperatura esterna colo potenza invernale)	-6,0	°C			8			
Perr	meanza	200,00 0	10 <sup>-12</sup> kg/	sm²Pa					
Mas (con	sa superficiale n intonaci)	280	kg/m²			8			
Mas (sen	isa superficiale nza intonaci)	280	kg/m²						
			22.2			88	XXXXI		
Tras	smittanza periodica	0,632	W/m²K			KX KX	XXXX		
Tras Fatt Sfas	smittanza periodica ore attenuazione samento onda termica	0,632 0,463 -7,4	W/m²K - h			EX.	хрон		
Tras Fatt Sfas	smittanza periodica core attenuazione samento onda termica tigrafia:	0,632 0,463 -7,4	W/m²K - h			KDX	х <del>дара</del>		
Tras Fatt Sfas Stra N.	smittanza periodica sore attenuazione samento onda termica tigrafia: Descrizione	0,632 0,463 -7,4	W/m <sup>4</sup> K - h	5	Cond.	R	<u>жүсчсча</u> м.v.	С.Т.	R.V.
Tras Fatt Sfas Stra N.	smittanza periodica icore attenuazione samento onda termica tigrafia: Descrizione Resistenza superficiale inter	0,632 0,463 -7,4 strato	W/m²K - h	5	Cond.	R 0,130	м.v. -	С.т.	R.V.
Tras Fatt Sfas Stra N. - 1	smittanza periodica ore attenuazione samento onda termica tiorafia: Descrizione Resistenza superficiale inter Tamponamento Italprefabbr	0,632 0,463 -7,4 strato na icati	W/m²K - h	5 - 200,00	Cond. 0,360	R 0,130 0,556	M.V. 1400	C.T. 0,88	R.V. - 5
Tras Fatt Sfas Stra N. - 1	mittarza periodica ore attenuazione samento onda termica tigrafia: Resistenza superficiale inter Resistenza superficiale ester	0,632 0,463 -7,4 strato na icati ma	W/m²K - h	5 - 200,00 -	Cond. 0,360	R 0,130 0,556 0,047	M.V. - 1400 -	C.T. 0,88	R.V. - 5
Tras Fatt Sfas Stra 1 - - - - - - - - - - - - - - - - - -	smittanza periodica ore attenuazione samento onda termica titarafia: Resistenza superficiale inter Tamponamento Italperfabin Resistenza superficiale ester nda simboli Spessore d. Conduttività termica, o	0,632 0,463 -7,4 e strato na icati na	W/m <sup>4</sup> K - h	5 200,00 -	Cond. - 0,360 - szione	R 0,130 0,556 0,047	M.V. 1400	<u>с.т.</u> К	R.V. 
Tras Fatt Sfas Stra - 1 - - s Con- R	mittanza periodica ore attenuacione aamento onda termica tioarafias Descrizione Resistenza superficial ner Resistenza superficial rest Resistenza superficiale ester nda simboli Spessore d. Conduttività termica, or Resistenza termica	0,632 0,463 -7,4 strato na icati na	W/m <sup>4</sup> K - h	s 200,00 e maggiori	Cond. - 0,360 - - azione	R 0,130 0,556 0,047	M.V. - 1400 - W/m m <sup>2</sup> K/	<u>с.т.</u> <u>о,88</u> - К	R.V. - - - -
Tras Fatt Sfas Stra - 1 - - - - - - - - - - - - - - - - -	smittanza periodica ore attenuazione samento onda termica tiarafia: Descrizione Resistenza superficiale inten Tamponamento Italprefabir Resistenza superficiale ester nda simboli Spessore d. Conduttività termica, o Resistenza termica Massa voluminica	0,632 0,463 -7,4 i strato na icati ma	W/m <sup>4</sup> K	s 200,00 -	Cond. 	R 0,130 0,556 0,047	M.V. - 1400 - W/m m <sup>2</sup> K/ kg/m	C.T. - 0,88 -	R.V. 







### $645677-\mathsf{SMART\,GEMS}-\mathsf{H2020}\text{-}\mathsf{MSCA}\text{-}\mathsf{RISE}\text{-}2014$

D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Descrizione della struttura: Pavimento industriale Trasmittanza termica 1,674 W/m²K		
Trasmittanza termica 1,674 W/m²K		Codice: P1
Trasmittanza controterra 0,166 W/m²K		
Spessore 650 mm		XXXX,
Temperatura esterna (calcolo potenza inversale) -6,0 °C		<del>22222</del>
Permeanza <b>3,960</b> 10 <sup>-12</sup> kg/sm <sup>2</sup> Pa		
Massa superficiale 1390 kg/m <sup>2</sup>		
Massa superficiale <b>1390</b> kg/m <sup>2</sup> (senza intonaci)		
Trasmittanza periodica 0,087 W/m²K	and a	er-c-
Fattore attenuazione 0,524 -		
Sfasamento onda termica -15,7 h		
Stratigrafia:		
N. Descrizione strato s	Cond. R M	.V. C.T. R.V.
- Resistenza superficiale interna	0,170	
1 Massetto ripartitore in calcestruzzo con rete 150,	0 1,490 0,101	2200 0,88 70
	0 2,500 0,120	2400 1,00 130
2 C.I.s. armato (2% acciaio) 300,	0 1 200 0 167	1700 0,84 5
2         C.I.s. armato (2% acciaio)         300,           3         Ghiaia grossa senza argilla (um. 5%)         200,	1,200 0,107	
2     C.I.s. armato (2% acciaio)     300,       3     Ghiaia grossa senza argilla (um. 5%)     200,       -     Resistenza superficiale esterna	· · 0,040	
2     C.I.s. armato (2% acciaio)     300,       3     Ghiaia grossa senza argilla (um. 5%)     200,       -     Resistenza superficiale esterna	0,040	
2     C.I.s. armato (2% accialo)     300,       3     Ghala grossa senza argilla (um. 5%)     200,       -     Resistenza superficiale esterna	0,040	
2     C.Ls. armato (2% accialo)     300,       3     Ghaia gross ensa argilla (un. 5%)     200,       -     Resistenza superficiale esterna       expenda simboli     s       s     Spessore	0,040	
2         C.J.s. armato (2% accialo)         300,           3         Chaia grosses max anglia (un. 5%)         200,           -         Resistenza superficiale esterna         -           -         Resistenza functional esterna         -           -         Resistenza superficiale esterna         -           -         S         Spresore         -           Cond.         Condutività termica, comprensiva di eventuale mag         -	orazione	mm W/mK
2         C.I.s. armato (2% excelus)         300,           3         Ghaia gross sensa argilla (un. 5%)         200,           -         Resistenza superificiale esterna         200,           -         Conductività termica, comprensiva di eventuale mag         Resistenza termica	orazione	
2         CLs. a rmato (2% acciaio)         300,           3         Chaia gross sensa anglia (um. 5%)         200,           -         Resistenza superficiale esterna         esterna           s         Spessore         Spessore           Conductività termica, comprensiva di eventuale mag         R         Resistenza termica           NV         Massa volumica         F	orazione	
2         C.J.s., armato (2% accialo)         300,           3         Citaia gross serva anglia (um. 5%)         200,           -         Resistenza superificiale esterna         200,           -         Resistenza superificiale esterna         200,           -         Conductivitale esterna         200,           -         Conductivitale esterna         200,           -         Conductivitale esterna         200,           -         Conductivital termica, comprensiva di eventuale mag         Resistenza termica           M.V.         Hassas voltumica         Conductivita termica exercifica	orazione	mm W/mK m²K/W kg/m³ vt/kok

Desc	crizione della struttura	Copertura						Codic	e: 51
Tras	mittanza termica	0,272	W/m²K						
Sper	ssore	205	mm						
Tem (calc	nperatura esterna colo potenza invernale)	-6,0	°C						
Pern	neanza	0,728	10 <sup>-12</sup> kg/s	sm²Pa	100			2	
Mass (con	sa superficiale h intonaci)	90	kg/m²		67	and a star	417 - 4 - 15 - 16 - 16 - 16 - 18 - 18	Carl Con	
Mass (sen	sa superficiale iza intonaci)	90	kg/m²						
Tras	imittanza periodica	0,183	W/m²K						
Fatte	ore attenuazione	0,672							
Fatte	ore attenuazione samento onda termica	0,672 -5,6	h						
Fatte Sfas	ore attenuazione samento onda termica tigrafia: Descrizione	0,672 -5,6	h	s	Cond.	R	M.V.	C.T.	R.V.
Fatto Sfas Stra N.	ore attenuazione samento onda termica tigrafia: Descrizione Resistenza superficiale ester	0,672 -5,6 strato	h	\$	Cond.	R 0,047	M.V.	С.Т.	R.V.
Fatte Sfas Strat	ore attenuazione amento onda termica tigrafia: Descrizione Resistenza superficiale ester Impermeabilizzazione con bi	0,672 -5,6 strato na tume	h	s - 5,00	Cond. 0,170	R 0,047 0,029	M.V. -	C.T. 1,00	R.V. - 50000
Fatte Sfas Strat	ore attenuazione amento onda termica tigrafia: Resistenza superficiale ester Impermeabilizzazione con bi Polistrene espanso, estruso	0,672 -5,6 strato na tume con pelle	h	s - 5,00 80,00	Cond. 0,170 0,035	R 0,047 0,029 2,286	M.V. - 1200 35	C.T. 1,00 1,25	R.V. - 50000 300
Fatte Sfas Strat	ore attenuazione amento onda termica ttigrafia: Descrizione Resistenza superficiale ester Impermeabilizzazione con bi Polistirene espanso, estruso sottofondo alleggerito	0,672 -5,6 strato na tume con pelle	h	s - 5,00 80,00 70,00	Cond. - 0,170 0,035 0,061	R 0,047 0,029 2,286 1,148	M.V. - 1200 35 450	C.T. - 1,00 1,25 0,85	R.V. - 50000 300 7
Fatte Sfas itrat N. - 1 2 3 4	ore attenuazione amento onda termica tiurafia: Descrizione Resistenza superficiale ester Impermeebilizzazione con bi Polistirene espanso, estruso sottofondo alleggento Copertura industriale prefabili	0,672 -5,6 strato na tume con pelle	h	s - 5,00 80,00 70,00 50,00	Cond. - 0,170 0,035 0,061 0,800	R 0,047 0,029 2,286 1,148 0,063	M.V. - 1200 35 450 1000	C.T. - 1,00 1,25 0,85 0,84	R.V. - 50000 300 7 6
Fatte Sfas N. - 1 2 3 4 -	ore attenuazione aamento onda termica ttorrafia: Descrizione Resistenza superficale ester Impermensibilizzazione con bi Polistirene espanso, estruso sottofrondo alleggerito Copertura industriale pertabila Resistenza superficiale interr	0,672 -5,6 strato na tume con pelle pricata ta	h	s 5,00 80,00 70,00 50,00	Cond. - - 0,170 0,035 0,061 0,800 -	R 0,047 0,029 2,286 1,148 0,063 0,100	M.V. - 1200 35 450 1000 -	C.T. 1,00 1,25 0,85 0,84 -	R.V. - 50000 300 7 6 -
Fatter Sfas Strat 1 2 3 4 - - S Conce R	ore attenuazione aamento onda termica tiorafia: Descrizione on bi Polstrene espanso, estruso sotofondo allegarrio Copertura industriale partelabi Resistenza superficiale interr uda simboli Spessore d. Conduttività termica, co	0,672 -5,6 strato na turme con pelle oricata ne oricata	eventuale	s 5,00 80,00 70,00 50,00 -	Cond. - 0,170 0,035 0,061 0,800 -	R 0,047 0,029 2,286 1,148 0,063 0,100	M.V. 1200 355 1000 - mm W/m m <sup>2</sup> K,	C.T. 1,00 1,25 0,84 - - - - - - - - - - - - -	R.V. 50000 300 7 6 -
Fatter Sfas Sfas Strat 1 2 3 4 - 2 3 4 - 2 3 4 - 2 3 4 - 2 3 Conc R M.V.	ore attenuazione iamento onda termica tiorafía: Descrizione Resistanza superficiale ester Impermeabilizzazione con bi Polistirene espanso, estruso satofindo alleggento Copertura industria perdalà Resistenza superficiale inter sda simboli Spessore d. Conduttività termica, ec Resistenza termica Massa volumica	0,672 -5,6 strato na turme con pelle oricata ta	eventuale	s 5,00 80,00 70,00 50,00 -	Cond. - - 0,170 0,035 0,061 0,800 - -	R 0,047 0,029 2,286 1,148 0,063 0,100	M.V. - 1200 35 450 1000 - - -	C.T. - 1,00 1,25 0,85 0,84 -	R.V. 50000 300 7 6 -







