CETIEB

D8.4 Report on training activities

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COOPERATION

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1. Preface

Buildings are at the pivotal centre of our lives. The characteristics of a buildings, its design, its look and feel, and its technical standards not only influence our productivity, our well-being, our moods and our interactions with others, they also define how much energy is consumed by a building, and how much heating, ventilation and cooling energy is needed in order to create a pleasant environment. Through building retrofitting to high standards of efficiency, we can demonstrate that ambitious climate change mitigation actions and improvements in living quality can go together. In this respect, this report wants to encourage a wider debate on how stakeholders within the building sector can collaborate to transform the European building stock into a highly efficient living and working environment which enables society to become more sustainable, in all aspects of the words meaning.

Acronyms

EPBD	Energy Performance of Building Directive
WHO	World Health Organization
EU	European Union
MPA	Institute of Material Testing (University of Stuttgart)
IGE	Institute of Building Energetics (University of Stuttgart)
IFK	Institute of Combustion and Power Plant Technology (University of Stuttgart)
IPM	Institute for Physical Measurements Techniques (Fraunhofer)
ENEA	Italian National Agency for New Technologies, Energy and Environment
E2BA	Energy Efficient Building Association
ECTP	European Construction Technology Platform
PTIC	Italian Construction Technology Platform
ACEN	Associazione Construttori Edili Napoli (Association of Construction Sector in Naples)
ASHRAE	American Society of Heating, Refrigerating and Air
ISO	International Organization for Standardization
DIISM	Department of Industrial Engineering and Mathematical Sciences (Università Politecnica delle Marche)

Abbreviations

IEQ	Indoor Environmental Quality
SME	Small and Medium Enterprise
PCMs	Phase-Change Materials
HVAC	Heating, Ventilation and Air Conditioning
VOCs	Volatile Organic Compound
3D	Three-dimensional space
N/A	Not applicable
DCM	Demand Controlled Ventilation
IAQ	Indoor Air Quality
SBS	Sick Building Syndrome
EN	European Normative
ODA	Outdoor Air Quality
NDIR	Non-Dispersive-Infra-Red
LED	Light-Emitting Diode
PMV	Predicted Mean Value
PPD	Percentage of People Dissatisfied
DR	Draught Rate
A/D	Analog-to-Digital converter
IDE	Integrated Development Environment
RGB	Red, Green and Blue
UV	Ultraviolet
FID	Flame Ionisation Detector

2. Project presentation

The European Energy Performance of Buildings Directive (EPBD)[1] promotes more and more efficient buildings as a viable path towards energy saving. The energy consumption of buildings in developed countries comprises 20–40% of total energy use[2] as people spend 90 % of their time indoor[3]. Most of energy use in buildings is due to space heating and cooling[4]. The increasing demand for building services and human comfort levels has spurred energy consumption worldwide. Nowadays about 210 million of existing buildings within EU will have to be retrofitted in order to achieve the EU's 2050 target of 80-95% CO_2 emissions reduction. This target can be met by providing a deep retrofit of 5 million buildings per year on average, over a 40-year period, achieving 84% energy performance improvement compared to current levels. Since the demand for energy efficiency leads to enhanced air tightness and thermal insulation in new and refurbished premises it might eventually result in a degraded indoor environmental quality (IEQ). High air tightness for instance, reduces the outside air flow rates; while mechanical ventilation might be the only workable solution to guarantee the necessary air exchange, an effective control strategy has to be implemented in order to prevent it to raise the overall energy consumption. Therefore the safeguard of human indoor well-being should not be neglected while trying to limit the unnecessary energy use. Furthermore, already in 1984 the World Health Organization (WHO) revealed people to suffer from health and comfort related illness in more than 30% of new and remodelled buildings worldwide[5]. The expression "Sick building syndrome" was coined to describe those symptom clusters coming from poor indoor air quality such as allergy, lethargy, headaches, dizziness, itchy and dry skin, dry eyes, throat, airways[6,7]. In the just depicted framework the EU funded project CETIEB (Cost Effective Tools for Better Indoor Environment in retrofitted energy efficient Buildings) devotes itself to the study of cost effective solutions to better monitor the indoor environmental

The CETIEB project main objective is to develop innovative solutions for better monitoring indoor environment quality and to investigate active and passive systems for controlling it.

The project is based on three main objectives:

1. Development of monitoring systems (wireless and/or partly wired) to detect insufficient comfort and health parameter. It is foreseen to develop a modular version for allowing common end users making a quick check of the indoor air quality. However, this system could also be used by advanced users for detailed and continuous measuring and also for controlling active systems like ventilation. For that purpose several upgrade options will be available.
2. Development of control systems for indoor environments which could be based on passive elements like cost effective photo catalytic materials or PCMs and active systems which control the air flow rates based on the monitoring data. Provision of alarm values for action, if automatic control is not sufficient. The effect and the influence of passive elements can be proven by the developed monitoring systems.
3. Modelling of indoor environments for the assessment and validation of monitoring data and optimize with respect to energy efficiency, the control parameters and systems. Identifying the new air flow patterns in energy efficient buildings taking into account high thermal insulation

[1] Directive 2002/91/EC of the European parliament and of the Council on the energy performance of buildings. European parliament and Council, Dec. 2002.
[2] J.W.Wan et al. "A new method of determination of indoor temperature and relative humidity with consideration of human thermal comfort". In: Building and Environment 44 (2009), pp. 411–417.
[3] S.C.Lee and M.Chang. "Indoor and outdoor air quality investigation at schools in Hong Kong". In: Chemosphere 41 (2000), pp. 109–113.
[4] D.Wang, E.Arens, and C.Federspiel. Opportunities to save energy and improve comfort by using wireless sensor networks in buildings. Tech. rep. Center for Environmental Design Research 390 Wurster Hall, University of California, Berkeley, CA, 94710.
[5] Indoor air quality reasearch. Tech. rep. World Health Organization Regional Office for Europe Copenhagen, Aug. 1984.
[6] P.Carrer et al. "Health e_ects evaluation in modern office buildings and health risk assessment". In: Oct. 2013.
[7] Sick Building Syndrome. Tech. rep. United States Environmental Protection Agency, Feb. 1991.

and air tightness and also low temperature heating systems. This will give hints for the placement of the sensors and for the development of the monitoring systems. It can also be investigated the influence of the position of sources and sinks into the room. So the refurbishing design can be improved.

The project will demonstrate in a real building the efficiency of technologies and systems developed. The final objective is to disseminate results and recommendations for new policies and regulations within the EU.

3. Consortium overview

The consortium is composed by 15 organizations from 7 different countries: Germany, Italy, Spain, Ireland, France and Greece, and the non-EU member Taiwan; as a whole it is well defined/established, taking into account the above mentioned terms and geographical location, where different climate changes, request different technological applications in relation to energy efficient buildings.

