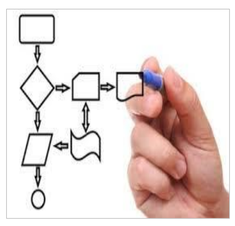
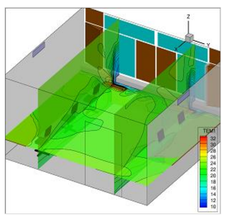
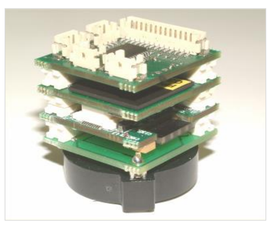
RESEARCH PORTFOLIO

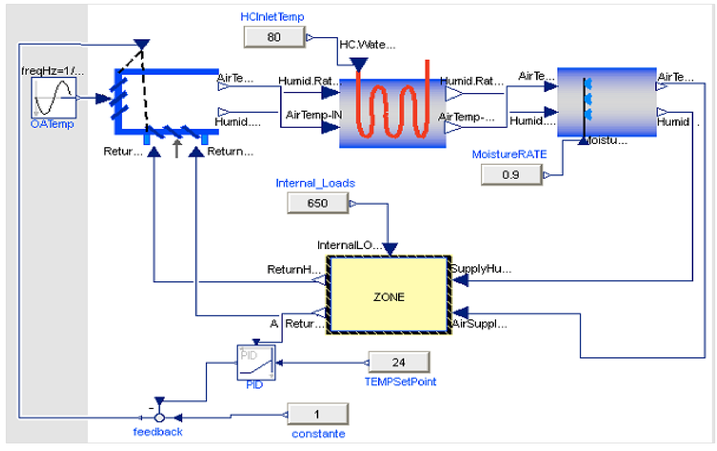
CAMPUS 21

Control and Automation Management for Buildings and Public Spaces in the 21st Century









BIM
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Energy
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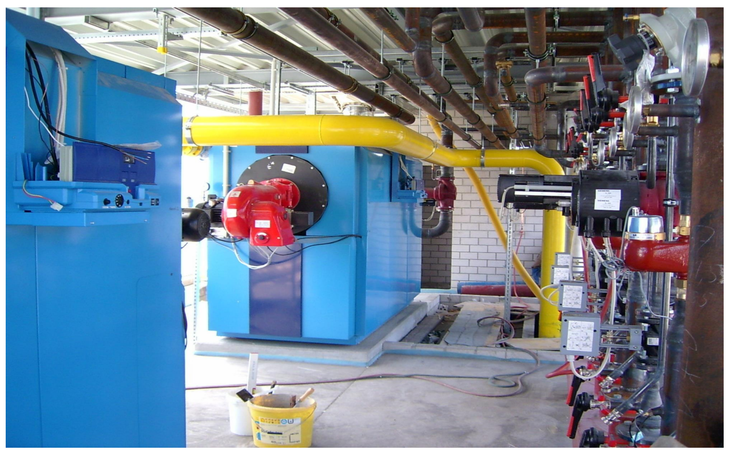
People

Smart
Buildings
and
Big Data



UCC School of Engineering
University College Cork, Ireland
Coláiste na hOllscoile Corcaigh

http://www.campus21-project.eu

PROJECT PARTNER

University College of Cork

University College Cork (UCC) is a member of the National University of Ireland (NUIC). UCC is Ireland 's leading research institute (3,000 employees, incl. more than 800 faculty). UCC is involved in the project through the Informatics Research Unit for Sustainable Engineering (IRUSE) and the Cork Constraint Computation Centre (4C).

IRUSE is a research unit at UCC and was one of the founding members of UCC's Environmental Research Institute (ERI). It is committed to research and development of Sustainable Built Infrastructure Systems and Technologies.
4C was established in 2001. The major research expertise of 4C lies in constraint programming and advances in artificial intelligence (AI) to make constraint programming easier to use.

HSG Zander

As a reliable partner of the real-estate industry, HSG Zander has been working in the entire spectrum of facility management for many years. Long-term experience, expertise and readiness for innovation of the group are available for all possible services. The company portfolio includes facility management activities, technical, infrastructural

and commercial FM – with integrated packages that combine all facility services, HSG Zander can offer the complete range of possible services.

HSG Zander does also successfully launch PFI- and contracting-projects and operates real estate portfolios for key account customers via operating companies - with the Commerzbank Arena as a typical example.