### **Characteristics of Windows and Doors**

Descriptions dalla finantia: Mo	dula fiamete	* continu				Cadio	
Caratteristiche del serramento	unito mitestri	a commu					100 110
Tipologia di serramento	Singolo						
Classe di permeabilità	Classe 3 s UNI EN 1	secondo h 2207	torma				
Trasmittanza termica	U,	2,339	W/m <sup>2</sup> K				
Trasmittanza solo vetro	U <sub>9</sub>	2,763	W/m <sup>2</sup> K	_			_
Dati per il calcolo degli apporti s	olari						
Emissività	E	0,837			_		1.11
Fattore tendaggi (invernale) Fattore tendaggi (estivo)	fent	0,80	2				
l'attore di trasmittanza solare	Dein	0,750					
Caratteristiche delle chiusure os	curanti						
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W				
f shut		0,6					
Dimensioni del serramento							
Larghezza		550,0	cm				
- Addition			2000				
Caratteristiche del telaio							
Trasmittanza termica del telaio V distanziale	U <sub>t</sub>	2,50	W/m <sup>2</sup> K				
Area totale	A.	8,250	m <sup>3</sup>				
Area vetro	Ay	6,630	m <sup>2</sup>				
Area telaio Fattore di forma	A <sub>t</sub>	1,620	mz				
Perimetro vetro	L,	18,000	m				
Perimetro telaio	Le	14,000	m				
Stratigrafia del pacchetto veti	ato_						
Descrizione strato Resistenza superficiale interna	5	A .	R 0,130		AA		
Primo vetro	6,0	1,00	0,006		1	Ŷ	
Intercapedine Secondo vetro	6.0	1.00	0,173				
Resistenza superficiale esterna	-		0,047		1000	1	
legenda simboli							
s Spessore					mm		
R Resistenza termica					m <sup>2</sup> K/W		
SERFICLI Engineering Via Grandi, 45h - 60131 Ancone (Al	W.						pag. 10
SERVILI Engineering Vie Grandi, 45k - 60131 Ancona (Al Constituciations dat modulo	N)						pag. 10
SERFILLE Engineering We Grand, 45b - 60131 Ancons (Al Caratteristiche del module Trasmittanza termica del modu	njo fi	2,501	9 W/m²K				pag. 10
SERFICI Employeering Via Grand, 45h - 60131 Ancons (Al Caratteristiche del module Trasmittanza termica dei modi Poote termica dei serramento	vj ilo U	2,501	0 W/m <sup>2</sup> K				pag. Id
SCRIPTLI Engineering Via Grandi, 45n - 60131 Ancors (Al Caratteristiche del module Trasmittanza termica del mod Ponte termico ael serramento Ponte termico associate	v) 10 ∪ 21	2,501 P.T. sen	) W/m²K	orte e fin	estre		pag. 10
SCRIPTILLI Explorenting Via Ganad, 450 - 60131 Ancore (Al Caratteristiche del module Trasmittanza termica del mod Poete termico del serramento Poete termico associato Trasmittanza termica lineica	ال oh 10 ت 21 12	2,501 P.T. sen 0,100	) W/m²K ramenti, p ) W/mK	iorte e fin	estre		peg. 10
SERVILI Englewriae Vir Grandt, 459 - 68/31 Anonar (A Caratteristicha del module Trasmittanza termica del mod Porte termico associato Porte termico associato Trasmittanza termica inesta Lunghezza perimetrale	۷) ماد ۲۱ ۳	2,501 P.T. sen 0,100 14,00	) W/m²K ramenti, p ) W/mik ) m	orte e fin	estre		pag. If
SCRIPTLI Deplementa Va Grande, 455 - 46331 Ansona (Al Caratteristiche del module Tresmittanza termica del mod Decle termica del seranento Porte termica sociato Trasmittanza termica lineica Lunghezza perimetrale	9) 180 U 211 2	2,501 P.T. sen 0,100 14,00	) W/m²K ramenti, p ) W/mK ) m	iorte e fini	estre		pag. If
SCHTTLI Engineering SCHTTLI Engineering Caratteristichs dal modulo Tramittansa terrica dal mod Ponte terrinico associato Ponte terrinico associato Ponte terrinico associato Langhezza perimetrale	4) がっし で	2,501 P.T. serr 0,100 14,00	) W/m²K ramenti, p ) W/mK ) m	orte e fini	estre		pag. If
SERTILI Englewing Gand, 45t - 60331 Anons (A Caratteristicha dL modula Trasmittanza ternica del mod Ponte ternico ad Larramento Ponte ternico ad Larramento Ponte ternico ad Larramento Lunghezza perimetrale	۷) ۸۵ U ۲۲ ۳	2,501 P.T. serr 0,100 14,00	9 W/m²K ramenti, p 9 W/mik 9 m	orte e fin	estre		pag. 16
SCRIPTLI Deplevente Va Grand, 454 - 46331 Anome (Al Caratteristiche del module Trasmittanza termica del mod Porte termico associato Trasmittanza termica lineica Lunghezza perimetrale	۷) ۱۹۵۰ U ۲۲ ۳	2,501 P.T. seri 0,100 14,00	9 W/m²K ramenti, p 9 W/mK 9 m	orte e fin	estre		pag. 10
SPRTLI I Pupinering Vergenziehen (d. 1990) Caratteristiche del modulo Tramittania ternica del mod Porte ternica secondo Tramittania ternica lineica Lunghezza perimetrale	۷) ماد U ع	2,501 P.T. sen 0,100 14,00	9 W/m²K ramenti, p 9 W/mK 9 m	iorte e fini	estre		pag. 10
Statisti Engenering Gandi, 45t - 60331 Accurs (A Caratteristicha dal modulo Tramittarias terrica del mod Porte terrico asociato Porte terrico inecciato Lunghezza perimetrale	U ok U ok T	2,501 P.T. sen 0,100 14,00	9 W/m²K ramenti, p 9 W/mK 9 m	iorte e fini	estre		pag. 10
SCRIPTLI Explorentia Va Grand, 45 - 40.31 Ansana (A Caratteristiche del module Tresmittanza termica del mod Porte termico associato Trasmittanza termica lineica Lunghezza perimetrale	9 do U 21 T	2,501 P.T. sen 0,100 14,00	) W/m²K ramenti, p W/miK ) m	iorte e fini	estre		pag. 10
SPRTLI Ingineering Gand, 459 - 40331 Arcons (A Garatteristicha del modulo Trasmittana ternica del mod Porte ternica seconda Trasmittana ternica lineica Lunghezza perimetrale	ν) do U 21 Ψ	2,501 P.T. serr 0,100 14,00	) W/m²K ramenti, p W/mX ) m	iorte e fini	estre		pag. If
SPRTLI Engineering We Grand, 454 – 40331 Arcons (A Caratteristicha dal modulo Tramittanas termica del mod Porte termico associato Porte termico associato Tramittanas termica leneta Lunghezza perimetrate	9) 10 U 21 7	2,505 P.T. seri 0,100 14,00	y W/m²k ramenti, µ y W/mK y m	orte e fin	estre		ραφ. Ιζ
SERTICI Deplementa Ve Grande, 45 - 6031 Ansona (A Caratteristiche del module Trasmittanza termica del mod Parte termica associato Trasmittanza termica lineica Lunghezza perimetrale	थ) Ao U ह	2,505 P.T. serr 0,100 14,00	) W/m <sup>2</sup> K amenti, p ) W/mit ) m	orte e fini	estre		pag. 16
SERFILI Engineering WE Grand, 454 – 40331 Arcons (A Caratteristiche del modulo Trasmittanas termica del mod Decte termica sociati Trasmittanas termica lineica Lunghezza perimetrale	9) do U 21 7	2,504 P.T. ser 0,100 14,00	y W/m²k ramenti, p ) W/m% ) m	orte e fini	estre		pag. 16
SPRTLI Ingineering We Grand, 452 – 60331 Accors (A Caratteristicha dal modulo Trasmittanas termica del mod Porte termico associato Porte termico associato Langhezza perimetrale	۷) عام ل	2,505 P.T. sen 0,10( 14,0(	W/m <sup>2</sup> K w/m <sup>2</sup> K W/mK m	vorte e fin	estre		pag. 16
SERTFLI Duplevente Ve Grand, 45 - 6031 Ansan (A Caratteristiche del module Trasmittanza termica del mod Parte termica associato Trasmittanza termica lineica Lunghezza perimetrale	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,505 P.T. sen 0,106 14,00	) W/m²K ramenti, p ) W/mK ) m	oorte e fin	estre		pag. 16
SPRFLI Invitentia WE Grand, 4b - 4033 Access (A Caratteristiche del module Trasmittanas termica del mod Decte termica sociata Trasmittanas termica lineica Lunghezza perimetrale	9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,509 P.T. serr 0,100 14,00	9 W/m²K ramenti, p 9 W/mX 9 m	vorte e fini	esfre		pag. 16
SPRTLI Ingineering We Grand, 454 – 40331 Arcons (A Caratteristicha dal modulo Trasmittanas termica del mod Porte termico associato Porte termico associato Langhezza perimetrale	η φ Π	2,501 P.T. sen 0,100 14,00	9 W/m <sup>2</sup> k <i>ramenti, p</i> 9 W/mk 9 m	vorte e fin	estre		pag. 16
SERTFLI Dupleventa Ve Grand, 45 - 6031 Anna (A Caratteristicha del modula Trasmittanza termica del mod Boote termica associato Trasmittanza termica lineica Lunghezza perimetrale	U U da da U U da zz w	2,501 P.T. sen 0,10( 14,0(	9 W/m²k ramenti, µ 9 W/mk 9 m	orte e fin	estre		pag. 16
SERFLIS Invidenting WE Grandt, 454 – 40331 Access (Al Caratteristiche del module Trasmittanas termica del mod Decte termica sociata Trasmittanas termica lineica Lunghezza perimetrale	40 U 21 27 27	2,506	y W/m²k amenti, py W/mk y W/mk y m	oorte e fini	estre		pag. 16
SERTILI Engleening Grand, 4b - 4033 Arcons (A Grand, 4b - 4033 Arcons (A Trasmittania ternica del mod Porte ternico associati Porte ternico associati Langhezza perimetrale	U oh tz W	2,505	<ul> <li>W/m<sup>2</sup>K</li> <li>W/m<sup>3</sup>K</li> <li>W/m</li> <li>m</li> </ul>	orte e fin	esfre		pag. 16
SERFLI Dupleventa Ve Grand, 45 - 6031 Access (A Caratteristiche del module Trasmittanza termica del mod Porte termica sociato Trasmittanza termica lineica Lunghezza perimetrale	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,505	) W/m <sup>3</sup> K	orte e fini	estre		pag. 16
SPRFLI Invitentia WE Grand, 4b - 4033 Access (al Caratteristiche del module Tramittanas termica del mod Decte termica ossociata Tramittanas termica lineica Lunghezza perimetrale	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,501 P.T. sero 0,100 14,00	W/m <sup>2</sup> K amenti, p Wrm m	arte e fini	estre		pag. 15
SERTICI Espinentia Ve Grana, 45 - 6031 Anona (A Caratteristiche del module Traemitanza tornica del mod Porte ternico ad arranmito Porte ternico associate Transittanza ternica lineica Lunghezza perimitrale	U ah ta U U	2,505 P.T. seri 0,100 14,00	) W/m <sup>2</sup> K	orte e fin	estre		pag. 15
SERFICI Explorente Va Grand, 45 - 6031 Annae (A Caratteristiche del module Tresmittanza termica del mod Porte termica sostote Trasmittanza termica lineica Lunghezza perimetrale	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,505 P.T. serr 0,106 14,06	9 W/m²k amenti, p 9 Wirsk 9 m	oorte e fini	esfre		pag. 10
SPRTIJ Engineering Gonda, 45 - 4031 Access (al Transittanas terrinca del mod Porte terrinco associato Transittanas terrinca lineica Lunghezza perimetrale	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	2,500 P.T. seri 0,10( 14,0(	<ul> <li>W/m<sup>3</sup>K</li> <li>W/m<sup>3</sup>K</li> <li>W/m<sup>3</sup>K</li> <li>m</li> </ul>	erte e fin	estre		pag. 10
SERFICI Explorente Ve Grand, 45 - 6031 Account (Al Traumittanza torreica del modula Traumittanza torreica del mod Porte termico adel asrramento Porte termico asocciote Traumittanza termica lineica Lunghezza perimittrale	U ah U	2,500	<ul> <li>W/m<sup>2</sup>K</li> <li>W/m<sup>2</sup>K</li> <li>W/m<sup>3</sup>K</li> <li>m</li> </ul>	orte e fini	estre		pag. 10
SERFICI Explorente We Grand, 4b - 6031 Annae (A Caratteristiche del module Trasmittanza termica del mod Porte termico associato Trasmittanza termica lineica Lunghezza perimetrale	9) do U 21 V	3,500 P,T. sen 0,0100 14,00	y W/m²k amenti, p y W/mk y m	orte é fin	esfre		pag. 16
SPRTIJ Engineering Warden, 45 - 4031 Arcens (at Caratteristicha del modulo Transittanas termica del mod Perete termica sociati Transittanas termica lineica Lunghezza perimetrale	U oh 112 v	2,500	W/m <sup>2</sup> K	norte e fini	estre		pag. 15