Table 1. Overview of CETIEB partner consortium

Partner	Overview
Universität Stuttgart – USTUTT	**The Institute of Materials Testing (MPA)** (www.mpa.uni-stuttgart.de) is an independent research organisation and the central materials testing institute of the University of Stuttgart with about 400 co-workers. Two departments of the Division 4 "Protection of buildings and plants" are involved in the project. Department 41 "Durability and protection of buildings and plants" & Department 43 "Non-destructive testing and monitoring techniques". **The Institute of Building Energetics (IGE)** (http://www.ige.uni-stuttgart.de/) at the University of Stuttgart is engaged in research, processing and calculation of heating, ventilation and conditioning systems (HVAC-systems) and its components. It also builds test devices for these HVAC-systems. **The Institute of Combustion and Power Plant Technology (IFK)** (http://www.ifk.unistuttgart.de) with the Department of Air Quality Control has long years experiences in the experimental fields of combustion techniques, in air pollution control; especially experimental investigations of emissions, ambient air and indoor pollutants and issues regarding measurement techniques.
Delap & Waller EcoCo – Integrated Sustainable Design Consultants – DWE	**Delap & Waller EcoCo** is an Integrated Sustainable Design Consultancy which provides a unique service to the building development, construction and property industries to create a more sustainable built environment. Delap & Waller EcoCo works internationally and, with its parent company Delap & Waller, has offices in Dublin, London, Belfast, Warsaw, Bucharest ,Tripoli and Abu Dhabi.
S&B Industrial Minerals S.A. – S&B	**S&B Industrial Minerals S.A.** constitutes a Group of companies, with a strong international presence, selling its products in more than 60 countries worldwide. It was established in Greece in 1934 and is listed on the Athens Stock Exchange since 1994. As per 31/12/06 its Consolidated Sales were € 455,6 million and Net Profits were € 23,54 million**.** The S&B Group consists of subsidiary and affiliated companies, operating mines, processing plants and distribution centres in more than 20 countries across 5 continents (among others in Greece, Germany, France, Italy, Spain, Bulgaria, Hungary, USA, China, Brazil, India and Korea).
SOLINTEL M&P –	**SOLINTEL** (www.solintel.eu) is a high-tech SME specialized engineering and

SOL	consulting company located in Spain. Its goal is to satisfy in an effective way the needs of the environment on engineering, innovating and energetic efficiency of industrial processes. The Energy Efficiency department of SOLINTEL works on the full development of systems for the generation, transport and energy consumption. SOLINTEL designs all kinds of installations for buildings, especially HVAC, domestic hot water and lighting systems. SOLINTEL uses, wherever possible, renewable energy or high efficiency generation such as district heating and cooling or CHP systems. It also designs plants of electric power generation with green energy sources such as photovoltaic, wind or biomass. An important part in developing this type of projects is the energy simulation. SOLINTEL makes a high effort to use the **most advanced simulation software**.
UNIVERSITÀ POLITECNICA DELLE MARCHE, Dipartimento di Meccanica – UNIVPM	**The Università Politecnica delle Marche** was founded in 1971. This University now includes the faculties of Engineering, Medicine, Economy&Business, Agriculture and Science. The number of employees (professors, researchers, technicians, and administrates) is in total around 1000. The Mechanical Department will participate in the project with the Mechanical and Thermal Measurement Group. Main areas of research are connected with development and application of new sensors and experimental techniques for material characterization, structural and environmental monitoring, non-destructive testing and embedded systems. Main fields of application of interest for the project are: smart sensors for indoor environments, building and construction materials structural monitoring, quality and process control in ceramic industry. The Mechanical and Thermal Measurement Group of the Mechanical Department is managed by 4 professors, composed of more than 30 researchers and engineers.
R.E.D. S.r.l. – RED	**R.E.D. S.r.l.** is an Italian SME founded the 23rd of January 2006 as a spin-off with the Consiglio Nazionale delle Ricerche as one of the shareholders. The company is active in research, development, production and installation of innovative devices, sensors, instruments and monitoring/management systems for the sectors of climatology, microclimatology, environmental monitoring, also applied to Cultural Heritage. The company is also active in the renewable energy field with geothermal coaxial heat exchangers coupled to heat pumps. Its strategy is (i) to innovate and develop devices and instruments outside of the range of conventional applications and/or of precision levels not available to date in the market (ii) to develop, assemble and manage monitoring systems (including ad hoc software) (iii) to provide systems and services in the energy field, particularly combined with Cultural Heritage Conservation, based on geothermic and monitoring.
TTI GmbH – TGU Smartmote – TTI	The TTI GmbH – TGU Smartmote is a spin-off company of the University of Stuttgart. The main business of Smartmote is non-destructive testing in the field of civil engineering, while main objective of Smartmote is to transfer findings and experiences from research of many years to practical solutions. Smartmote develops hard- and software solutions and thus fulfils the demands for non-destructive test methods in the field of materials testing and civil engineering.
Fraunhofer	The **Fraunhofer-Gesellschaft** is the leading organization of applied research in Germany, undertaking contract research on behalf of industry, the service sector and the government. Commissioned by customers in industry, it provides rapid, economical and immediately applicable solutions to technical and organizational problems. At present, the organization maintains 80 research establishments at 40 locations throughout Germany with around 13,000 em-

	ployees. The *Fraunhofer Institute for Physical Measurement Techniques IPM* develops optical sensor and imaging systems as well as systems based on thin film technology. In the business field "Integrated Sensor Systems", Fraunhofer IPM is engaged in the development of microsystems and compounds in the areas of thin film technologies for sensor applications, gas sensors, microsystems and infrared systems.
InfraTec GmbH – ITC	The company **InfraTec GmbH** is an owner managed SME acting in the field of infrared detectors, components and systems. Since its foundation in 1991 after Germany's reunification, two business units, Sensor Division and Infrared Measurement Division, were developed. Starting with 3 employees a company with more than 150 employees, a turnover of more than 18 Mio € and subsidiaries in U.S.A., and UK was formed.
CEA INES – Institut National de l'Energie Solaire – CEA	**CEA** is involved in CETIEB through its Technological Research Division. Part of this division, the CEA LITEN (Laboratory of Innovation for New Energy Technologies and Nanomaterials) is a CEA department located for the most part in Grenoble and Chambéry (on the INES site – French National Institute for Solar Energy). It is one of Europe's newest and most important research centres in the new energy technology field.
STAM SRL - STAM	**STAM** is a private engineering company founded in 1997, with a staff of more than 10 people, and based in Genoa, Italy. The main mission of the company is to provide engineering services to industries. STAM is a SME member of E2BA, and it is also supplier of the European Space Agency since 1999 with the Technology Transfer Programme. In European Research, STAM has been involved as participant in more than 20 Projects in the last 10 years, in the fields of advanced mechatronic systems, new materials, automation and energy. STAM has been deeply involved in compact actuation systems, automation and new product development since 1997. It has contributed to several applications, like a penetrometer for soil investigation, advanced robotic architectures and reengineered a textile manufacturing machine for the drawing of hi-tech wires for smart textile.
Schwenk Putz und Mörteltechnik GmbH – Schwenk	**SCHWENK PutztechnikGmbH & Co. KG** with head office in Ulm is a 100-percent subsidiary of SCHWENK Zement KG, an owner-managed family company with more than 160 years of company history. SCHWENK PutztechnikGmbH & Co. KG currently employs approx. 340 people at 7 production sites, 4 distribution offices and a distribution company in Switzerland and makes an annual turnover of approx. €95 million. As a façade specialist, the focus of Putztechnik is on the production and distribution of mineral plasters, mortars and thermal insulation composite systems. The company is extremely well arranged and, for the most part, maps the essential added value chains for its products itself.
Consorzio TRE – TRE	**Consorzio TRE, Technology for Building Renovation**, is a non-profit research consortium of public and private organisations, born in 1998 for the development of research activities on constructions. Headquarters and technical offices are based in Naples, Italy. Its public partners are ENEA (Italian National Agency for New Technologies, Energy and Environment) and the University of Naples "Federico II" and the private ones include construction companies, engineering firms and research organizations. Consorzio TRE, operating in the field of applied research for the construction sector, aims at the enhancement of the levels of eco-sustainability of new and existing buildings, through an integrated approach to safety, environmental impacts, maintenance and comfort related to economical, social and