Technische Universität Wien

As a centre for advanced studies, the overall mission of the Department of Building Physics and Building Ecology, Vienna University of Technology (TU Wien) is to promote, develop,

and disseminate scientific and technical knowledge, methods, tools, and skills toward enhancing the sustainability and habitability of the built environment.

NEC Laboratories Europe

NEC Laboratories Europe (NLE) is the corporate research facility of NEC Europe Ltd, a wholly-owned subsidiary of NEC Corporation, a leading provider of telecommunication infrastructures, service platforms, service enablers, cloud platforms, and IT solutions. The laboratories are located in Heidelberg, Germany and Acton, UK.

Work focuses on software oriented research and development for the Future Internet. NLE has been a key partner in projects of the European Commission's Information and Communication Technologies Programme. The Department has a sustained and successful track record in conducting nationally and internationally funded research projects especially in the areas of building physics, building diagnostics, and building automation.

Fundación Cartif

Fundación CARTIF is a leading Spanish Applied Research Centre created in 1994. CARTIF is formed up by 9 technical divisions and 200 researchers specialised in several areas such as Energy, Environment, Food and Chemicals, Biomedical, Robotics, etc.

Moreover, CARTIF is the Spanish National Liaison Point of the European E2BA (Energy Efficient Buildings Association). Cartif works in close collaboration with the AYUNTAMIENTO DE VALLADOLID. CARTIF has expertise in measurement and verification of energy savings (IPMV by www.evo.org), ICT development and dissemination.

Electricity Supply Board (ESB)

ESB is the largest Electricity Utility in Ireland. It is vertically integrated with generation, distribution and retail. Its retail area is being expanded from electricity to include gas, energy efficiency and renewable offerings to customers. ESB is involved in exploring the potential of smart meter systems and electric vehicles.

It has more than 75 years experience of energy generation, supply and engineering expertise. ESB has many years experience of a variety of procurement, business and operational models and a thorough understanding of the practical impact of energy efficiency and renewable energy design in buildings, and the difficulty of balancing and integrating multiple technologies.

United Technologies Research Centre

UTC is the multi-national parent corporation of such companies as Carrier, UTC Fire & Security, Otis, Pratt & Whitney, etc. It has significant expertise in product offerings such as building management solutions, HVAC systems, fuel cells, gas turbine systems, combined heat and power systems, and on-site energy generation solutions.

UTRC-I is the recently established European leg of United Technologies Corporation's (UTC's) central research organization, the United Technologies Research Center (UTRC). UTRC has a proven track record of successfully partnering to develop new concepts and commercialise them through the UTC business units.

Royal BAM Group nv (bam)

Royal BAM Group nv is a successful European construction group and unites operating companies in five home markets with the administrative centre in the Netherlands and listed at Euronext Amsterdam.

BAM is active in the sectors of construction, property, civil engineering, public private partnerships, mechanical and electrical contracting, consultancy & engineering, and facilities management. The Group ranks among the largest companies in Europe.

Temperature Ltd (SIRUS)

Sirus Engineering Systems (SES) was established in 1988 to provide Building Control Solutions to clients. Sirus is UCC-NUIC's major subcontractor for HVAC maintenance including the control, operation, and energy management of approximately 50% of all Campus buildings.

SES works in partnership with Siemens Building Technologies, Honeywell, Cylon, and KIMO in the application of their systems in all types of building environments.

Through strategic mergers, Sirus Engineering Systems became the Irish agents for the largest controls companies in the world.

Ayuntamiento de Valladolid

The participation of the Valladolid Municipal Council is going to be carried out through its Energy Department (Agencia Energética Municipal de Valladolid – AEMVA). It is a managing and operation unit that works in the framework of the

council, whose main purpose is the optimisation and rationalization of the energy consumption and by extension of the public services offered by the Council. It was created in 1992 with the determination of treating the municipal energy optimization as a whole.

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PROJECT OVERVIEW

Objectives

Campus 21 addresses the need for integration strategies of ICT in building and neighbourhood energy management systems.

Campus 21 aims to achieve optimised and holistic operation of Energy-, Security-, Safety and other Facilities Services.

Campus 21 aims to optimise the energy usage and operational cost and to reduce the overall CO_2 emission of buildings and public spaces.

Campus 21 develops an integration strategy which addresses four key areas:

1. Technical Integration Strategy,
2. Integrated Business and Procurement Models,
3. A Holistic Validation Concept, and
4. An Integrated Standardisation Concept.