D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Descrizione della finestra: Ve	trata ingres	150			Codice: W
Caratteristiche del serramento					
Tipologia di serramento	Singolo				
Classe di permeabilità	UNI EN S	2207	io/ma		
Trasmittanza termica Trasmittanza solo vetro	0 11.	2,317	W/m <sup>2</sup> K W/m <sup>2</sup> K		
	1212				
Emissività	e e	0,837	100		100
Fattore tendaggi (invernale)	Reise	0,80	÷0		1.1
Fattore di trasmittanza solare	Fic est Oature	0,80	1		
Comparison and the state					
Resistenza termica chiusure	curanti	0,16	m <sup>2</sup> K/W		
f shut		0,6	5		
Dimensioni del serramento					
Larghezza		831,0	cm		
Altezza		250,0	cm		
Caratteristiche del telalo					
Trasmittanza termica del telaio	U <sub>f</sub>	2,50	W/m <sup>2</sup> K		
is distanziale Area totale	Ka A	0,08	W/mK		
Area vetro	A.,	17,618	m <sup>2</sup>		
Area telaio Fattore di forma	~	3,157	m,		
Perimetro vetro	Lo	33,720	m		
Perimetro telaio	Le	21,620	m		
Stratiorafia del pacchetto veti	rato.				
Descrizione strato Resistenza superficiale interna	-	A .	R 0,130	AA	
Primo vetro	6,0	1,00	0,006		
Secondo vetro	6,0	1,00	0,175		
Resistenza superficiale esterna			0,047	- Contraction of the Contraction	
Leasaria simboli					
and a construction of the second s					
s Spessore λ Conductività termica				mm W/mK	
s Spessore A Conductività termica R Resistence termica				mm W/mK m <sup>1</sup> K/W	pa
Spessore     Spessore     Conductività termica     Resistence termica     (RMULI Englineer/og     Grand, 43h – 60131 Ancona (AM)				mm W/mK m <sup>1</sup> K/W	рв
A Spessive A Conductività termica R Resistence termica (RPILLI Englaneering a Grand), 45h - 60121 Ancona (AM)				mm W/mK m <sup>1</sup> K/W	βð
Spessore     A Conductively berretes     A Conductively berretes     Resistences berretes     Resistences berretes     Grands, 4350 - 60131 Ancones (AN)     aratterriteitche del mondulo			Winder	mm W/mK m <sup>3</sup> K/W	ра
Spenare     Spenare     Spenare     Condutinit termica     Restlemant termica     Restlemant termica     Restlemant     Spenare     S	υ	2,421	W/m <sup>2</sup> K	mm W/mK m <sup>3</sup> K/W	ps
Common      C	U	2,421	W/m <sup>2</sup> K	mm Wynek m <sup>4</sup> X/W	pa
Separative     Grandwich bernics     A Conductive bernics     Bestena termics	υ <b>Ζ1</b> Ρ Ψ	2,421 7. serren 0,100	W/m <sup>2</sup> K nenti, pol	mm Wrek w*K/W	pa
Beynster     Construintibit territos     A Construintibit territos     Resistenos territos     Resistenos territos     Construintibit     Construintiterrito     Construintibit     Construintiterrito     Construinti	U Z1 P ¥	2,421 7.7. serven 0,100 21,62	W/m <sup>2</sup> K nenti, poi W/mK m	ma WinK w <sup>in</sup> KW	ps
Construinti formica     A construinti formica     A construinti formica     Resistena termica     CONTRACT Functional     Construinti formica     Construinti     Constru	U 4 15 4	2,421 7. serran 0,100 21,62	W/m <sup>2</sup> K nenti, pou W/mK m	ma Work w%W	pa
Separative     Grandwich bernics     Restereas termics     Restereas termics     (R)     (R)     (L) finalterology     (R)     (R	U 21 P U	2,421 7. serven 0,100 21,62	W/m²K nenti, poi W/mK m	nn Work ar¥/W	ph
Beynster     Constructive termics     Resistance termics     Besistance     Besistance	U 21 P W	2,421 7. serran 0,100 21,62	W/m²K nenti, poi W/mK m	ma wine m*r/w	ра
Egensor     A condutibilit tornica     A condutibilit tornica     Resistence tornica     Resistence tornica     Econol, 455 - 4032 Ancona (Att)     Econol, 455 - 4032 Ancona (Att)     Traumitanza termica del modulo     Ancona del serzanatelo     otto termico addi serzanatelo     Traumitanza termica lineica     Lunghezza perimetrale	U 21 P W	2,421 7. serran 0,100 21,62	W/m <sup>2</sup> K nenti, po W/mK m	ma work wityw	pa
Separative     A Conductive Services     Restances termins     Restances termins     Restances termins     Restances termins     Restances     Restance	U 21 P W	2,421 7. serran 0,100 21,62	W/m <sup>2</sup> K nenti, po W/mK m	ma Wrot wirkfw	pa
Bennore     Construction termina     Bennore     Restatemas termina     Restatemas termina     CONTLI Explanation     CONTLINE     CONT	U 21 P W	2,421 .T. serran 0,100 21,62	W/m <sup>2</sup> K nenti, por W/mK m	ma Wang wingw wingw	pa
Separative     S	U 21 P U	2,421 7. serran 0,100 21,62	W/m²K nenti, po Wimi m	ma winek winek rte e finestre	pb
Separative     Separative     A ConstructiveStructure     Restances termins     Restances termins     Restances termins     Restances	U 21 P W	2,421 7. serran 0,100 21,62	W/m²K nenti, poo WimiX m	ma Wink m'R/W	<b>9</b> 8
Egensor     A constructivity territors     Restrements     Restrements	U 21 P W	2,421 7. serren 0,100 21,62	W/m²K nenti, po Wimi m	ma Work wirk/W	00 
Beynsom     Construction     Beynsom     Construction     Beynsom     Bey	U 21 P W	2,421 5.T. serven 0,100 23,62	W/m²K senti, po W/mK m	ma warek wirkiw	ph
Separative     A ConstAutività terretos     Resteros     Resteros	U 21 P 4	2,421 7.T. servan 0,100 23,62	W/m²K senti, po WimK m	ma Wrot where where	ρλ
Equation	U ZI P V	2,421 7.T. sarran 0,100 21,62	W/m²K senti, pos W/mK m	ma Work m*KW	pk
Separative     S	U Z1 <i>p</i> V	2,421 5.7. serran 0,100 21,62	W/m²K senti, poi W/mK m	ma winek n'iVW	ря
Separative     Separative     A Constructive Separative     Restances termins     Restances termins     Restances termins     Restances     Restances	U Z1 P U	2,421 6,100 21,62	W/m <sup>3</sup> K senti, poo W/mK m	ma Wink m'k/W	ря 
Equation	U ZIP P	2,421 3.7. serran 0,100 21,62	W/m²K senti, poo WimK m	ma Wrot wirk/W	pk
Separative     S	U 21 p V	2,421 0,100 21,62	W/m²K senti, pos	ma winek n'iKW	ря
Separative     Separative     A Constructive     Restances     Rest	U 21 P 9	2,421 7. servan 0,100 21,62	W/m <sup>3</sup> K senti, po W/mK m	ma Wink m'k/W	βλ
Equation	U 22 p 9	2,421 A.T. sarvan 8,100 21,62	W/m²K W/mK W/mK m	ma Wrot wirk/w	ps.
Separator     A Conductivity beneficial     Separator     Restances termics     Restances termics     Restances termics     Restances	U 21 P 9	2,421 5.7. serran 6,100 21,62	W/m <sup>3</sup> K senti, post Wink m	ma Wink wirk/w	ρ.
Equation     Expension     Expension     Expension     Expension     Restances termins     Restances termins     Restances termins     Restances     Re	U XI P V	2,421 0,100 21,62	W/m²K senti, poo Wimik m	ma Wink m'k/W	ρ.
Equation	U 21 p V	2,421 5.T. sorran 6,100 21,62	W/m <sup>3</sup> K senti, pos W/mK m	ma Work nºK/W	ря 
Separator     A Conductività territori Restatoria territori Restatoria territori Restatoria territori Restatoria territori Restatoria territori Restatoria territoria del modulo reamittana territoria secondan Traemittana territoria secondan Traemittana territoria selecia auritoria secondan Traemittana territoria secondan	U 21 P 9	2,421 5. seren 6,100 21,62	W/m <sup>2</sup> K senti, po Wimk m	ma Wink wirk/w	58