	environmental factors. Its action strategies are based on the definition and development of "Best Practices", derived by the design and the realization of technology demonstrators, intended as applications of innovative technologies and methodologies studied and developed during the research activities. Consorzio TRE is member of the European Construction Technology Platform (ECTP), and actively participates in the work for the development of a strategic vision for the construction industry. It is also in the board of the Italian Construction Technology Platform (PTIC) and is responsible for the Focus Area Quality of Life.
FCC CONSTRUCCION, S.A. – FCCCO	**FCC CONSTRUCCION, S.A.** (FCCCO) is one of the largest Spanish contractors. Its activities in the construction sector have operated since 1900. The construction activity represents 50% of the business. Its business portfolio is now highly diversified. FCC's core businesses are environmental services and water management, construction of large infrastructure, cement production, and renewable energy production. It has a footprint in 54 countries worldwide and over 44% of its revenues come from outside Spain (mainly Europe and the US). Revenues in 2009 amounted to 12.700 billion euro and the group had 92,324 employees.
The National Taiwan University of Science and Technology - NTUST	The Institute comprises five colleges (engineering, electrical and computer engineering, management, design, and liberal arts and social sciences), twenty-one separate departments and graduate schools, fourteen interdisciplinary programs, and over thirty technological research and development laboratories, as well as centers for materials science and technology, automation and control, university-industry cooperation, ecological and hazard mitigation and engineering, nanotechnology, information security, wireless communications and electromagnetic compatibility, optomechatronics, and power electronics.

4. Introduction and Objectives of the Training activities

4.1 First training activities (Naples, Italy)

A training workshop was conducted on day 12 of April of 2013 (from 10:00 till 12:00) at ACEN (*Associazione Construttori Edili Napoli*, Piazza dei Martiri, 58 Napoli http://www.acen.it/acen/) meeting room, Naples (Italy). The course was attended by engineers and workers from private building industries and fellowship training students from the Universities in the Campania region of Italy.
The training workshop programme is given below in Table 2.

Table 2. Training Workshop programme.

Time	No.	Topic	Responsible
10:00 – 10:20	1	**Welcome and Introduction to CETIEB project**	**TRE, ACEN and Coordinator (USTUTT)**
10:20 – 10:40	2	**Indoor environment quality and impact of building retrofit** • Identification of quality parameters and addressing regulatory gaps	**WP2 Leader (DWE)**
10:40 – 11:20	3	**Wireless monitoring of indoor environment quality** • Sensing of Volatile Organic Compounds (VOC) • Sensing of thermal surfaces	**WP3-Leader (TTI-Smartmote), Fraunhofer-**

		• Lighting concepts	**IPM, UNIVPM, RED and NTUST**
11:20 – 11:40	4	**Active control and modelling of indoor environments** • Active control of HVAC systems • Use of biofilters • 3D modelling of indoor environments	**WP4 (TRE) & WP 6 Leader (USTUTT)**
11:40 – 12:00	5	**Cost effective photo-catalytic mortars to improve indoor environments**	**WP5-Leader (S&B) and Schwenk**

The training workshop was conducted by the following persons:

1. Welcome and introduction to CETIEB project.
   a. Carmine Pascale (TRE)
   b. Rodolfo Girardi (ACEN)
   c. Jürgen Frick (USTUTT)
2. Indoor environment quality and impact of building retrofit.
   a. Jay Stuart (DWE)
3. Wireless monitoring of indoor environment quality.
   a. Markus Krueger (TTI-Smartmote)
   b. Marco Arnesano (UNIVPM)
   c. Martin Ebermann (Fraunhofer-IPM)
   d. Luc Pockele (RED)
   e. Allen Jong-Woei Whang (NTUST) presented by Luc Pockele (RED)
4. Active control and modelling of indoor environments.
   a. Carmine Pascale (TRE)
   b. Thomas Schlosser (USTUTT-IGE)
5. Cost effective photo-catalytic mortars to improve indoor environments
   a. Antonia Ekonomakou (S&B)
   b. Johann Balau (Schwenk)

President of ACEN Mr. Rodolfo Girardi was very helpful in providing adequate accommodation and training facilities for Training Workshop of CETIEB project.

The objectives of the training workshop were:

- To introduce audience from various companies and Universities to the concepts of cost-effective tools for better indoor environment in retrofitted energy efficient buildings;
- To provide background in quality parameters and addressing regulatory gaps;
- To provide information on current wireless monitoring of indoor environment quality;
- To provide training, at an introductory level, in the use of active control and modelling of in-door environments, as well as cost-effective photo-catalytic mortars.

Press reviews including a television report about project and workshop in Italian language could be found at the homepage of partner Consorzio TRE:

http://www.consorziotre.com/index.php?option=com_content&view=article&id=88&Itemid=62

4.1.1 Training results and evaluation of participants

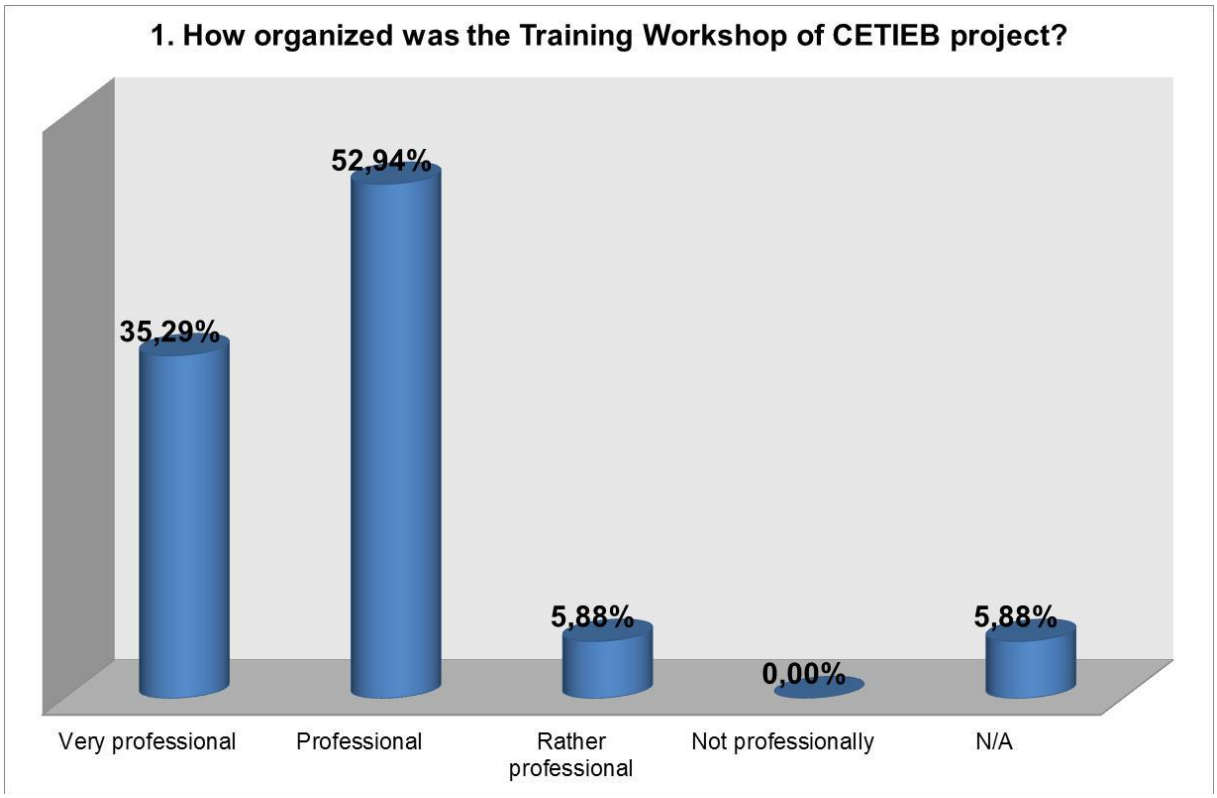
The level of apparent interest of the individual participants varied according to the topic being discussed, but in general all the audience appeared to be interested in all aspects of the course. As mentioned above, the training was provided as preliminary information, bringing the audience to the point where they can understand the background of the developed solutions in CETIEB project.