The following Scientific and Technological Objectives (STO) have been identified in order to achieve the objectives:

- STO 1: Creation of concepts for new Business Models
- STO 2: Development & Performance Evaluation of Buildings & Public Spaces
- STO 3: Development of an Integrated Energy Systems Management Concept
- STO 4: Development and Deployment of an ICT Service Platform for Energy Systems Management
- STO 5: Development of predictive systems control, and load balancing
- STO 6: Determination of a "Performance Baseline" and evaluation of "Advanced control tools
- STO 7: Development of a Procurement Schema and widespread dissemination
- STO 8: Development of a Standardisation Plan

Approach

The key technological innovations of CAMPUS 21 are:

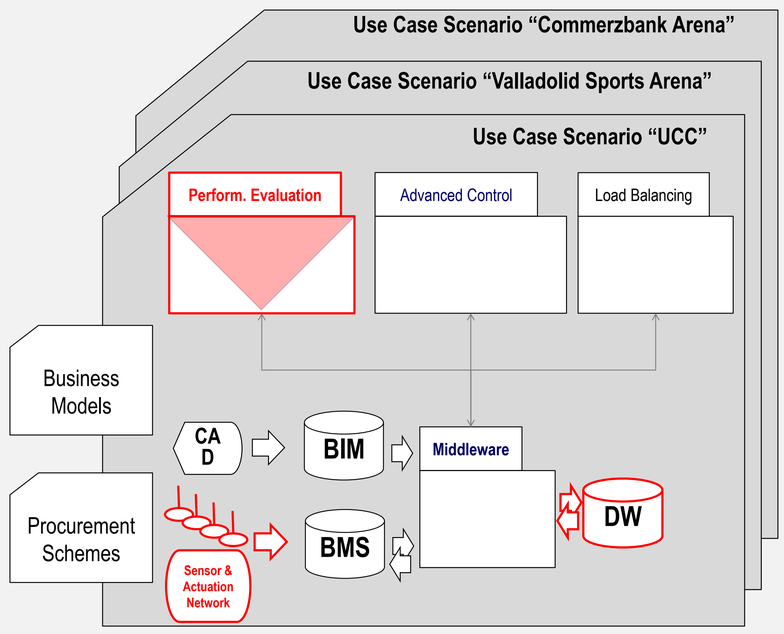
1. Integration concepts for energy management systems including the related middleware components,
2. Methodologies for intelligent, optimised control of building services systems,
3. Algorithms and tools to support load-balancing between renewable micro-generation, storage systems, and energy consuming devices in buildings and public spaces.

This is complemented by the development of key business elements, including:

1. New business models for integrated energy management and the underpinning novel procurements schemes.
2. Performance Metrics and a holistic Evaluation Concept for Systems Integration.

Work Packages

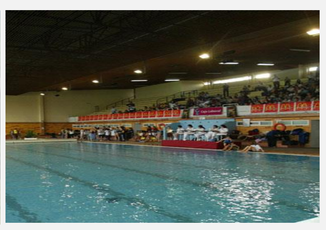
No.	WP Title
WP 1	Business Models and Procurement Schemes
WP 2	Evaluation and Monitoring Concept
WP 3	Use Cases & Guidelines for Integrated Energy Systems Management
WP 4	Integration Concept and Middleware Components
WP 5	Algorithms & Tools for Control of Micro Generation and Energy Storage Components
WP 6	Load Balancing for BMS and Local Energy Distribution Grids
WP 7	Dissemination and Standardisation



Demonstration Sites







Campus University College Cork (incl. District Heating), Ireland Commerzbank Arena, Germany Sports Complex, Spain

Partner

University College of Cork
http://www.ucc.ie

Electricity Supply Board (ESB)
http://www.esb.ie

HSG Zander
http://www.hsgzander.com

United Technologies Research Centre, Ireland
http://www.utrc.utc.com

Technische Universität Wien
http://www.tuwien.ac.at

Royal BAM Group nv (BAM)
http://www.bam.eu

NEC Laboratories Europe
http://www.neclab.eu

Temperature Ltd (SIRUS)
http://www.sirus.ie

Fundación Cartif
http://www.cartif.es

Ayuntamiento de Valladolid
http://www.valladolid.es

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MONITORING and EVALUATION CONCEPT

Objectives

This research focuses on the development of concepts for monitoring and validation of building performance. The emphasis is on instruments to produce the evidence for energy savings and reduced total cost of operation. Work includes:

1. The definition of information and subsequent **evaluation requirements** for building performance evaluation.
2. The development of a **modular, hierarchical, block based monitoring concept** including a corresponding data acquisition schema.
3. The development of a Performance Evaluation Metrics which supports the integrated, holistic analysis of performance criteria.