D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Caratteristiche del modulo Trasmittanza termica del mode	ulo U	2,64	5 W/m <sup>2</sup> K			
Ponte termico del serremente						
Ponte termico associato	Z1	P.T. ser	ramenti, porte	e finestre		
Trasmittanza termica lineica	Ψ	0,10	9 W/mK			
Lunghezza perimetrale		5,4	9 m			
CARATTERISTIC	1E TERM)	ICHE D	EI COMPO	NENTI FIN	ESTRATI	
CARATTERISTICH secondo UNI TS	1E TERM) 11300-1 -		ЕЇ СОМРО 1 ISO 6946 -	NENTI FIN UNI EN ISO	ESTRATI 10077	
CARATTERISTICH secondo UNI TS	1E TERM) 11300-1 -		EI COMPO 1 ISO 6946 -	NENTI FIN UNI EN ISO	ESTRATI 10077	
CARATTERISTICI secondo UNI TS Descrizione della finestra: Us	1E TERM) 11300-1 - cita di sicure	ICHE D UNI EN	EI COMPO 1 ISO 6946 - 250	NENTI FIN UNI EN ISO	ESTRATI 10077 Cedice: V	14
CARATTERISTICH secondo UNI TS Descrizione della Jinestra: Un Caratteristiche del serzamento	HE TERM) 11300-1 - cita di sicure Singolo	ICHE D UNI EN	EI COMPO I ISO 6946 - 250	NENTI FIN UNI EN ISO	ESTRATI 10077 <u>Cedice</u> : V	44
CARATTERISTICI secondo UNI TS Descrizione della finestra Un Construistiche dai serramento Tupologia di serramento Dasse di aerroadilità	1E TERM) 11300-1 - cita di sicure Singolo Classe 3 s	ICHE D UNI EN 135x	EI COMPO I ISO 6946 - 250	NENTI FIN UNI EN ISO	ESTRATI 10077 Codice: P	
CARATTERISTICC secondo UNITS Descrizione della finestra: Une Crastitristiche del serramento Diobiga di serramento Casse di permestitità Tasandhane turneria.	HE TERM) 11300-1 - cita di sicure Singolo Clesse 3 s UNI EN 1	ICHE D UNI EN 135x 135x 135x 12207	EI COMPO I ISO 6946 - 250 Iorma Wanik	NENTI FIN UNI EN ISO	ESTRATI 10077 Codice: P	14
CARATTERISTICE secondo UNI TS Descriziona della finastra: Un Carattoristiche dei sarramento Toologia di serramento Casse di permesbilità Trasmithana solo vetro	HE TERMI) 11300-1 - cita di sicure Singolo Classe 3 a UNI EN 1: Un Un	ECHE D UNI EN 135x 135x 12207 2,356 2,763	DEI COMPO I ISO 6946 - 250 Iorma W/m <sup>3</sup> K W/m <sup>3</sup> K	NENTI FIN UNI EN ISO	ESTRATI 10077 Codice: V	V4
CARATTERISTICI secondo UNI TS Descrizione della finestra Un Constitución del serramento Casse di permesbittà Transitienza termico Transitienza termico	HE TERM) 11300-1 - cita di sicure Singolo Classe 3 s UNI EN 1: Un Un Un	ECHE D UNI EN 2228 135x 2207 2,356 2,763	EI COMPO I ISO 6946 - 250 V/m <sup>2</sup> K W/m <sup>2</sup> K W/m <sup>2</sup> K	NENTI FIN UNI EN ISO	ESTRATI 10077 Codice: V	14
CARATTERISTICI secondo UNITS Descrizione della finestra: Un Caratteristiche dei serramento puologia di serramento Diologia di serramento Casse di permeabilità Transitutana solo velto Transitutana solo velto Dali ane La solodo degli apportis	HE TERMI) 11300-1 - cita di sicure Singolo Classe 3 s UNI EN UNI EN UNI EN UNI EN	ECHE D UNI EN 2228 135x 2207 2,356 2,763 0,877	EI COMPO I ISO 6946 - 250 W/m <sup>3</sup> K W/m <sup>3</sup> K	NENTI FIN UNI EN ISO	ESTRATI 10077 Cedice: P	14
CARATTERISTICE secondo UNI TS Descritiona della finastra: Un Caratteristido: del serramento Cases de permessittà Trasmittanza sterinica Trasmittanza solo vetro Dati ser 8. atolico dedi aspociti Emissività Fattere tendagi (inversale)	4E TERMI 11300-1 - cita di sicure Singolo Clesse 3 s UNI EN 1 UNI EN 1 UNI UNI UNI Solati E feme	ECHE D UNI EN 2228 135x 2207 2,356 2,763 0,837 1,00	EI COMPO I ISO 6946 - 250 Jarma W/m <sup>3</sup> K W/m <sup>3</sup> K	NENTI FIN	ESTRATI 10077 Eedice: P	14
CARATTERISTICC secondo UNITS Descrizióne della finastra Un pología di serramento Diología di serramento Classe di permeshilità Trasmittanza senternica Trasmittanza senternica Trasmittanza senternica Trasmittanza senternica Trasmittanza finastra Finastrata Fattore Innalagi (stativo)	HE TERMI 11300-1 - cita di sicure Singolo Classe J a UNI EN 2 UNI EN 2 UN UN UN Solari feren feren feren	ECHE D UNI EN 2228 135x 2,356 2,763 0,837 1,00 1,00	EI COMPO ISO 6946 - 250 Vorma W/m <sup>3</sup> X W/m <sup>3</sup> X - - -	NENTI FIN UNI EN ISO	ESTRATI 10077 Cadica: P	4
CARATTERISTICA secondo UNITS Descrizione della finestra UP Caratteristiche del serramento Dipologia di serramento Dipologia di serramento Tamentona solo vetro Dati aer il calcolo degli apporti Pattere indiaggi (invernale) Fattere indiaggi (invernale) Fattere indiaggi (invernale)	1E TERM) 11300-1 - Singolo Classe 3 a UNR EN U <sub>N</sub> U <sub>N</sub> U <sub>N</sub> Solati f <sub>c</sub> ss f <sub>c</sub> ss f <sub>c</sub> ss f <sub>c</sub> ss Q <sub>0,6</sub>	ECHE D UNI EN ezza 135x econdo N 2,356 2,763 0,837 1,00 1,00 0,750	EI COMPO I ISO 6946 - 2250 Vorma W/m <sup>3</sup> K W/m <sup>3</sup> K	NENTI FIN	ESTRATI 10077 Cedices V	14
CARATTERISTICI: secondo UNITS Descrizión della finestra: Un Usologia di serrarento Usologia di serrarento Usologia di serrarento Tasmitanat termina Trasmitanat termina Trasmitanat termina Trasmitana solo vetro Dati ser i calodo degli secorti Fattore Innalggi (nivernale) Fattore Innalggi (nivernale) Fattore Innalggi (nivernale) Fattore I trasmittana solo	HE TERMI 11300-1 - scita di sicure Classe 3 s UNI EN 3: UNI UNI UNI Solati f.cws f.cws f.cws f.cws scurenti	ECHE D UNI EN 2220 135x 2207 2,356 2,763 0,837 1,00 1,00 0,750	DET COMPO I ISO 6946 - 250 Wm²k Wm²k Wm²k - - -	NENTI FIN	ESTRATI 10077 Cedica: P	va
CARATTERISTICI: secondo UNITS Descrizione della finestra Ure Dobajosi di serramento Topologia di serramento Topologia di serramento Tasmittansa bio vetro Dali per Lalacito dedi apocti Frattere Indago (Invernale) Fattere Indago (Invernale) Fattere Indago (Invernale) Fattere Indago (Invernale) Fattere Indago (Invernale)	HE TERMI 11300-1 - cita di sicure Singolo Classe 3 a UNI EN 3 UNI EN 3	CHE D UNI EN 2220 135x 2207 2,356 2,763 0,837 1,00 1,00 0,750 0,750	EI COMPO I ISO 6946 - 250 Arma W/m <sup>3</sup> K W/m <sup>3</sup> K W/m <sup>3</sup> K - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Codica: V	
CARATTERISTICE secondo UNITS Descriziona della finestra: Un Caratteristiche dei serramento Tipologia di serramento Desse di permesbilità Trasmithana solo vetro Dati per il calcolo degli accorti i Fratore Indraggi (Invienzie) Pattore Indraggi (Invienzie)	HE TERMI) 11300-1 - cita di sicure Singolo Classe 3 a UNI EN 23 UNI EN 23 UNI E Solati E Solati E Solati Solati	CCHE D UNI EN 2220 135x 2,356 2,763 4,837 1,00 0,750 0,750	EI COMPO I ISO 6946 - 2250 Vorms W/m <sup>3</sup> K W/m <sup>3</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cadica V	va
CARATTERISTICC secondo UNITS Descrizión de la finastra Un pología di serramento Diología di serramento Dialiser de la calodo degli acocci Trasmittana termica Trasmittana termica Trasmittana solo vetro Dali ser La calodo degli acocci Fratore endaggi (stalvo) Fatore endag	HE TERMI 11300-1 - singolo Classe 3 s UNE EN 21 UN UN Solar) E ferse ferse ferse ferse scuranti	CCHE D UNI EN 2220 J35x 2,356 2,263 1,00 1,00 0,750 0,16 0,6	EI COMPO 130 6946 - 250 Jorna W/m <sup>3</sup> K W/m <sup>3</sup> K - - - - - -	NENTI FIN UNI EN ISO	ESTRATI 10077 Codica: P	14
CARATTERISTICI secondo UNITS Descrizione della finestra Un Caratteristiche dei serzamento pologia di serzamento Dosse di permeabilità Transrituna solo velto Dali ane Latolodo degli apporti Transrituna solo velto Dali ane Latolodo degli apporti Tettore Inotaggi (Invernale) Fattore Inotaggi (Invernale) Fattore Inotaggi (Invernale) Fattore di transrittanos solare Caratteristiche delle chiusuce or Fattore Interistente reterica chiusure Fattore Interistente reterica chiusure Fattore Interistente di competento Langhezza	1E TERMI) 11300-1 - Cita di sicure Singolo Classe 3 a UNI EN 2 UNI EN 2 Solari En 2 Solari Solari Solari	CCHE D UNI EN 2207 2,356 2,263 1,00 0,750 0,16 0,6 135,0	EI COMPO I ISO 6946 - 2250 Wim <sup>2</sup> K Wim <sup>2</sup> K Wim <sup>2</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN UNI EN ISO	ESTRATI 10077 Cadica: V	14
CARATTERISTICE secondo UNI TS Descriziona della finestra: Un Caratteristicho del seramento Topologia di seramento Case di permesitità Trasmithana sulo velto Dall ner. Il calcolo degli accorti i Fratere Indiagi (Invienzie) Pattere endiagi (Invienzie) Pattere endiagi (Invienzie) Pattere di trasmittana sobre Caratteristiche delle chiuane co Resistenza termica chiusare fahot:	HE TERMI 11300-1 - scita di sicure Singole Classo 3 UNI EN 3 Solari E fere Quis Solari E	CCHE D UNI EN 2220 135x 2,763 0,837 1,00 0,750 0,750 0,16 0,6 135,0 250,0	EI COMPO 1 ISO 6946 - 250 Norma W/m <sup>3</sup> C W/m <sup>3</sup> C - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cedice: P	
CARATTERISTICC secondo UNITS Descrizione della finestra Ure Crastitatische dei serraremito Topologia di serraremito Diali ser f. alatoko della apocoti. Trasmittanza solo vetro Dali ser f. alatoko della apocoti. Fattore Indiaga (Invernale) Fattore Indiaga	LE TERMI 11300-1 - cita di sicure Singolo Classe 3 s Un V Un V Un Solati few few few Gut Solati	ECHE D UNI EN 2220 135x 2,356 2,763 1,00 1,00 0,750 0,16 0,6 135,0 250,0	EI COMPO I ISO 6946 - 250 Varma W/m <sup>1</sup> K W/m <sup>1</sup> K W/m <sup>1</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cadica: V	4
CARATTERISTICA secondo UNITS Descrizione della finestra Un Caratteristiche del serramento Diopogia di serramento Diopogia di serramento Diata del anti anti anti anti anti anti Termittanza termica Tesnettanza termica Tesnettanza termica Tesnettanza del calino Testere e indiaggi (invernate) Fattere indiaggi	HE TERMI 11300-1 - cita di sicure Singolo Classe 3 a UNI EN 22 UNI UNI Case 3 a UNI Classe 3 a Classe 3 a UNI Classe 3 a Classe 3 a Clas	ICHE D UNI EM 22207 2,356 2,763 0,837 1,00 0,750 0,16 1,35,0 250,0	EI COMPO I ISO 6946 - 2250 Wark Wark Wark - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cedice: V	
CARATTERISTICC secondo UNITS Descrizióne della finestra Un pologia di serramento Topologia di serramento Dala esta calcolo dell'acocci il manuttana termica Tratmettana solo vetro Dala esta calcolo dell'acocci il fratore tendagi (invienza) Fatore endagi (invienza) Fatore	HE TERMI 11300-1 - cita di sicure Singolo Cine en 3 Une Un Un Un Un Un Solati E fene Que scoranti	CCHE D UNI EN ezza 135x 2207 1,00 0,750 0,750 0,16 0,6 135,0 2550,0 2,590,0 0,0	EI COMPO I ISO 6946 - 250 Vornia W/m <sup>3</sup> C W/m <sup>3</sup> C - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077	
CARATTERISTICI secondo UNITS Descrizione della finestra Un Caratteristiche dei serramento puologia di serramento Tasmitanza ternica Tasmitanza ternica Tasmitanza ternica Tasmitanza ternica Pattore tendaga (invernale) Fattore tendaga (invernale) Fattore tendaga (invernale) Fattore tendaga (invernale) Fattore di trasmitanza solare Caratteristiche del chiusacco fattore fattore di marmitanza solare Caratteristiche del chiusacco fattore fattore fattore fattore mento Lueptezza Nezza	HE TERMIN 11300-1 - cita di sicure Singolo Classo 3 a si UNI EN 12 UNI EN 12 UNI EN 12 UNI EN 12 UNI EN 12 Casso 3 a Casso 3 a	CCHE D UNI EN 2220 135x 2,356 2,763 1,00 0,750 0,837 1,00 0,750 0,0,8 135,0 2,500,0 2,500,0 0,0,0	EI COMPO I ISO 6946 - 2250 Vorma W//m <sup>3</sup> K W//m <sup>3</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cedice: V	44