Few days later, the participants were asked to fill out the short questionnaire, evaluating the Training Workshop of CETIEB project. Below is attached the list of questions of questionnaire:

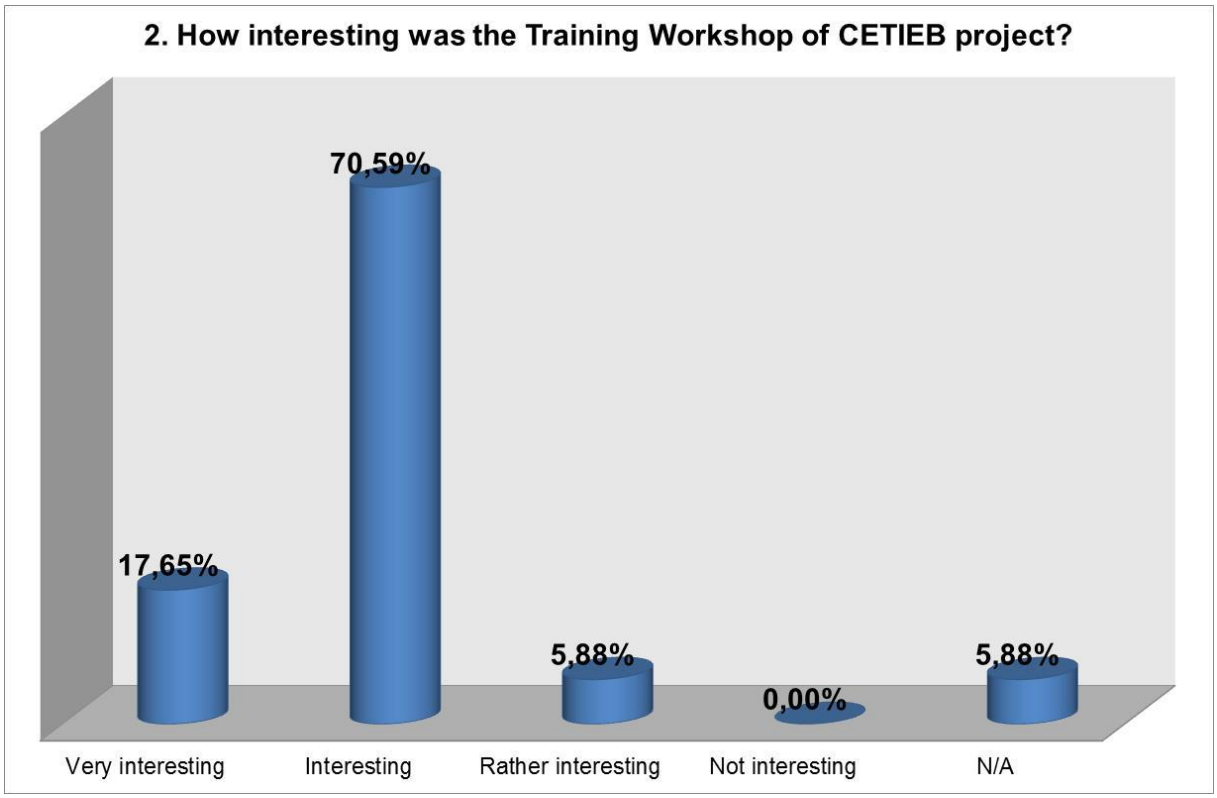
1. How organized was the Training Workshop of CETIEB project?
    a. Very professional,
    b. Professional,
    c. Rather professional,
    d. Not professional,
    e. N/A,
    f. Other (please specify)
2. How interesting was the Training Workshop of CETIEB project?
    a. Very interesting,
    b. Interesting,
    c. Rather interesting,
    d. Not interesting,
    e. N/A,
    f. Other (please specify).
3. How useful was the information presented at the Training Workshop of CETIEB project?
    a. Very useful,
    b. Useful,
    c. Rather useful,
    d. Useless,
    e. N/A,
    f. Other (please specify).
4. Prior to the Training Workshop of CETIEB project, how much of the information that you needed did you get?
    a. Very much,
    b. Sufficiently,
    c. Not so much,
    d. N/A,
    e. Other (please specify).
5. Which topic of Training Workshop of CETIEB project was interesting to you?
    a. Indoor environment quality (WP2),
    b. Monitoring (WP3),
    c. Active systems (WP4),
    d. Passive systems (WP5),
    e. N/A.
6. Overall, are there innovative the presented results of the CETIEB project?
    a. Very innovative,
    b. Innovative,
    c. Rather innovative,
    d. Not innovative,
    e. N/A,
    f. Other (please specify).
7. Will you apply those solutions in your home?
    a. Yes,
    b. Rather yes,

c. Rather not,
d. Not,
e. N/A,
f. Other (please specify).