Approach

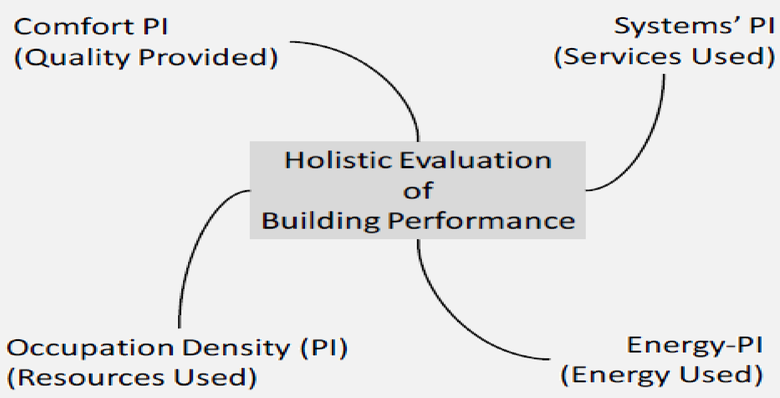

Figure 1: Evaluation Criteria

WHAT to evaluate?

COMFORT PERFORMANCE INDICATORS (PI)
This set of PI ensures that buildings are operated in compliance with technical or legislative requirements for

OPERATIONS PERFORMANCE INDICATORS (PI)
This set of PI ensures that all building services are operated in an integrated way.

ENERGY PERFORMANCE INDICATORS (PI)
This set of PI ensures that the energy consumption of systems is monitored and optimised.

USE EFFICIENCY PERFORMANCE INDICATORS (PI)
This set of PI ensures that spaces are neither 'under utilised' (i.e. booked and not used) or 'over utilised.

WHERE to monitor?

The monitoring concept supports building opera-tors to determine required points and components to be monitored.

BLOCK BASED concept

This means a 'group' of components delivering a specific functionality is always considered.

HIERARCHICAL concept

This means users are supported to identify links between monitoring and actuation.

MODULAR concept

This means different sub-systems can be integrated on different 'spatial zone levels'.