CARATTERISTICC secondo UNITS Descrizión della finestra Un publica di serramento Diologia di serramento Clesse di permesbilità Trasmittana termina Trasmittana termina Trasmittana termina Tratore tendagi (nuenaine) Fattore tendagi (nuenaine) Fattore tendagi (nuenaine) Fattore tendagi (nuenaine) Fattore tendagi (nuenaine) Fattore di russimittana sobre Constitución del serramento Larghezza Altezza Caratteristiche del Latela. Trasmittanas termica del Italia. Trasmittanas termica del Italia.	HE TERM.           11300-1           11300-1           Silapón           Classo 3           NIX EF 3           Casso 3	CCHE D UNI EN 2,356 2,763 0,837 1,00 0,750 0,16 0,0,837 1,00 0,750 0,16 0,16 0,0,837 2,50,0 2,50,0	EI COMPO I ISO 8946 - 250 Vorms W/m <sup>3</sup> C W/m <sup>3</sup> C - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cedica: V	
CARATTERISTICC secondo UNITS Descritation della finastra Ure Crastiteritation del serramento Diologia di serramento Diali ser la calcolo della accosti Trasmittanza solo vetro Dati ser la calcolo della accosti Trasmittanza solo vetro Dati ser la calcolo della diolizia Fattore Indiagni (invernale) Fattore Internalizzatione della dializzatione Caratteristiches del Latalio. Trasmittanza termica del Italia K distanziale Accosa vetro Accos tellos	НЕ ТЕКМ 11300-1 - Singolo Слово 3 - Ц. 	CCHE DU UNI EM 2223 135x 2207 2,356 2,763 0,63 1,00 1,00 0,750 0,16 0,6 135,0 2550,0 2,550,0 2,550,0 2,550,0 8,3,275 2,550,0 8,83 2,550,0 8,83 2,550,0 8,83 2,550,0 8,83 2,550,0 8,83 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,837 2,550,0 8,937 2,550,0 1,000,0 1,000,0 2,550,0 2,	EI COMPO I ISO 6946 - 250 lorma W/m <sup>3</sup> K W/m <sup>3</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Codica: V	
CARATTERISTICI secondo UNITS Descrizione della finestra Un Caratteristiche del serzamento Diopogia di serzamento Dasse di permesbilità Transmitanza solo vetro Dali ane Laladod dedi apporti J Tattore indraggi (miernale) Tattore indraggi (miernale) Fattore indraggi (miernale) Fattore indraggi (miernale) Fattore di transittanza solare Caratteristiche del chiusacco e fahat. Dimensioni del serzamento Larghezza Mezza Caratteristiche del Islaio. Tattorettanza terrica del Islaio. K distanziale Avas totale Avas totale Avas totale Avas totale Pattore in forma	IE TERMI           11300-1           cite of sicure           Classed 3           U.e.           U.e.           U.e.           Singule           free	CCHE D UNI EN 22207 2,356 2,763 0,837 1,00 0,750 0,750 0,750 0,750 0,750 0,750 0,750 0,750 0,750 0,750 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,857 2,50 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0 0,0,0,0,0 0,0,0,0,0,0 0,	EI COMPO I ISO 6946 - 2250 W/m <sup>3</sup> K W/m <sup>3</sup> K - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Cedice: V	
CARATTERISTICC secondo UNITS Descrizione della finestra Ve Constituito del serramento Diologia di serramento Dati ser i coloso dogli accorti Tramuttanta suo vetro Dati ser i coloso dogli accorti Frattore tendagi (invernate) Fattore tendagi (invernate) Fattore tendagi (invernate) Fattore tendagi (coloso) Fattore di tramuttanas adare Constituito del colosore di Constituito del colosore di Antezza Dimensioni del serramento Larghezza Altezza Caratteristiche del telalo. Tramuttanas termica del telalo. Pattore di forma Perimeto vetro Perimeto vetro	HE TERMIN 11300-1 - Singelo Claures 2 J U, U, U, U, U, U, U, U, U, U, U, U, U,	CCHE D UNI EN 2,356 2,763 1,00 0,750 0,16 0,6 135,0 250,0 0,837 2,50 0,0,8 3,375 2,50 0,0,845 0,0,845 0,700	EI COMPO I ISO 6946 - 250 Vorma W/m <sup>1</sup> X W/m <sup>1</sup> X W/m <sup>1</sup> X - - - - - - - - - - - - - - - - - - -	NENTI FIN	ESTRATI 10077 Codice: W	
CARATTERISTICC secondo UNITS Descrizione della finestra Un Cratteristiche dei serramento Diologia di serramento Dali ane faciologi della della transmittanta solo vetro Dali ane faciologi della della ristori tendisgi (tivernale) Fattere indisgi (tivernale) Fattere indisgi (tivernale) Fattere indisgi (tivernale) Fattere di transmittanta solare Cestiteristiche die chiusare o fatter. Bestiterna termica chiusare fatte. Bestiterna termica dei tolalo. Tasenttanta dei Italia. Tasenttanta dei Italia. Kasia total Anas total Anas total Anas total Fattere indisgi (titeria dei Italia). Tasenttanta dei Italia. Sata total Anas total Anas total Anas total Permetro totalo Statalaria. dei apachetto yetti	НЕ ТЕРМІ 11300-1 - Singolo Classo 3 - U., U., U., U., Q., Q., Q., Q., Q., Q., Q., Q	CCHE D UNI EN 0,2220 135x 2207 2,356 2,356 2,263 0,837 1,00 0,750 0,68 135,0 2,500 0,68 135,0 2,500 0,68 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,530 0,088 2,550 0,088 2,550 0,088 2,550 0,088 2,550 0,088 2,550 0,088 2,550 0,088 2,550 0,000 0,000000	EI COMPO I ISO 6946 - 250 w//m <sup>1</sup> k w//m <sup>1</sup> k - - - - - - - - - - - - - - - - - - -		ESTRATI 10077 Cedice: V	
CARATTERISTICA secondo UNITS Descrizione della finestra Un Caratteristiche del serramento Diopogia di serramento Date de serramento Tramittana solvetto Dati ber il calodo degli apporti france intenza territo Dati ber il calodo degli apporti preserve intenza della conte tramittana solvetto Dati ber il calodo degli apporti preserve intenza della conte restore di resmittana solve Caratteristiche del calono Patera di resmittana solve Caratteristiche del taloio. Tasenttana terrica dei taloio A distantole Avea totalo Avea totalo Patere di forma Patere di forma	HE TERM) 11300-1- cite di sicure Classes 3 (c. 1, c. 1, c. 1	CCHE D UNI EN 2520 135x 2,763 1,00 1,00 0,750 0,16 0,6 135,0 250,0 0,08 4 3,375 2,50 0,084 5 0,700 1,700	EI COMPO ISO 6946 - 250 lorms W/m <sup>3</sup> C W/m <sup>3</sup> C - - - - - - - - - - - - -		ESTRATI 10077 Cedice: P	~*
CARATTERISTICC secondo UNITS Descrizión della finastra Un Crastieristiche del serramento Topologia di serramento Topologia di serramento Trasmittana termica Trasmittana termica Trasmittana serra Fattore Indiago (Invernate) Pattore International International Area vetro Area vetro Area vetro Area vetro Pattore Informa Permetoro vetro Permetoro vetro Permetoro vetro Permetoro suporfición Interna	HE TERMIN 11300-1 - Singele Classed 3 deared Use the second second Use the second Use the second Use the second Out of t	CCHE D UNI ER 2220 2207 2,356 2,356 2,356 0,837 1,00 0,6 0,6 0,6 0,6 0,6 0,6 0,6 0,6 0,6	EI COMPO I ISO 6946 - 250 250 250 250 250 250 250 250 250 250		ESTRATI 10077	
CARATTERISTICC secondo UNITS Descrizione della finestra Une Caratteristiche dei serramento Dioboja di serramento Tasmittana solo vetro Dali cer E alcelo dodi apociti Frateristiche dei solo vetro Dali cer E alcelo dodi apociti Fratere entraggi (nivernale) Fattere tendagi (nivernale) Fattere di tramittanas solare Caratteristiche dei chiusace o fattere di tramittanas solare Caratteristiche dei tendas Tattere intraggi (nivernale) Fattere di tramittanas dare Caratteristiche dei tendas Mezza Nezza Caratteristiche dei tendas K distantale Anas totale Anas totale Pattere di forma Pattere di forma pattere Discrizione state Neovito	HE TERMI           11300-1           cita di sicure           Simpolo           Classa 3           U.a.           U.a.           U.a.           Garanti Sicure           Garanti Sicure           Garanti Sicure           Garanti Sicure           K.a.           No.contenti           Sicure           Li           Sicure	CCHE D UNI EN eccondo N 2,250 1,00 0,750 0,750 0,0750 0,08 135,0,0 2,530 0,08 3,3,275 2,530 0,08 3,3,275 2,530 0,08 3,3,275 2,530 0,08 4,530 2,530 0,08 4,537 2,530 2,500 2,50	EI COMPO I ISO 6946 - 250 ///////////////////////////////////		ESTRATI 10077 Codices #	4
CARATTERISTICC secondo UNITS Descrizión della finestas Un Crasticitàrio del serramento Diologia di serramento Teamittana termina Tramuttana sub vetro Dati per i calorio dell'anocci il Teamittana termina Tatore Indiagi (Invernate) Fattore Internationa sofare Constitucibile del chalano co Resistenza termica del talalo Aneza vetro Aneza telao Anea vetro Anea vetro Anea vetro Permetro vetro Permetro vetro Permetro vetro Permetro solaro Statiana fattore interna Descritore estato Resistenza superiore metano Descritore estato Reseatores superiores estato Reseatores superiores estato Reseatores superiores estato	HE TERMIN 11300-1 - Cita di sicure Simpolo Guerra 12 Guerra Guera	ECHE D UNI EN 2007 2,356 2,762 2,366 2,760 0,687 0,750 0,166 0,6 0,550 0,6 0,550 0,6 0,550 0,750 0,250,0 0,0845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,750 0,845 0,750 0,845 0,750 0,845 0,750 0,750 0,845 0,750 0,750 0,845 0,750 0,750 0,750 0,845 0,750 0,75	EI COMPO I ISO 8946 - 250 Vorase W//m <sup>3</sup> C W//m <sup>3</sup> C - - - - - - - - - - - - - - - - - - -		ESTRATI 10077	
CARATTERISTICC secondo UNITS Descrizione della finastra Un Crasticità de di serranemio Topologia di serranemio Topologia di serranemio Topologia di serranemio Tastori di permeshità Tastori tendagii (nivernale) Tastori tendagii (nivernale) Pattore indiago (stato) Pattore di rasmittana solare Caratteristiche dele chalane Fattore indiago (stato) Pattore di rasmittana solare Caratteristiche del chalane Tabate nendagii (stato) Pattore di rasmittana solare Caratteristiche dele chalane Tabate nendagii (stato) Pattore di tasmittana solare Caratteristiche del chalane. Tamentana firmitta del telalo Caratteristiche del telalo Caratteristiche del telalo Tamentana firmitta del telalo Pattore di forma Permetro verto Permetro verto Permetro verto Permetro verto Permetro verto Intercapito Escondo verto Intercapito Escondo verto Intercapito	HE TERMIN 11300-1 - Class of a scarce U.C. Class of a scarce U.C. Class of a Class of a	CCHE D UNI EN eccondo N 2,356 2,763 1,00 0,750 0,68 2,500 0,750 0,68 1,35,0 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,088 2,500 0,750 0,088 2,500 0,088 2,500 0,750 0,088 2,500 0,750 0,088 2,500 0,750 0,088 2,500 0,750000000000	EI COMPO I ISO 6946 - 250 250 250 250 250 250 250 250 250 250		ESTRATI 10077	4
CARATTERISTICI secondo UNITS Descrizione della finatza Un Caratteristiche dei serramento pubolga di serramento Tammittana solo velto Dali ant Laladoi dolli apporti Trammittana solo velto Dali ant Laladoi dolli apporti Tattore tendaga (Invernale) Fattore tendaga (Invernale) Fattore tendaga (Invernale) Fattore tendaga (Invernale) Fattore di tramittanas solare Caratteristiche dei balauco fattore di tramittanas solare Caratteristiche dei balauco fattore in diagona di seguina fattore tendaga (Invernale) Fattore fondaga (Invernale) Fattore di tramittanas solare Caratteristiche dei balauco fattore di tramittanas data Dimensioni dei sorramento Luopiezza Nezza Caratteristiche dei balau K distantale Anas totalo Anas totalo Parimeto velto Parimeto velto Parimeto velto Parimeto velto Parimeto velto Parimeto velto Intercapatale Socono velto Resolutore solato	HE TERMIN           11300-1           cita di sicure           Simpole           Classa 3           U.a.           U.a.           U.a.           Simpole           f.u=           Gata           Simpole           Simpole           K.a.           Simpole	CCHE D UNI EN 2,356 2,763 2,763 0,837 1,00 0,750 0,16 0,6 135,0 0,250,0 0,16 0,6 135,0 2,50 0,0,8 3,375 2,50,0 0,845 7,700 X - 1,00 1,00 1,00 1,00 2,0	EI COMPO I ISO 6946 - 250 ////// ////// ////// ////// ////// ////		ESTRATI 10077	