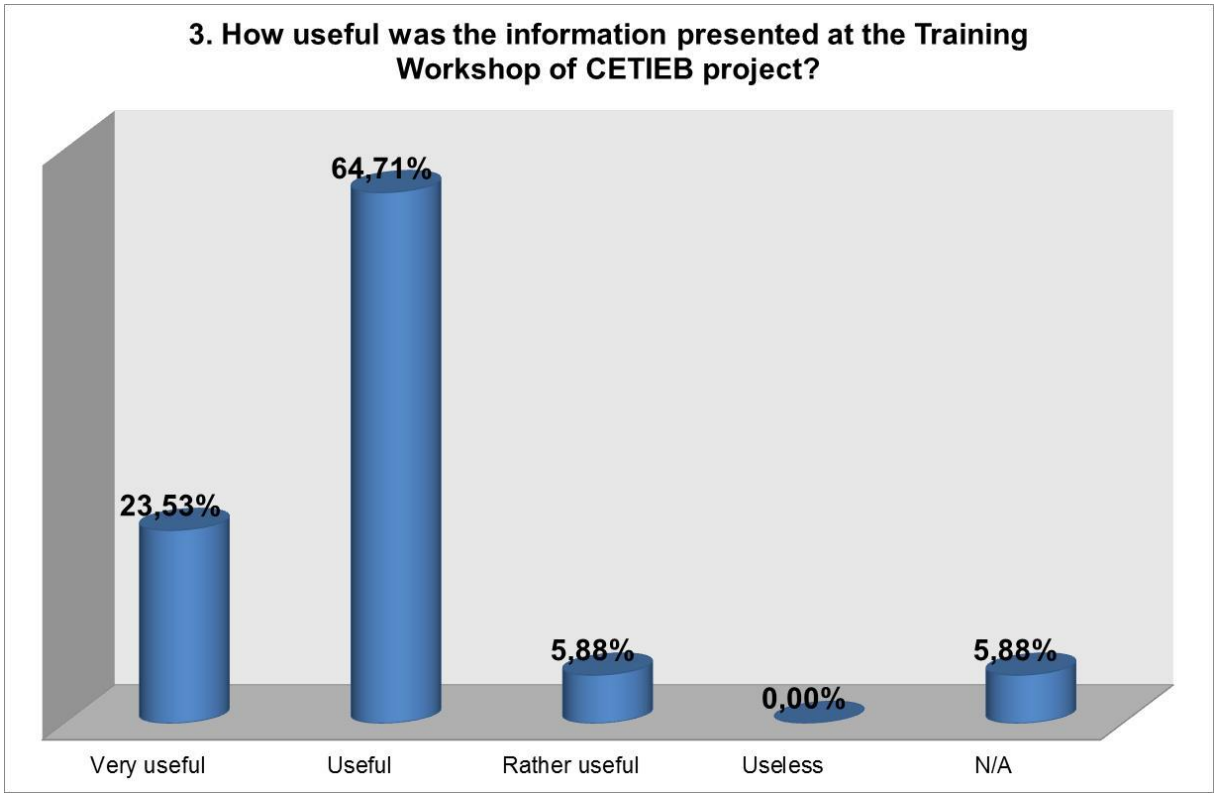
8. Overall, how would you rate the Training workshop of CETIEB project?
   a. Very high,
   b. High,
   c. Rather high,
   d. Low,
   e. N/A,
   f. Other (please specify).
9. How likely are (or will) you to recommend the Training Workshop of CETIEB project to a friend?
   a. Very likely
   b. Likely
   c. Rather likely
   d. Unlikely
   e. N/A,
   f. Other (please specify).
10. Is there anything else you would like to share about event?



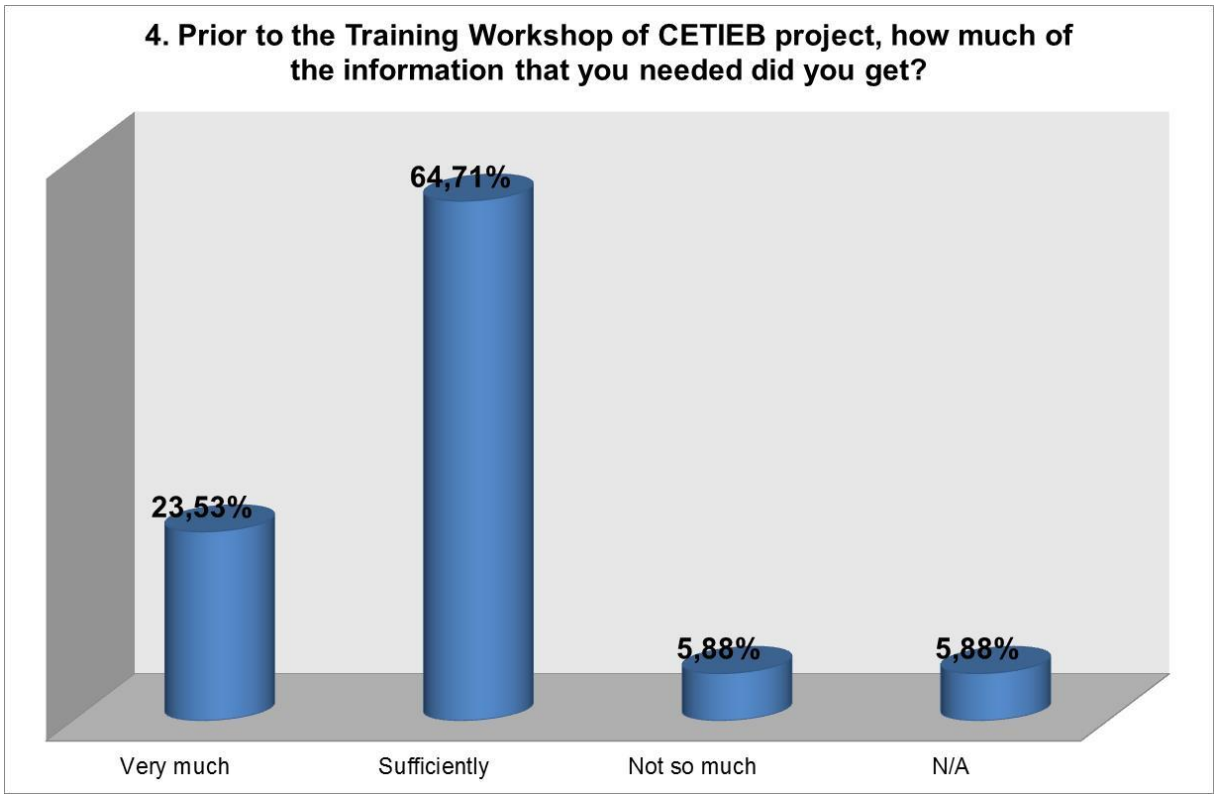
Most of the participants (**88.24%**) have considered, that the Training Workshop of CETIEB project was organized – Very professional or professional.