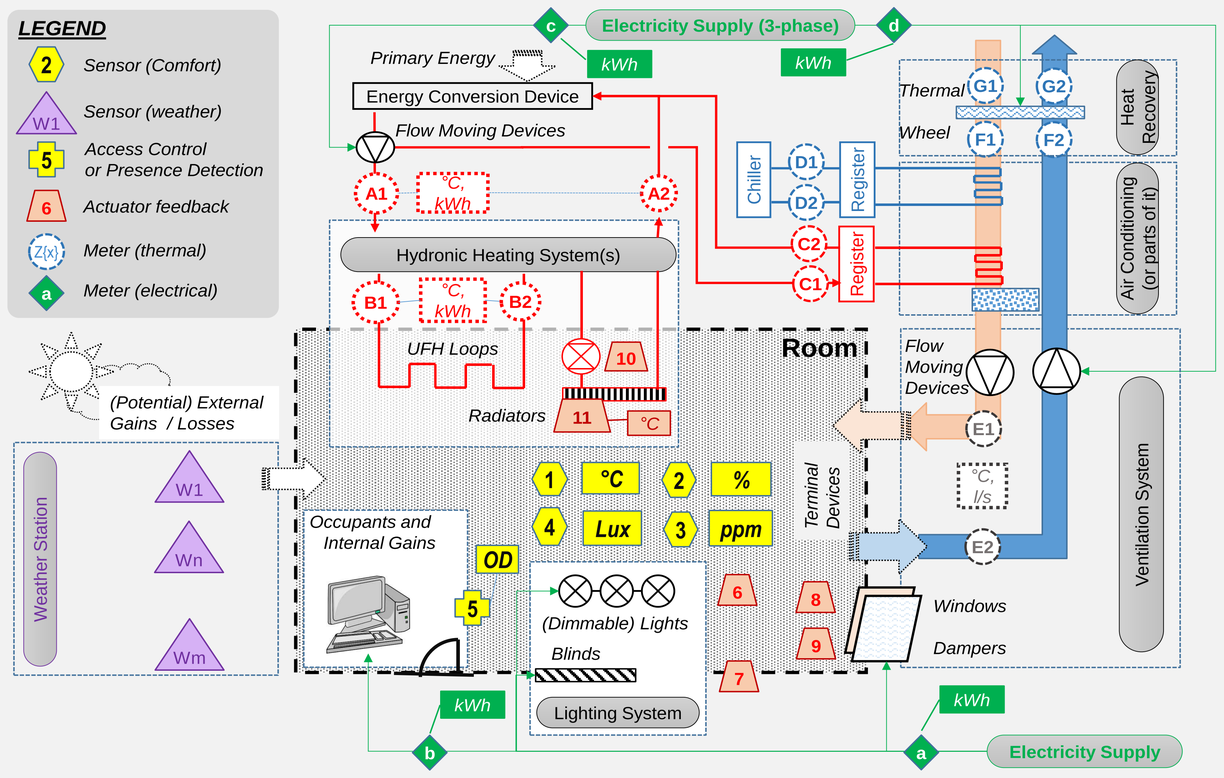

Figure 2: Block-base, hierarchical, modular monitoring concept

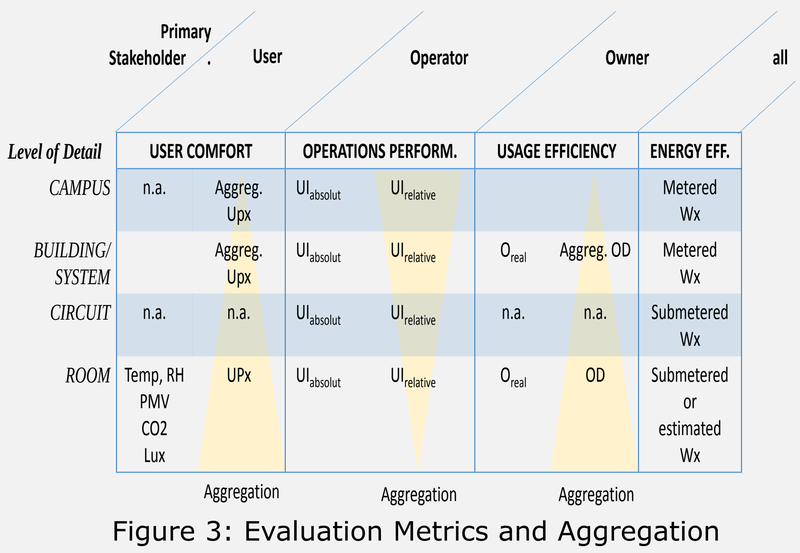

Figure 3: Evaluation Metrics and Aggregation

AGGREGATION:
Since all relative values are available on a scale from 0 to 100% PI can be aggregated into KPI

HOW to evaluate?

UNDER PERFORMANCE (UP) Performance Indicators:
UP-PI are measured on space and floor level and determine user comfort. Absolute values are converted into relative values (0 to 100%).

USE INTENSITY (UI) Indicators:
UI-PI are measured on component or (sub)system level and are used to characterise the operations performance. Absolute values are converted into "relative ranges" (i.e. 70% < high UI <= 100 %).

USE EFFICIENCY (OD) Indicators:
OD-PI are compiled fr, access-control systems. Absolute head-counts are compared to the maximum occupation density for a space (0 to 100%).

ENERGY CONSUMPTION Indicators:
Absolute values are compiled from (sub)meters. A conversion into relative values is possible by comparison against an agreed "baseline", e.g. the normalised, metered energy consumption before a retrofit.

Contact

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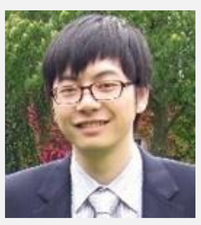

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OCCUPANCY MONITORING USING RFID TECHNOLOGY

Objectives

A challenge in accommodating efficient energy usage in buildings is how to service building spaces with optimum energy while the relevant spaces experience varied levels of occupancy.

Normally building spaces are serviced with a standard level of heating, ventilation and air conditioning throughout normal business hours. This creates the scenario where there is needless usage of energy when building spaces are unoccupied.

By using the real-time occupancy data captured from the monitoring system, better building control algorithms can be provided to specify the necessity to supply a relevant building space with constant levels of building services (lighting, heating, ventilation, and air conditioning).

Radio Frequency Identification (RFID) is one method of analyzing occupancy activities in buildings.

This research transferred the experience gained from an experimental set-up of a RFID gate demonstrator deployed in the IRUSE-Labs to four room control systems in the Civil & Environmental Engineering (CEE) building in UCC. Installations were combined with a commercial room access control system, to provide a comparison of monitored results.