D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

	SARVILL Fragmening SARVILL Fragmening Catatharitationa del modulo Transmittanna termica del modulo Ponte termico associato Transmittanna termica lineica Lunghezza perimetrale	U 2,584 W/m <sup>3</sup> K 21 P.T. serramenti, porte e finestre 9 0,100 W/mK 2,70 m		
CARATTERISTICHE TERMICHE DEI COMP secondo UNI TS 11300-1 - UNI EN ISO 6940 santteritados del arramento lande di permatilità del 12027 lande di permatilità UNI EN 1200 cansittaria toleviro U, 2,743 W/m <sup>2</sup> k ramittaria temica manttaria solo Voro U, 2,743 W/m <sup>2</sup> k santariataria dol Voro U, 2,743 W/m <sup>2</sup> k	ONENTI FINESTRATI - UNI EN 150 10077 Cedice: W3		SCRIPTLI Engineering Viii Grand, 455 – 68121 Ancore (44) Caratteristiche del modulo Trasmittanza termica del modulo Roste termico associato Trasmittanza termica lineica Lunghezza perimetrale	U 2,765 W/m <sup>3</sup> K ZI P.T. serramenti, porte e finestre Ψ 0,100 W/mK 4,00 m
atteristiche delle chanare souranell         6,16         m <sup>2</sup> /CW           wit         0,6         -           tensioni del serramento         0,00         cm           gheza         100,0         cm           etas         100,0         cm           statuto del serramento         metas         metas           atteristiche del telaio.         U,         2,50         W/m <sup>2</sup> K           statuto della del				







		estra singol	la 110x32	10		Codice: W6
Taka in a manaka in a sama a sama a manaka in a sama a sama a manaka in a sama a sama a manaka in a sama a s	Caratteristiche del serramento					
Class of permaching       UNT 0F (1200"         Transmittance and works       U, 2,255 Wink's         Transmittance and works       U, 2,255 Wink's         Data per Lobels dell apport and end works       0,600 ·         Fattore of the dell apport and end works       0,600 ·         Fattore of the dell apport and works       0,600 ·         Fattore of the dell apport and works       0,600 ·         Fattore of the dell apport and works       0,600 ·         Fattore of the dell apport apport the dell apport apport of the dell apport of the dell apport apport of the dell apport of the dell apport apport of the dell apport of the dell appor	Tipologia di serramento	Singolo	and the second se	Manager		
<pre>rimethics at the view of the second sec</pre>	Classe di permeabilità	UNI EN 1	2207			1
Terminant and records       Q       2.99       Non-K         Emissional and records       6.977       -         Emissional and records       6.978       -         Emissional and records       7.978       -         Acta table       4.978       -       -         Promoter vetors       A.       2.528       m <sup>2</sup> Promoter vetors       A.       2.528       m <sup>2</sup> Promoter vetors       A.       2.528       m <sup>2</sup> Acta table forma       F.       0.728       F.         Promoter vetors       A.       2.528       m <sup>2</sup> Acta table forma       F.       0.728       F.         Acta tabl	Trasmittanza termica Trasmittanza solo vetro	U.,	2,355	W/m <sup>2</sup> K		
			411.04	adha a		
<pre>bindbooks (versus) from 0, 40 0, 40 0 0 0, 40 0, 50 0 0 0, 50</pre>	Dati per il calcolo degli apporti s	olari			_	
	Emissinta Fattore tendagol (invernale)	6	0,837	1		
Patter et attransituata solar       9x, 0       9, 0       9, 0       9, 0         Canditation faile attransmont       0, 0       0       9, 0       9, 0         Residence termodation faile attransmont       0, 0       0       9, 0       9, 0         Canditation faile attransmont       0, 0       0       9, 0       9, 0       9, 0         Canditation faile attransmont       0, 0       0, 0       9, 0	Fattore tendaggi (estivo)	feast	0,80			
	Fattore di trasmittanza solare	9 gen	0,750	-	1.000	
Residence terminal data surramental         0,8         -           Entensistati data surramental         20,0         em           Atterza         20,0         em           Tamatikana termina dal latan         0,4         2,50         Win/k           Kattanziak         32,00         em         -           Tamatikana termina dal latan         0,4         2,50         Win/k           Kattanziak         A,2,220         m²         -           Area tata         A         4,200         -         -           Area tata         Area tata         -         -         -         -           Area tata         Area         -         -	Caratteristiche delle chiusure os	curanti				
If Multiple         Q. 6           Densitie densemente Legebrazz Atezza         10.0 g         0.0 d           Cast Legebrazz Atezza         10.0 d         0.0 d         0.0 d           Tomistance termine del balan Acces tables         M. d         0.0 d         0.0 d           Acces tables         M. d         0.0 d         0.0 d           Interceologine datale caschette vertree         0.0 d         0.0 d         0.0 d           Interceologine datale caschette vertree         M. d         0.0 d         0.0 d           Interceologine datale caschette vertree         0.0 d         0.0 d         0.0 d           Macces tabente stemis         M. d         0.0 d         0.0 d           Macces tabentes         M. d         0.0 d <td>Resistenza termica chiusure</td> <td></td> <td>0,16</td> <td>m<sup>2</sup>K/W</td> <td>Lett.</td> <td></td>	Resistenza termica chiusure		0,16	m <sup>2</sup> K/W	Lett.	
	f shut		0,6			
Ling bezz     J.0.6     (m)       Abeza     J.0.6     (m)       Catactaticato et entee     (m)     J.0.6     (m)       Catactaticato at entee     (m)     J.0.6     (m)       Acas atom     (m) <td< td=""><td>Dimensioni del serramento</td><td></td><td></td><td></td><td></td><td></td></td<>	Dimensioni del serramento					
Alarza u 2,0,0 m Canadizational de Heales U, 2,5,9 W/m <sup>2</sup> K A castatale A 2,6,0 m <sup>2</sup> A castata	Larghezza		110,0	cm		
	ARezza		320,0	cm		
	Caratteristiche del telaio					
Kilstanki       K.       0.00 Winki         Area tatia       A.       2,520 m <sup>2</sup> Area tatia       A.       2,520 m <sup>2</sup> Area tatia       F.       0,74 ·         Pennetro veto       L.       0,600 m         Remetro veto       L.       0,600 m         Statiantia automitationa vetoria       L.       0,600 m         Statiantia       Winki       Ministrantia         Statiantia       Winki       Ministra	Trasmittanza termica del telaio	U,	2,50	W/m <sup>3</sup> K		
Area vatie       A.       2,52 m <sup>2</sup> Area vatio       A.       2,52 m <sup>2</sup> Area vatio       A.       0,52 m <sup>2</sup> Perimetro vatio       L.       9,600 m         Numero vatio       A.       0,52 m <sup>2</sup> Terraceleriza       A.       0,50 m         Terraceleriza       A.       0,50 m         Area vatio       A.       0,50 m         Terraceleriza       A.       0,50 m         Terraceleriza       A.       0,50 m         Terraceleriza       A.       0,50 m         A.       Conductor vation       M.       0,50 m         S.       Sector       m <sup>2</sup> m <sup>2</sup> A.       Conductor vation       M.       M <sup>2</sup> A.       Conductor vation <td>K distanziale</td> <td>Ka</td> <td>0,08</td> <td>W/mK</td> <td></td> <td></td>	K distanziale	Ka	0,08	W/mK		
Transmission       N.       6,030       Private         Restriction       F.       8,460       III         Structures       F.       8,460       III         Structures       Transmission       F.       8,460       III         Structures       Transmission       F.       8,460       III         Structures       Transmission       Transmission       IIII       IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	Area totale	An	3,520	m <sup>2</sup>		
	Area telaio	A,	0,910	m <sup>2</sup>		
Permetto vetro         Li         9,400 m           Conductor vetro         Li         4,600 m           Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.           Teaching acid acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.           Teaching accentrate vetrate vetrate.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.           Statistical acid acchetto vetrate.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.           Statistical acid acchetto vetrate.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.         Image: Statistical acid acchetto vetrat.           Parallel Acid acid accomption acid acid accomption acid acid acid acid acid acid acid acid	l'attore di forma	F,	0,74			
Restanding all accherito vertrat.          Statistandi all accherito vertrat.	Perimetro vetro Perimetro telaio	- La La	9,400	m		
Anonan Markan Markan Markan Terrent Markan M	Etestimofis del asochetto		0,000			
Instruction       1       1       0       0.4.00       0.4.00       0.0	Descrizione strate		λ.	R	Dr. Dr.	1
Interception         4.0         4.07         4.07           Decretary with         4.0         4.007         Interception           Statisticants approximation         1         0.007         Interception           Interception         1         0.007         Interception         Interception           Interception         1         0.007         0.007         Interception         Interception           Interception         1         0.007         0.007         0.007         Interception         Interception           Interception         1         0.007         0.007         0.007         Interception         Interception </td <td>Resistenza superficiale interna</td> <td>-</td> <td></td> <td>0,130</td> <td>AA</td> <td></td>	Resistenza superficiale interna	-		0,130	AA	
Seconda verte         - 0         - 0         0.0000           Autobalca strategical control to observe to obse	Phmo vetro Intercapedine	6,0	1,00	0,005		
Material Subscription     -     0.047       Section     mm       Section     mm       Conductivation     wh/cw         Problem	Secondo vetro	6,0	1,00	0,006		
tanuta tandi s Sestor M M M M M M M M M M M M M M M M M M M	Resistenza superficiale externa	-	-	0,047	1000	
aratteriaticha del modulo U 2,599 W/m <sup>3</sup> K zote termico del servamento Varte termico associato T 21 P.T. servamenti, porte e finastre Transmittarate termica V V/mK 8,60 m	R Resistonza tormica					pag.
Arakteristikka del modulo U 2,599 W/m <sup>2</sup> K onte termico del seramento Varte termico associato Tarantitaras termico indica U 0,000 W/mK 0,000 W/mK 0,000 W/mK	R Resistenza termica					pag.
varamanata atomicii Oti Mozilei U 4,077 W(M'K) varamanata atomicii Oti Mozilei V 9,0100 W(MK) parattarase tennisi unghezza perimetrale 8,60 m	R Resistenza termica HIPPILLI Engineering a Grandi, 45h - 60131 Ancona (All)					pog.
onte territo asolita inerica 21 P.T. servamenti, parte e finastre Trasmitaroa termica lineica 9 0,100 V/mk ungheza permetrale 8,60 m	R Resistenza termica			Weeder		pog.
Varte tarmon associato point and a second association (a) (b) (b) (b) (b) (b) (b) (b) (b) (b) (b	R Resistence territice	U	2,599	W/m <sup>2</sup> K		pag.
ungheza perinetale 6,60 m	R Resistenza termica triPPULI Engineering a Grandi, 45h - 60131 Ancora (AR) aratteristiche del modulo frasmittanza termica del modulo onte termico del serramento	U	2,599	W/m <sup>2</sup> K		pag.
	R Reditiona termica Internet, Esphanorog aratteristiche del modulo fraamitanaa termica dei modulo fraamitanaa termica dei modulo vorte termico associato Yorte termico associato	U 21.	2,599 P.T. serra	W/m <sup>2</sup> K	te e finestre	pag.
	R Reditiona termica HIP/LLF Exploadering e Exercise 25 - 40132 Anicona (AKI) aratteristiche del modulo fraamtitanca termica del modulo onte termico adocidato transittanca termica lineica unpheze parioritanea termica lineica	U 21 4	2,599 P.T. serra 0,100 8,60	W/m <sup>3</sup> K meneti, port W/mK m	te e finestre	pag.
	R Reditiona termica IOPTILI Explorening d Carrell, 45h - 60132 Anonas (AH) aratteristicha.del.medula caratteristicha.del.medula pote termica ale medula brate termica ale medula brate termica associato tramittana termica lineica urghezza perimetrale	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m <sup>2</sup> K menti, port W/mK m	te e finestre	pog.
	R Reditiona termica International Control Control Control International Control Control Control International Control Control Control Control Control Control Control International Control	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m <sup>2</sup> K umenti, pori W/mK m	te e finestre	pog.
	R Reditiona termica rem/LLF Explosuring e termin, etc e0137 Annona (Aki) aratteristiche del medulo fraumittana termica del modulo onte termico administrato a termica unghezza perimetrale	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m²K Mmenti, pori W/mK m	te e finestre	pag.
	R Reditiona termica INTELLE Explorencing In Carnell, 455 - 60132 Ancora (AH) arratemitanca termica del modulo prete termico ales carramento forde termico alescalato Tramittanca termico alescalato Tramittanca termico alescalato torate termico alescalato termico al	υ 21 μ	2,599 P.T. serra 0,100 8,60	W/m²K mmenti, pori W/mK m	te e finestre	p86.
	R Reditiona termica International Control Control Control International Control Control Control Control International Control Control Control Control Control International Control Control Control Control Control Control Control International Control Con	U 21 W	2,599 P.T. serra 0,100 8,60	W/m²K menenti, port W/mK m	te e finestre	1996.
	R Reditiona termica rem/LLF Explanaring e termin, etb e0137 Annona (Akt) aratteristiche.del.medulo reamittana termica del modulo onte termico associato trasmittana termica lineica Junghezza perimetrale	U 21 4	2,599 P.T. serra 0,100 8,60	W/m <sup>3</sup> K unentl, port W/mK m	te e finestre	<b>199</b> 6.
	R Reditiona termica INFILLI Explorencing In Carnell, 45h - 60131 Anoneu (AH) arrateristiche All medulo arrateristiche All medulo ante termico ale serramento Vorte termico alescalato Transmittana termica inicia Lunghezza perimetrale	υ 21 μ	2,599 P.T. serra 0,100 8,60	W/m <sup>3</sup> K umenti, port W/mK m	te e finestre	1996.
	R Reditiona termica International Contentions International Internationes Internationes Inte	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m²K umentl, peri W/mK m	te e finestre	pag.
	R Reditiona termica rem/LLF Explanation e termin, etb e0137 Annona (Akt) aratteristiche.del.medulo reamittana termica dei modulo onte termico associatio trasmittana termica lineica Junghezza perimetrale	U 21 4	2,599 P.T. serra 0,100 8,60	W/m <sup>2</sup> K menti, pori m	te e finestre	pag.
	R Reditiona termica (1991) J. Explosivity or Genes, 439 - 68322 Anome (AB) aratteristiche del medialo aratteristiche del medialo ante termico adel sorrameta onte termico associato fraemittanza termica limitca umphezza perimetciale	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m <sup>2</sup> K mentl, port W/mK m	te e finestre	pag.
	R Reddena termisa Harricul Fundamentary Familia Familia Constraints reamittanza termisa del modulo trasmittanza termisa del modulo note termino adosciato frasmittanza termisa lineica Lunghezza perimetrale	U ZI W	2,599 P.T. serra 0,100 8,60	W/m²K mentl, port W/mK m	te e finestre	99,
	R Reditiona termica rePRULI Enganaering te carmit, etb e0131 Anonas (Att) arantaeriaticha. del medulo arantaeriaticha. del medulo arantaeriaticha. del medulo arantaeriaticha del serrametta prote termico associatio trasmittanza termica lineica Junghezza perimetrale	υ 21 Ψ	2,599 P.T. serra 0,100 8,60	W/m²K umenti, port W/mK m	te e finestre	995.
	R Reditiona termica International Control of the International Control of Contro	U ZI W	2,599 P.T. serra 0,100 8,60	W/m <sup>2</sup> K Imenti, port W/mK m	te e finestre	99.
	R Reddenia termisa Harris 1 Eurohaming Harris 25 - 2013 Ancora (AR) aratteristicha del medulo frasmittana termica del modulo note termico ado sociato frasmittana termica lineica Lunghezza perimetrale	U ZX Y	2,599 P.T. serra 0,100 8,60	W/m²K W/mK m	te e finestre	99.
	R Reditiona termica	U 22. i 4	2,599 P.T. serra 0,100 8,60	W/m <sup>5</sup> K amenti, peri W/mK m	te e finestre	99.
	R Reditiona termica International Control of the International Internat	U ZI Ŧ	2,599 P.T. serra 0,100 8,60	W/m³K W/mK W/nK m	te e finestre	992.
	R Reddena termia	U 21 4 9	2,599 P.T. serra 0,100 8,60	W/m <sup>3</sup> K umenti, peri W/mK m	te e finestre	99.
	R Reditiona termica International Control of the International Control of Control o	U ZZ ( W	2,599 P.T. serra 0,100 8,60	W/m³K W/mK M	te e finestre	99.
	R Reddena termia	U 22.1 W	2,599 P.T. serrs 0,100 8,60	W/m²K umenti, peri W/mK m	te e finestre	99.
	R Reditiona termica	U 22. i V	2,599 9.7. serra 8,60	W/m <sup>3</sup> K W/mK m	te e finestre	99.
	R Reditiona termica International Control of the International Control of Control o	U 21 W	2,599 P.T. serra 8,60	W/m <sup>5</sup> K W/mK m	te e finestre	99.
	R Reddena termia	U 22.1 W	2,599 P.T. serra 0,100 8,60	W/m³K W/mk m	te e finestre	99.
	R Reddena termia	U 22. i 4	2,599 P.T. serra 0,100 8,60	W/m²K amenti, perin W/mK m	te e finestre	10