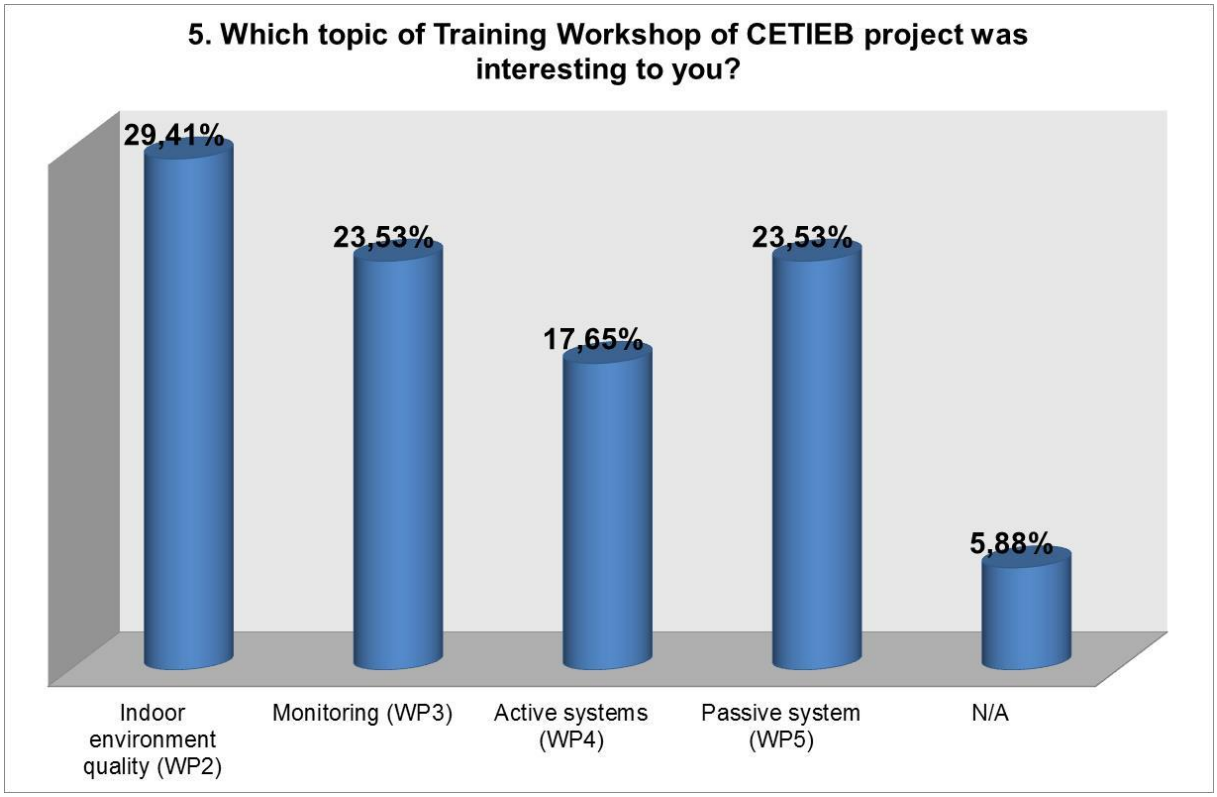
Most of the participants (**88,24%**) have considered, that the Training Workshop of CETIEB project was – Very interesting or interesting.



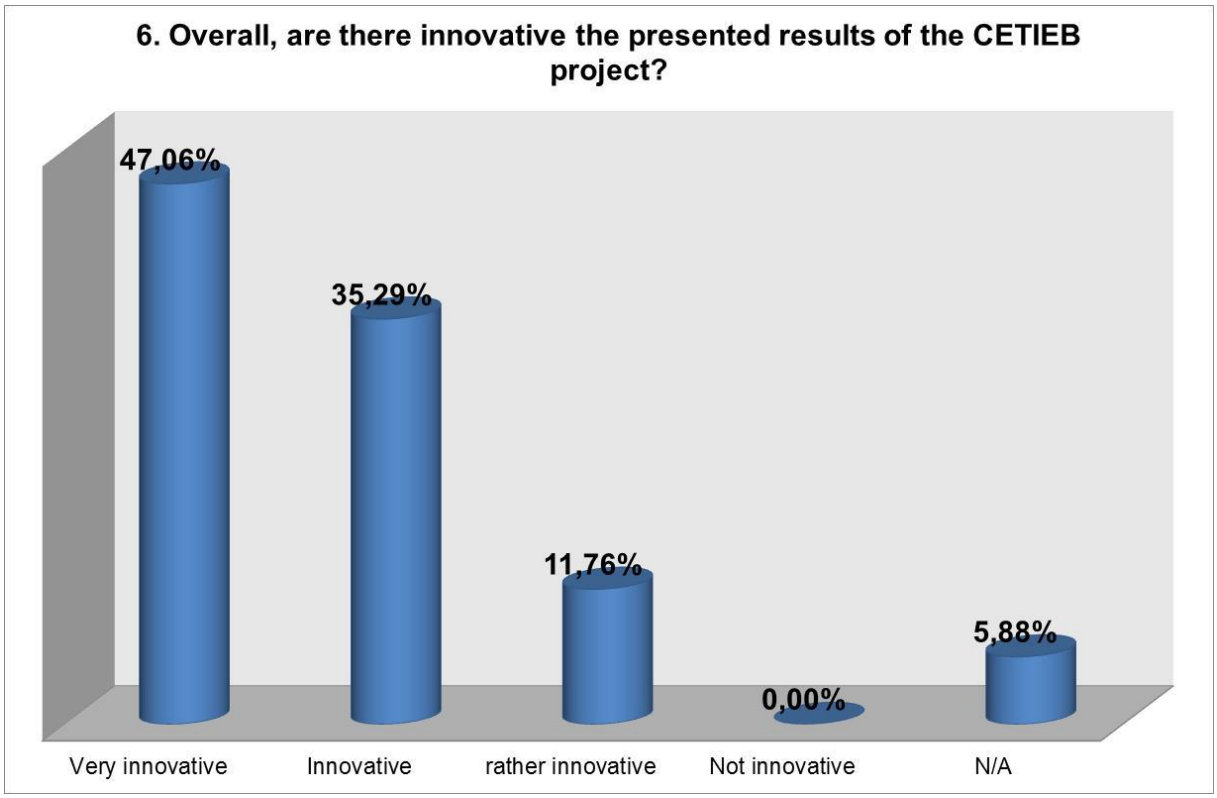
Most of the participants (**88,24%**) have considered, that the Training Workshop of CETIEB project was – Very useful or useful.



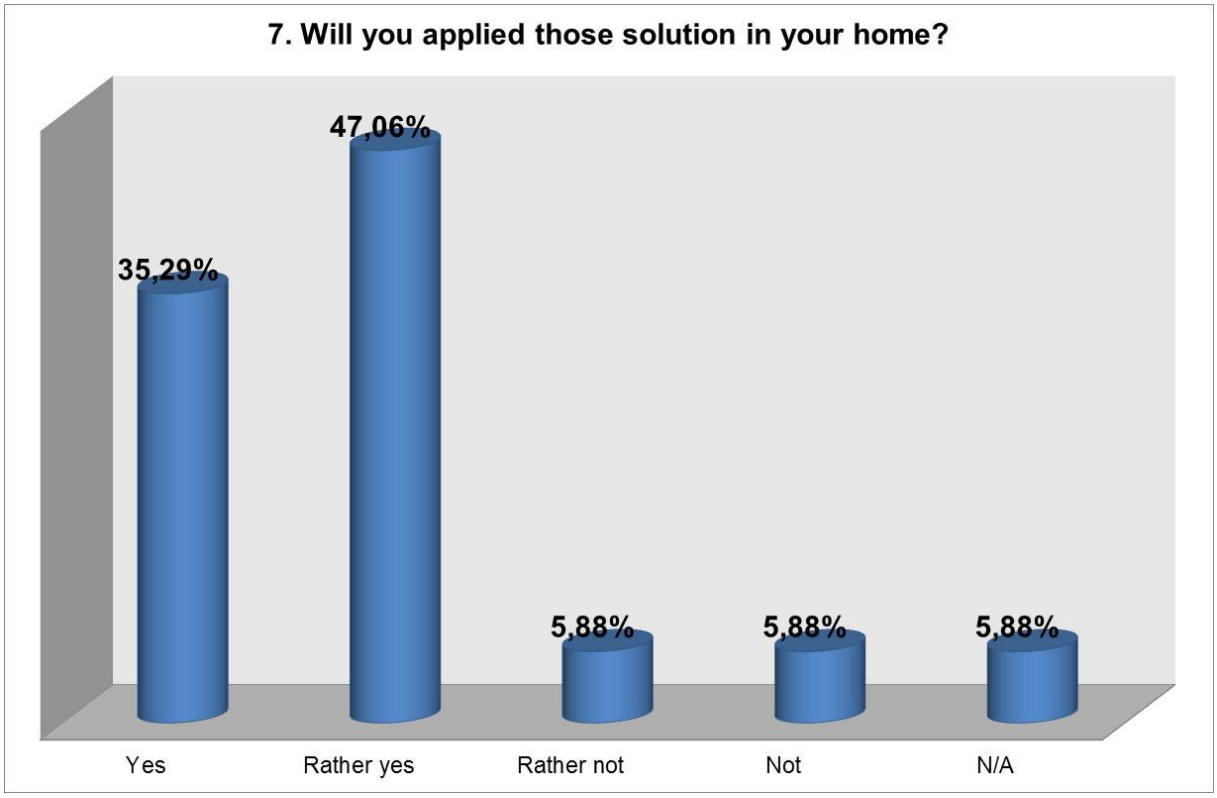
Most of the participants (**88,24%**) have considered, that the – Very much or sufficiently information have been presented on the Training Workshop of CETIEB project.