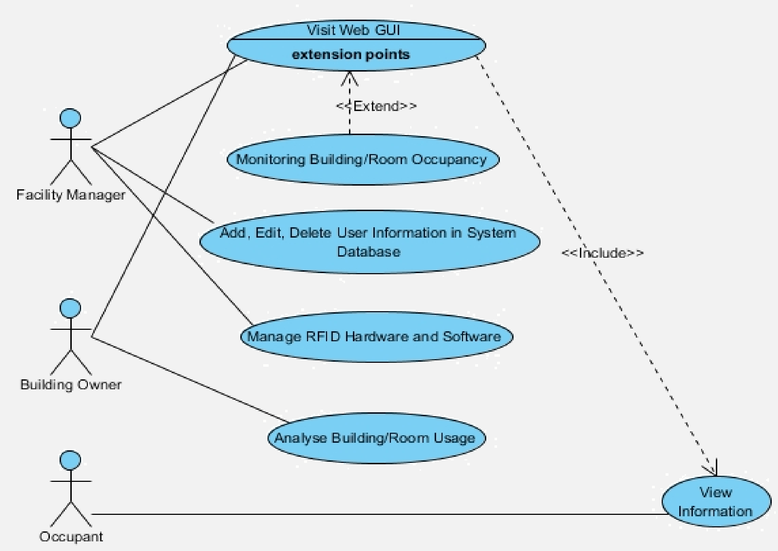

Figure 1: Use Case Diagram

The Use Case Diagram technique (see **Figure 1**) was used to identify main users of the system, which includes the building owner, facility manager and occupants. All of these users should be able to visit the client-side web GUI (Graphical User Interface). For all occupants, they should be able to view their information such as personal profile, RFID tag tracking record etc.

Approach

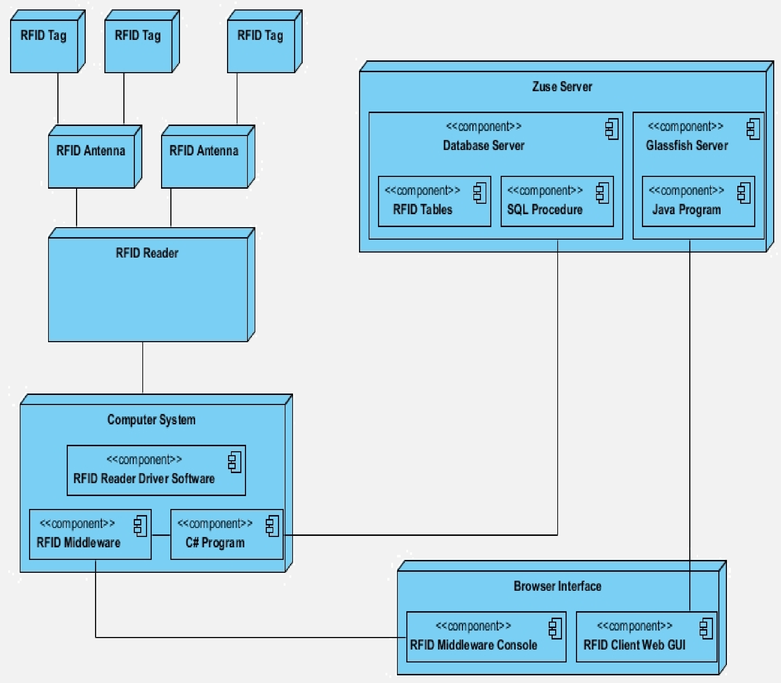

Figure 2: RFID System Deployment Diagram

Figure 2 (left) provides a UML-Deployment Diagram for the installed RFID gate reader system.

A Computer System is used to compile readings from different gate readers. It comprises of the RFID Reader Driver Software, the RFID Middleware, and C# Programs.

The RFID middleware allows users to configure, deploy, and send commands directly to readers through a common interface. Additionally, it can be used for checking for errors and duplicated values.

The C# Program element can be customised to adjust the RFID gate reader system to specific use cases and different database systems.

Data is stored on a database server abd can be accessed through web interfaces (Glassfish Server).

Figure 4 (below) provides an example for calculated values to determine the occupation density using both the RFID and the commercial access control system (TDS).

The first column is the timestamp calculated on a hourly basis. The second column displays the number of readings compiled from the TDS system. The third column displays the number of readings compiled from the RFID system.

TIMESTAMP	TDS_READS	RFID_READS
19-FEB-13 21	8	8
19-FEB-13 20	9	7
19-FEB-13 19	8	7
19-FEB-13 18	10	11
19-FEB-13 17	18	12
19-FEB-13 16	22	13
19-FEB-13 15	30	23
19-FEB-13 14	20	10
19-FEB-13 13	35	23
19-FEB-13 12	29	39
19-FEB-13 11	28	28
19-FEB-13 10	20	15
19-FEB-13 09	5	7
19-FEB-13 08	7	7

Figure 4: Calculated result for RFID and TDS System

Figure 3: Installation at CEE 1.09 Computer Lab

Figure 3 (above) is a picture of RFID gateway antennas and TDS access control system deployed in Room CEE 1.09 – a Computer Lab with 42 seats.