Descrizione della finestra: ve	trata Magas	zino 165x	860	Codice: W7
Caratteristiche del serramento				
Tipologia di serramento	Singele	racanda I	lorma	
Classe di permeabilità	UNI EN 1	2207		
Trasmittanza termica Trasmittanza solo vetro	U.,	2,331	W/m <sup>2</sup> K W/m <sup>2</sup> K	
Dati per il calcolo degli apporti s Emissività	solari	0.837	22 C	
Fattore tendaggi (invernale)	Ferry	0,80		
Fattore tendaggi (estivo)	fceat	0,80		
Fattore di trasmittanza solare	9 <sub>pt.n</sub>	0,750	-	
Caratteristiche delle chiusure os	icuranti	20.00		
Resistenza termica chiusure f shut		0,16	m*K/W	
Dimensioni del serremento		0.000		
Larohezza		165.0	cm	
Altezza		860,0	cm	
Caratteristiche del telaio	1.000		mit-2w	
K distanziale	K <sub>4</sub>	0,08	W/mK	
Area totale	Α,,	14,190	m <sup>2</sup>	
Area telalo	A,	2,445	m <sup>2</sup>	
Fattore di forma	Fr	0,83		
Perimetro vetro Perimetro telaio	L <sub>g</sub>	27,800	m	
Etrationalia del nacebotto cost		10,500	1999 ()	
Descrizione strate	8	٨	R	b b
Resistenza superficiale interna	-	-	0,130	
Intercapedine	6,0	1,00	0,008	
Secondo vetro	6,0	1,00	0,006	
RPILLI Engineering 9 Grandi, 45h - 60131 Ancona (AN)				149
aratteristishe del module Tresmittanze termica del modulo acto tarmito: del serramento Ponte termico associato Trasmittanza termica lineica Lunghezza perimetrale	U 21 P V	2,476 .T. serram 0,100 20,50	W/m <sup>2</sup> K Penti, porte d W/mK m	e finestre
aratteristicha del modulo Tremittanza termica del modulo azia termico del seramento Forde termico associate Tramittana termico sineia Lunghezza perimetrale	U ZI P V	2,476	W/m <sup>3</sup> K <del>Penti, porte d</del> W/mK m	e finestre
aratteristiche.del.modulo Tranmittanea termica del modulo 2010 termico del servamento Porte termico associato ramittanea termica tenica unghezza perimetrale	U ZI P U	2,476 ,7. serran 0,100 20,50	W/m <sup>9</sup> K NimK M	• finestre





	tone indus	triale		Codice: W8
Caratteristiche del serramento				
Tipologia di serramento	Singolo			Contraction of the local division of the loc
Classe di permeabilità	Senza cli	essificazio	ne	
Trasmittanza termica	Un	3,309	W/m <sup>2</sup> K	
Trasmittanza solo vetro	U,	5,468	W/m²K	TAX II I I I I I I I I I I I I I I I I I
Dati per il calcolo degli apporti s	olari			
Emissività	8	0,837		And the second
Fattore tendaggi (invernale)	fc tow	0,00		the second s
Fattore tendaggi (estivo)	fe est	0,00	1.4.2	sector and the sector of the sector of the
Fattore di trasmittanza solare	Que.e.	0,850		
Caratteristiche delle chiusure os	uranti			
Resistenza termica chiusure		0,16	m²K/W	
f shut		0,6		
Dimensioni del serramento				
Larohezza		200.0	cm	
Altezza		200,0	cm	
aratteristiche del telaio.		4.00	wundy	
Michaenialo	Or P	4,40	W/mk	
Area totala	10	4.000	and and	
Area water	-	0,000	m	
Area telain	~	4.000	m2	
Fattore di forma	2	0.00	-	
Perimetro vetro	12	3,600	100	
Perimetro telalo		8,000		
		4,000		
Conceiviene atosto	ato			
Resistenza superficiale interna		-	0.130	N.
Primo vetro	6.0	1.00	0.006	
Resistenza superficiale esterna		- 14 - L	0,047	
egenda simboli				mm
egenda simboli s Spassore				
egenda simboli s Spessore A Conduttività termica				W/mK
zgenda simboli s Spassore A Conduttività termica R Resistenza termica				W/mik m²k/W
coenda símboli s Spasore A Condutività termica R Resistanza termica Caratteristiche del modulo				W/mK m²K/W pog. 2
ogenda simboli s Spissore A Condutiva terrica R Resistenia terrica Rantteristiche del modulo CRFILLI Explorenzia o Granz, 45h - 60/23 Ancona (AND				Wink mRQU pag. 34
agenda simboli a Generatore tarmica A Conductive tarmica A Resistence termica Caratteristiche del modulo CAPILLI Explorensing a Gazan, 45 - 60131 Ancons (AN) Trasmittanza termica del modulo	U	3,509	W/m²K	Wink mRQW pag. 2
agenda simboli a Spissione A Conductiva Aterrica R Residencia termica Caratteristiche del modulo CAPILI Engineering o Canat, 55 - 60/31 Ancona (AN) no Canat, 55 - 60/31 Ancona (AN) Transittanza termica del modulo note termico dei seramento	U	3,509	W/m <sup>2</sup> K	Wind mikipu pog. 2
agenda simboli a Generatore termica A Conductive termica A Conductive termica R Resistence termica Caratteristiche del modulo CAPILLI Explorensing a Canad, 45 - 60131 Ancons (AN) Trasmittanza termica del modulo onte termica del seramento parte termica sociato	U	3,509 P.T. serra	W/m <sup>2</sup> K menti, pos	Wind mRQW pag. 2
agenda simboli a Spissione A Conductiva Arenica R Residencia termica Caratteristiche del modulo Caratteristiche del modulo Di Garadi, 950 - 60231 Ancona (AN) Insumittanca termica del modulo onte termica del arenanemo Parte termica associato Transmittanca Insuica Insuica	U 21 9	3,509 P.T. serra 0,100	W/m <sup>2</sup> K menti, pos W/miK	Wind whited whited ree a finestro







D3.1 Guidelines for integrated design towards smart / zero buildings & smart grids. Report on the design phase