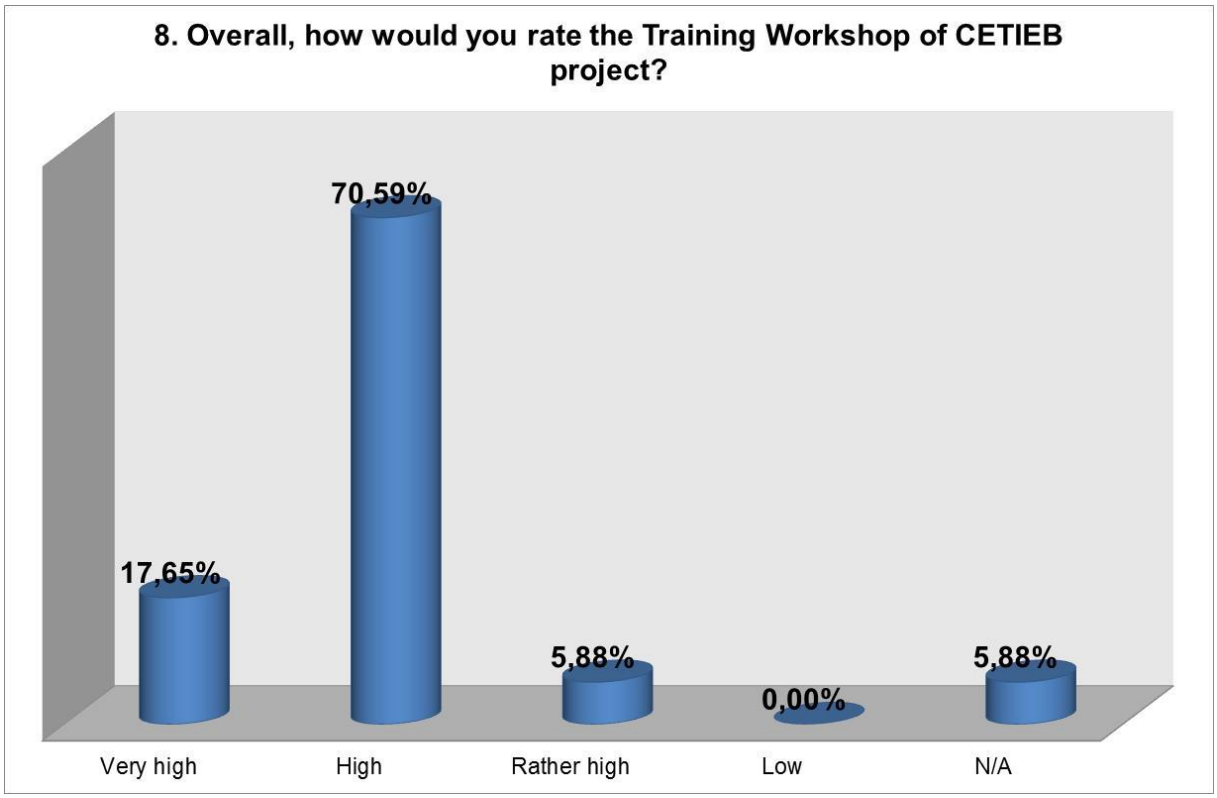
The participants have been almost equally interested in the topics of the CETIEB project, presented during Training Workshop.



Most of the participants (**82.35%**) have considered, that the presented results on Training Workshop of CETIEB project was – Very innovative or innovative.



Most of the participants (**82.35%**) have considered, that they – Apply or rather apply the developed solutions presented during the Training Workshop of CETIEB project.



Most of the participants (**88.24%**) have considered, that the rating of the Training Workshop of CETIEB project was – Very high or high.

Most of the participants (**82.35%**) have considered – Very likely or likely to recommend the Training Workshop of CETIEB project to a friend.

Recommendations from the participants:

- Another workshop activities should be organised focussing more on active and passive methods for indoor environment improvement;
- Organizers should provide support to participants to be involved more deeply in the CETIEB project;
- A series of workshops on the same topic should be organised for various groups of stakeholders, to encourage active participation in the trainings, by discussing the project issues.

5. Further training activities (Internships & thesis)

In the context of demonstration activities, Internships for selected students have been performed, focusing on the monitoring system, the passive materials and the Air Biofilter. The outcome of those activities is reported in the master Thesis/Talks of them, presented briefly below.

5.1 Internship of Tommaso Recanatini from UNIVPM

The work conducted by the MSc candidate Tommaso Recanatini within the CETIEB project has been performed at the MPA Institute of the University of Stuttgart (USTUTT, Germany) from 24/05/2013 to 31/10/2013 as cooperation between UNIVPM and USTUTT-MPA. The aim was to assess different sensors of the monitoring system. He finished his master thesis with title: "Experimental assessment of the performances of cost effective sensors for IAQ monitoring within the framework of the European project CETIEB" after the internship at the Department of Industrial Engineering and Mathematical Sciences (DIISM) of the Università Politecnica delle Marche.

The following introduction cited from the thesis describes the aim and the work performed:

"The present thesis is submitted to fulfil the requirements for the Master of Science in Mechanical Engineering at the Università Politecnica delle Marche (Ancona, Italy). The thesis accounts for the work conducted by the MSc candidate Tommaso Recanatini within the European project CETIEB at the MPA institute of the Universität Stuttgart (Stuttgart, Germany) and the Department of Industrial Engineering and Mathematical Sciences (DIISM) of the Università Politecnica delle Marche. Particular gratitude goes to Prof. Revel, Dr. Frick and their respective staff, for making this experience possible. The thesis starts with an introduction to the Indoor Environmental Quality and its main facets, i.e. the Indoor Air Quality (IAQ) and the thermal comfort. Then the experimental assessment and characterization of some cost effective measurement instruments is depicted. Firstly, different kinds of sensors for detecting the indoor CO2 concentration are compared: the amount of CO2 contained in the air strongly depends on the occupancy of enclosed spaces and is nowadays acknowledged as an effective indicator of the Indoor Air Quality. Accordingly CO2-based demand controlled ventilation (DCM) has become a rife practice for decreasing power consumption of HVAC systems [1][8]. At a later stage, the thesis traces out the characterization process of two similar air velocity sensors, as air velocity represents one of the physical parameters affecting the thermal comfort of the occupants. In particular the experimental investigation focused on some features of the sensors, such as their directional sensitivity in order to check out the accomplishment of the main standards on thermal comfort."