This room, another computer lab and the drawing office are equipped with a heat re-distribution system, using the computer labs as "energy source" (excess heat) and the drawing office as "sink" (north-east facing with 5.00m ceiling height).

For the installation and implementation an Alien RFID system was used, comprising of: Alien ALR-9900+ EMA readers and ALR-8696-C antennas operating at the European frequency band of 866MHz.

Contact

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STRATEGIES FOR CONTINUOUS COMMISSIONING OF INTELLIGENT BUILDINGS

Objectives

Continuous building monitoring techniques are used to provide the best possible level of detail for the analysis of building energy performance.

Maintaining Building Management Systems (BMS) can require significant efforts for the building management team. The performance of a BMS can be substantially reduced due to improper/incompatible equipment installation, degradation and failures, or even inappropriate settings of operational sequences.

This research aims:

- to develop algorithms for continuous monitoring outside of the trademarked CC® description, cf. fig. 1;
- to develop identification methods for faulty operation scenarios in building services system through data analysis;
- to establish an understanding of the relationship between sensor density, sensing accuracy for single physical parameters at a spatial and temporal level;
- to outline potential energy savings resulting from Continuous Commissioning.

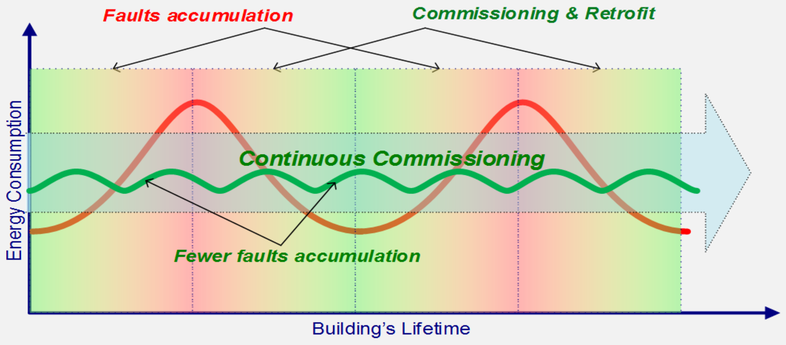

Figure 1: "Ad hoc" VS "Continual Commissioning"

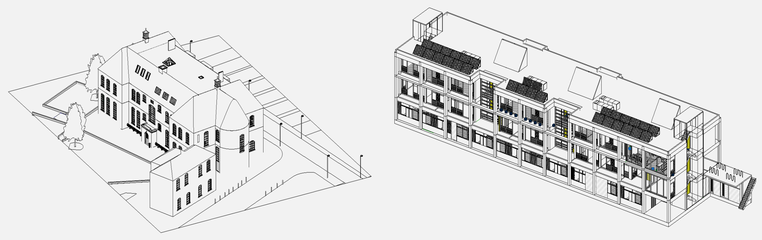

Figure 2: ERI and CEE buildings used as case study

Approach

Continuous commissioning is an ongoing process used for performance analysis, BMS optimisation, and energy benchmarking. It includes the analysis of BMS alarms and information about missing data or interrupted monitoring streams.

Figure 3 represents the data-related steps of ongoing BMS commissioning.

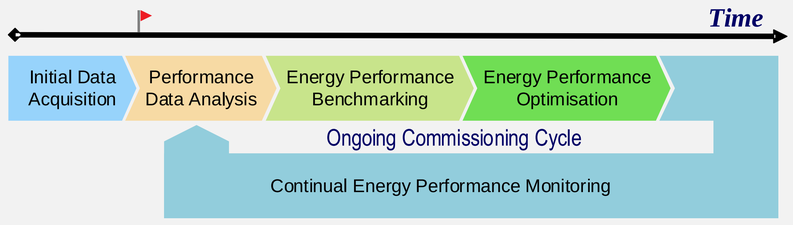

Figure 3: Data-related steps for CC of BMS

Building performance benchmarking requires the development of Key Performance Indicators (KPIs), which also can be called Energy Performance Indicators (EnPI). Additionally, reliable methodologies and techniques for raw data analysis are required (cf. fig. 4).