Descrizione della finestra: Ingr	esso over	it 195×286			Codice: W9
Caratteristiche del serramento					
Tipologia di serramento	Singolo				
Classe di permeabilità	Classe 3	secondo N	lorma	Sector and	
Trasmittanza termica	U_	2,402	W/m <sup>2</sup> K		
Trasmittanza solo vetro	U <sub>g</sub>	2,763	W/m²K		
Dati per il calcolo degli apporti so	lari				
Emissività		0,837			
Factore tendaggi (invernale) Eattore tendaggi (invernale)	Te inv	1,00	÷.		
Fattore di trasmittanza solare	Guin	0,750			
Caratteristiche delle chiusure osci	aranti				
Resistenza termica chiusure		0,16	m <sup>2</sup> K/W		
f shut		0,6	-		
Dimensioni del serramento					
Larghezza		195,0	cm		
Altezza		210,0	cm		
Altezza sopraluce		70,0	cm		
aratteristiche del telaio					
Trasmittanza termica del telalo	U <sub>2</sub>	2,50	W/m <sup>2</sup> K		
K distanziale	Ka	0,08	W/mK		
Area totale	A.,	5,460	m		
Area telaio	2	1,485	m <sup>2</sup>		
Fattore di forma	Fr	0,73			
Perimetro vetro	L <sub>10</sub>	19,600	m		
itratigrafia del pacchetto vetra	to		0		
Resistenza superficiale interna		-	0,130	MA	
Primo vetro	6,0	1,00	0,006		
Intercapedine Secondo vetro	6.0	-	0,173		
Resistenza superficiale esterna	-	-	0,047		
egenda simboli					
s Spessore				mm	
λ Conduttività termica				W/milC	
SERPILLI Engineering Via Grandi, 454 - 60131 Ancona (AN)					pag. 24
R. Resistenza termica				m <sup>2</sup> K/W	
Caratteristiche del modulo			Marco Bar		
Trasmittanza termica del modulo	U	2,576	W/m°K		
Ponte termico del serramento					
Ponte termico associato	Z1	P.T. serva	menti, porte	e finestre	
Trasmittanza termica lineica Lunobezza perimetrale		0,100	W/mK		







Descrizione della finestra: Fine	estra singol	la 110×12	0	Codice: W10
Caratteristiche del serramento				
Tipología di serramento	Singolo			
Classa di normeabilità	Classe 3 s	secondo N	torma	and the second sec
character of permeasure	UNI EN 1	2207		
Trasmittanza termica	Use	2,355	W/m*K	
Trasmittanza solo vetro	U <sub>g</sub>	2,763	W/m.K	
Dati ner il calcolo degli annorti s	olari			
Emissistà	Annis .	0.837		
Fattore tendagoi (invernale)	£	0.80		
Fattore tendagoi (estivo)	free	0,80	S	
Fattore di trasmittanza solare	9 alva	0,750		
Caratteristiche delle chiusure os	uranti			
Resistenza termica chiusure		0,16	m3K/W	
f shut		0,6	-	
Dimensioni del serramento				
kennen som ander som ander som				
Larghezza		110,0	cm	
Altezza		120,0	cm	
aratteristiche del telaio				
Trasmittanza termica del telaio	U,	2,50	W/m²K	
K distanziale	K,	0,08	W/mK	
Area totale	A.,	1,320	m	
Area vetro	Α,	0,900	m,	
Area telaio	A	0,420	m,	
Fattore di forma	14	0,68		
Perimetro vetro	-	3,800	m	
Perimetro telaito	4	4,000	-10	
tratigrafia del pacchetto vetr	ato			
Descrizione strate	- 8	À	R	D. D.
Resistenza superficiale interna	1990 - C	×	0,130	
Primo vetra	6,0	1,00	0,006	1
Intercopecane			0,173	
Resistenza superficiale esterna		2,00	0.047	
and the second				
egenos sintos				intro Million V
s Spessore				myrins.
egenos sillitos s Spessore A Conduttivită termica R Resistenza termica				m <sup>2</sup> K/W
eumua simboli s Spessore A Conduttivită termica R Resistenza termica				m <sup>2</sup> K/W
s Spessore A Conduttivită termica R Resistenza termica				m <sup>2</sup> K/W pag. 28
s Spesore A Conduttivită termica R Resistenza termica				m²K/W pag. 28
s Spesore A A Conduttivită termica R Resistenza termica				m²K/W pag. 28
s Spesore A Condutività termica R Resistenza termica SRFILLI Engineering				m <sup>2</sup> K/W pag. 28
summa vititute s Specore A Condutitvită termica R Resistenza termica SEPELI L'Engineering o Grandi, 45h - 60131 Ancona (AN)				n <sup>2</sup> K/W pag. 28
s Spesore A Condutitvità termica R Residenza termica RPILLI Engineering Grandy, 45h - 60131 Ancona (AN)				m <sup>4</sup> K/W pag, 28
s Spissore Condutitività termica Residenza termica SIPILLI Engineering Grand, 45h - 60231 Ancona (Aki) Instituristiche del modulo				т <sup>а</sup> кум рад. 28
s Spissore Conduttività termica Resistenza termica RENTLI Engineerity e Grandi, 455 + 60.23 Ancone (AN) tratteritiche del modulo		2.704	Wimłd	m <sup>9</sup> 6/W pag. 28
s Spissore Condutitività termica Residenza termica SIRFILI Engineering ci drandi, 45n - 60/31 Ancona (AN) tratteristiche del modulo rasmittanza termica del modulo	U	2,704	W/m <sup>2</sup> K	ni <sup>4</sup> 6/W pag. 28
earmas.attitoti 5 Spessor A Conduttività herrica Refitti Engineening Grand, 455 - 60/31 Ancone (AN) <b>Institutional Conductor</b> <b>Institutional Conductor</b>	U	2,704	W/m <sup>2</sup> K	nikow pag. 28
estimas.attituda 5 Spescore A Conduttivida herricca R Residenzia herricca (A) Conduttivida herricca (A) Conduttivida herricca (A) Conductivida herricc	U 21 J	2,704 P.T. serra	W/m²K menti, por	nikyw pag. 28 to a finestra
earma.attitoti 5 Spescie A Canduttività termica Refitti Engineento and, din - 60111 Ancona (AN) exatteristiche del modulo rantificate del modulo reatteristiche del modulo reatteristiche del modulo reatteristiche del serramento ovrie termico adel serramento avertare del modulo secolato reantificate almento alle da	U 21 / U	2,704 P.T. serrar 0,100	W/m²K menti, por W/mK	nitoru pag. 28 te a finestra
sprana, struttoliki s Spescore A Conduttividi Nemica Nesidenza formica NELL Engissening Grand, 4th - 60/31 Ancone (Aki) rattecisticha del modulo ratemitianza termica del modulo rete termico adi seranambo onte termico adi seranambo majheza perimetra terni	U 21 J U	2,704 P.T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nikyw pag. 28 te e finestre
sprana, struttori s Spessore A Could Hids hernica: Reflict/Explorenitg Grand, 454 - 60/21 Ancona (240) reatteristiche del modulo reatteristiche del servanezto orie termico associato reatteristiche Bieles unghezza perimetrale	U 21 4 4	2,704 P.T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nitoru pag. 28 te e finestre
estima attitudi s Spesore A Conduttivid Nemica Nestionas formica NELL Engineering Grand, 4th - 60/31 Ancone (AN) ratheristiche del modulo rateristianza termica del modulo rete termico adi seranentio nel termico adi seranentio rete termico adi seranentio namittanza termica lineica unghezza perimetrale	U 21 4 U	2,704 P.T. serrar 0,100 4,60	W/m²K menti, por W/mK m	nityw pag. 20 te e finestre
sprana, studioli 5 Spessore A Coudativida hermica: Refile[] Explorening damad, eth = 6021 Ancona (AN) rasmittanta termica del modulo rasmittanta termica del modulo cia termico. del serzamento orde termico. associato resmittanta termico. Sinden unghezza perimetrale	U 21 4 U	2,704 P,T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nityw pag. 20 te o finestro
estimas.attitoti 5 Spescie A Couldinida bernica Resolutiva formica 2011/1 Englisentia 4011/1 Englisen	U 21 / U	2,704 P.T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nikyw pag. 28 te e finestre
estransatulloti 5 Spescor A Conductivida hermica: Reflict/ Engineening clanad, etc. + 60/31 Ancona (AN) ransmittanza termica del modulo ransmittanza termica del modulo etc. Lermico. del serzamento ovria termico. associato ransmittanza perimetrale	U 21 / U	2,704 P.T. serrar 0,100 4,60	W/m²K menti, por W/mK m	nityw pag. 20 te o finestro
estrema strillotti e s Spescore A Conduttivida hermica Resolutivita hermica Resolutivita hermica Resolutivita hermica Resolutivita hermica resolution del servica resolutiona del servica resolutiona del servica tratemittanza termica llenica unghezza perimetrale	U 21 4 4	2,704 P.T. serrar 0,100 4,60	W/m <sup>2</sup> K menti, por W/mK m	nikyw pag. 28 te e finesire
estrema.stittotti E. Spescore A. Couldmick lumitica Reflict/Equipreening e.Gand, 45n - 60/32 Antonia (AN) Instances termica del modulo rasmittana termica del modulo rasmittana termica lenica unghozza porimetrale	U 21 4 4	2,704 P.T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nityw pag. 20 te o finestro
estimas.attitoti 5 Spescie A Couldinida bernica Resolutiva formica 2011/1 Englisentia e Grand, 45h - 60/31 Ancone (AN) arattecisticha del modulo rateristianza termica del modulo real termico del sertamento del cernico del sertamento rateristianza termica lineica unghezza perimetrale	U 21 y U	2,704 P.T. serra 0,100 4,60	W/m²K menti, por W/mK m	nikyw pag. 28 te e finesire
sprima, strillotti s Spesore A Couldmick lumitica Missiona tomica RPRLI Engineering <i>cGand</i> , 4th - 60331 Antonia (AN) <b>insteinational termica del modulo</b> rasmittanas termica del modulo rasmittanas termica limitica unghezza perimetrale	U 21 9	2,704 P.T. serrat 0,100 4,60	W/m²K menti, por W/mK m	nityw pag. 20 te o finestro
sprana. STUDIO S Spesore S Spesore M Conductività formica MPILLI Engineentag Grande, 45h - 60/23 Ancone (AN) ratteristicha del modulo rateristicha del modulo rateristicha del modulo reteristicho del sertamenta reteristicho del sertamenta reteristicha servica lineica unghezza perimetrale	υ 21 Ψ	2,704 P.T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nikyw pag. 28 te e finestre
sprima, strillolli s Spesore S Spesore Resolutions tomica REFLIT Engineering <i>Canad</i> , 4th - 60331 Antonia (AM) <b>Institution Strill Antonia (AM)</b> <b>Institution Strill Antonia (AM)</b> <b>Ins</b>	υ 21 / Ψ	2,704 P. T. serrai 0,100 4,60	W/m²K menti, por W/mK m	nitoru pag. 28 te a finestra
estrana.strutoti 5 Spescor A Conduttivid kernica Resolutivid kernica	U 21 U	2,704 P.T. serra 0,100 4,60	W/m²K menti, por W/mK m	nikyw pag. 28 te e finestre
serrena strillotti E Spescore A Couldinida luminica Rittul Engineensia Grand, 45h - 60/31 Ancone (AN) Institutional termica Institutional termica Antonia termica associato reamitanas termica lancia unghezza perimetrale	υ 21 4 Ψ	2,704 P.T. serrar 6,60	W/m³K menti, por W/mK m	nityu pag. 28
estrana.stutotti 5 Spescore A Couldinida korrica Resolutiva korrica 2011/1 Explorentia of Grand, 45h - 60/31 Ancone (AN) arattecistiche del modulo rasentianza terrica del modulo reaction del sertamento del territo del sertamento reactione del modulo reactione del sertamento prote territo ascistato rasentitanza terrica lineica unghezza perimetrale	U 21 U	2,704 P.T. serra 0,100 4,60	W/m²K menti, par W/mK m	nityw pag. 28 te e finestre
sprana, struttotti s Spesore S Spesore M Could the Innota M Resolutions toresca REFLICE Engineerista County of the Innotation Institution of the Innotation Innotation of the Innotation of the Innotation Innotation of the Innotation of the Innotation of the Innotation of the Innotation Innotation of the Innotation o	υ 21 φ	2,704 9,10 4,60	W/m <sup>9</sup> K m <del>enti, poo</del> W/mK m	nityu pag. 28 to a finestra
carma. Minoli S Spesicor A Condutivida kermica R Resolutivida kermica COMULI Explorenting a Grand, 459 - 60/321 Ancone (AN) aratteristicha del modulo traumittanza termica del modulo deta termico adi sertamanto deta termico adi sertamanto referet termico ascostito Prate termico ascostito	U 21 / J U	2,704 P.T. serrar 4,60	W/m <sup>a</sup> K menti, por W/mK m	nityw pag. 28 te e finestre