The outcome of the thesis was included in Deliverable 3.5 Laboratory tests with evaluation report for further sensor optimisation and finalisation.

[8] S.J.Emmerich and A.K.Persily. State-of-the-Art Review of CO2 Demand Controlled Ventilation Technology and Application. Tech. rep. National Institute of Standards and Technologies (NIST), 2001.

5.2 Internship of Dora Ya-Cie & Rongna Xiao-Rong from NTUST

The work was conducted by the two students Dora Ya-Cie and Rongna Xiao-Rong within the CETIEB project at the MPA Institute of Universitat Stuttgart (USTUTT-MPA, Germany) from 19/08/2013 to 06/09/2014.

They performed light intensity measurements with different light sources to validate the light sensors of the monitoring system (RGB-sensor, Global-Vis-Sensor and UV-Sensor), as well as they have given a talk about the development of the natural lighting system at NTUST.

The outcome of their performed work will be part of their thesis, later on.

5.3 Master thesis of Shuyang Song

The work conducted by the MSc candidate Shuyang Song within the CETIEB project has been performed at the IFK Institute of the University of Stuttgart (USTUTT-IFK, Germany) from 01/12/2012 to 31/07/2013. The aim was to assess the photocatalytic materials developed by the partners S&B and Schwenk. She finished her master thesis with title: “Measurement for Testing Indoor Air Cleaning Materials” at 31th July 2013.

The following abstract cited from the thesis describes the aim and work performed:

“The master thesis is under the EU project CETIEB. The purpose of this master thesis is to find a way to identify the indoor air pollutant reduction efficiencies of different coatings of the wall paintings. The indoor air pollutant will be reduced through photocatalytic oxidation. A parameter called “deposition velocity” will be developed and calculated. By this parameter it can easily compare different coatings’ reduction efficiencies.

A measurement system will be set up, which includes test gases, test box carrying test samples, measurement instruments and data acquisition system. Five kinds of gases will be tested as pollutants in the measurements. They are carbon dioxide, carbon monoxide, NO/NO2 and toluene. These gases are considered as the indoor pollutants. Some plates with different layers which mostly contain photocatalytic perlites and some powders with different percent of titanium dioxide will be measured in the test box for different light situation. The most effective reduction of the indoor air pollutant by the sample materials will be selected according to their deposition velocities.”

The outcome of the thesis was included in the Milestone reports: MS53 Report on properties of photocatalytic lightweight mortars and MS55 Description of experimental tools, and protocols and Deliverables D5.1 Photoactive plaster mortar and D5.3 Photoactive paints for indoor areas.

5.4 Final Year Dissertation of Mark Doyle

A cooperation between the partner DWE and Dublin Institute of Technology resulted in a final year dissertation of Mark Doyle within a BSc (Hons) Architectural Technology on the design of a plant based Air Biofilter (Submission date 9th May 2014). The title was: A Plant Based Mobile Air Biofiltration System: The Design, Construction & Testing of a Low Environmental Impact Prototype.

The following abstract cited from the thesis describes the aim and work performed:

“The aim of this research paper is to design, construct and test a plant based mobile air biofilter. The unit’s design and construction will be based on the use of materials and components of the lowest environmental impact possible.

The build-up of hazardous toxins known as volatile organic compounds (VOCs) within modern air tight buildings is detrimental to the health and welfare of building occupants and can contribute to poor indoor air quality leading to Sick Building Syndrome (SBS) and Building Related Illnesses (BRI). This paper will investigate the causes of poor indoor air quality and how they affect building occupants.

The use of a plant based mobile air biofilter was investigated to determine whether volatile organic compounds could be reduced or eliminated.

Plant based air biofiltration was researched and analysed. A mobile air biofilter prototype was designed and constructed in the Dublin Institute of Technology, Ireland. For the purpose of completing this report, this prototype will be called (PT No.1). The biofilter was based on an original design by "Nedlaw Living Walls", Canada. Upon completion of construction and testing of operation of PT No.1 in DIT, the biofilter was disassembled into two parts, packaged and transported to The University of Stuttgart, Germany. PT No.1 was reassembled, fully planted, switched on and left fully operational, where it was intended to be installed within a passivhaus school as part of a demonstration activity.

The unit was then transported (without being disassembled) to the National Institute of Solar Energy, France, where it was tested over a seven day period for Temperature, Relative Humidity, CO2 and reduction or removal of VOCs.

A second Prototype was designed based upon prototype one. This will be known as (PT No.2). PT No.2's design was based on improving PT No.1 through simplicity in manufacture and operation, combined with a reduction of materials and components with a high embodied energy. PT No.2 was not constructed or tested.

Results from testing of PT No.1 were inconclusive due to testing time frames and procedures. Although test results did indicate that given a larger time frame and more continuity in testing that plant based air biofilters have the potential to reduce TVOCs in air tight buildings."

6 Second workshop

Another dissemination and training activity will be performed during a German workshop on 30th September in Stuttgart. Translated title: "24th ALS-Colloquium in combination with the EU-Project CETIEB". The outcome of this workshop will be described in the 2nd periodic report. The presentations will be available for download on the CETIEB homepage.

7 Conclusions

In the first stage of the CETIEB project execution, on 12th of April 2013 the training workshop at ACEN (*Associazione Construttori Edili Napoli*) has been organized, attended by engineers and workers from private building industries and fellowship training students from the Universities in the Campania region of Italy. The workshop has been evaluated as successful. Generally, participant's evaluation confirmed that they were satisfied with the overall CETIEB project concept, as well as with each thematic area; especially on how the topic was presented and the information provided. In addition, most of the participants agreed that the topics treated were relevant to their interest; they share the opinion that more days were required for a deeper analysis and further discussions.

In the second stage of CETIEB project execution, individual student internship has been performed, focusing on detailed training. The outcomes of these activities is reflected in engineering thesis.

The thesis of Tommaso Recanatini has presented in comprehensive manner the State-of-the-Art of Indoor Environmental Quality (IEQ), and achievements of experimental assessment of the performances of cost effective sensors for Indoor Air Quality (IAQ).

The Internships of Dora Ya-Cie and Rongna Xiao-Rong have strengthened the cooperation with our non-EU partner NTUST.

The thesis of Shuyang Song has also resumed present status of knowledge, regarding to the Indoor Air Quality, and achievements of experimental measurements in terms of adsorption of indoor contaminants on the photocatalytic coatings.

The work of Mark Doyle has shown the design principles of Air Biofilters.

The second workshop will be described in MS82 and the outcome in the 2nd periodic report.