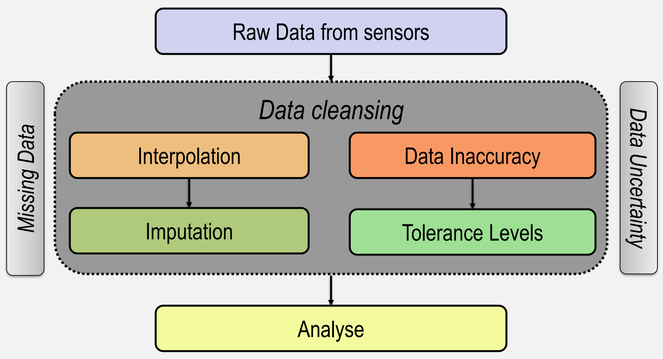

Figure 4: Data Value Generation Techniques

Closely and continually working with incoming data will:

- provide energy managers with information about the current status of systems' operations,
- Lead to knowledge how to adjust these systems,
- Provide maintenance costs savings.

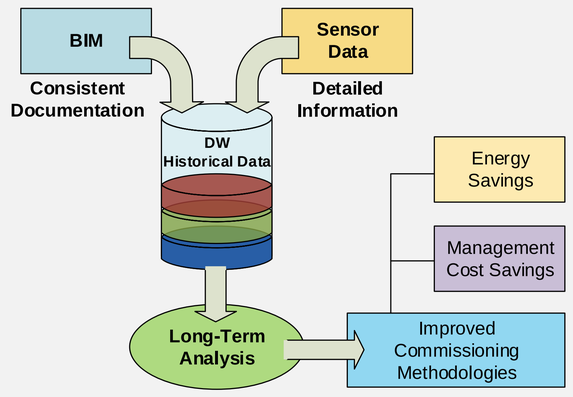

Figure 5: Continual Commissioning strategies

Achievements

Displayed (cf. fig 6 right) are the 2012 temperature data trends used for the analysis of thermal comfort (gathered from integrated wireless sensors in CEE building). The 'comfort band' is depicted in green.

Figure 7 (below) highlights the identified in-appropriate use of BMS scheduling for the preparation of Domestic Hot Water (DHW) in the ERI building. Since the gas boiler is used in the mornings to prepare DHW (blue line) the solar gains are insufficiently used for DHW generation (red line)

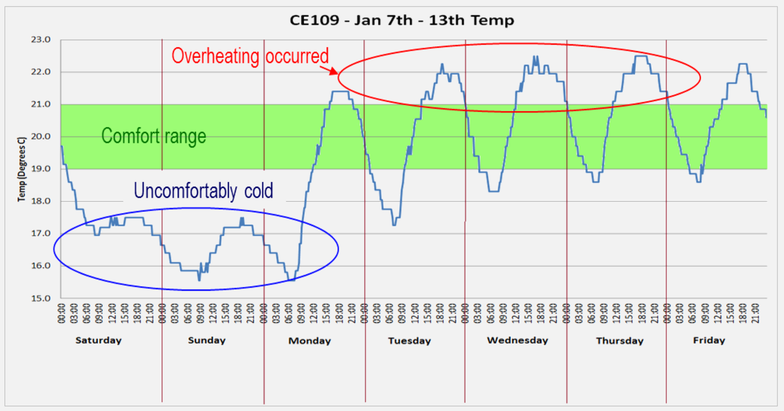

Figure 6: Example for thermal comfort analysis

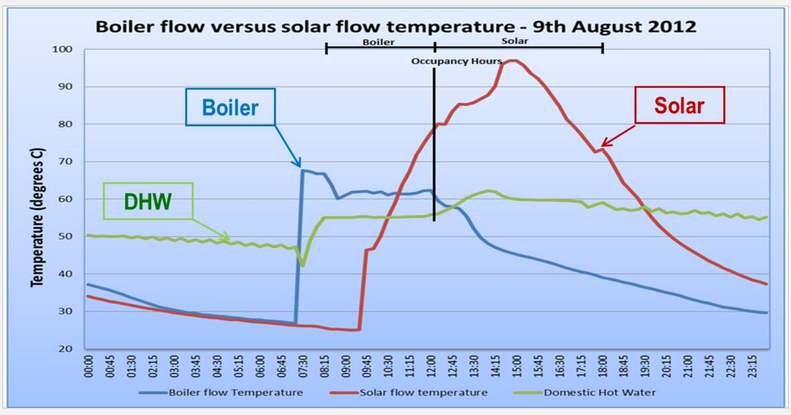

Figure 7: Example f. in-apropriate use of BMS scheduling

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