Network for Using BIM to Increase Energy Performance

HORIZON2020 project

Empirical study of BIM-based building life cycle: case of Net-UBIEP project

Tatjana Vilutienė, Arvydas Kiaulakis

Vilnius Gediminas Technical University

29th European Conference on Operational Research – EURO 2018
Valencia, 8-11 July 2018

Co-funded by the Intelligent Energy Europe
Program of the European Union

Introduction

The building sector is the largest consumer of energy in Europe, accounting for nearly 40% of the total consumption (EPBD 2010/31/EU). 2030 European Energy [COM(2014)16Final] and Energy Roadmap 2050 [COM(2011) 885 final], strongly requires more focus on the energy efficiency on housing sector. The Directive 2014/24/EU on public procurement, requires that all member states introduce electronic means to exchange information and communication in procurement procedures. The integrated approach of the Net-UBIEP project, based on BIM, integrated with energy performance requirements, will be key to solve all the problems in a more effective and efficient manner. The project proposes BIM Qualification Models integrated with energy competences, to widespread a better comprehension of energy issues along all the value chain of building industry so that both existing and new building will have better energy performances.

Article presents the process of identification of specific energy BIM competences for each target group needed to implement BIM models during the whole building life cycle. Data for analysis was gathered by use of direct and indirect observation and experiences of construction sector experts. During the project the integrated BIM Qualification Models will be validated by stakeholders and proposed for standardization to find a broader acceptance at European and international level through regulatory organizations (CEN/ISO).

Net-UBIEP partners

- ENEA - Italy
- CSA - Italy
- FCE - Croatia
- UZ - Croatia
- ViaEU - Slovakia
- UVS - Slovakia
- FLC - Spain
- CSIC - Spain
- VGTU - Lithuania
- Dig.Con. - Lithuania
- ISSO - Netherlands
- B&R - Netherlands
- EGLC - Estonia
- TUT - Estonia

Net-UBIEP partners

1 ENEA - Coordinator - (Italy)

2 CS Group (Italy)

3 Via Europa Competence Centre (Slovakia)

4 UVS Institute for Adult Education and Services (Slovakia)

5 Fundacion Laboral de la Constructiòn (Spain)

6 Spanish National Research Council (Spain)

7 VsJ "Skaitmeninė statyba" (Lithuania)

8 Vilnius Gediminas Technical University (Lithuania)

9 University of Zagreb – Faculty of Civil Engineering (Croatia)

10 Elips Jadran d.o.o.(Croatia)

11 ISSO Dutch Knowledge Institute for the buildings and building sector (Nertherlands)

12 Balance and Result (Neetherlands)

13 Tallin University of Technology (Estonia)

14 EGLC - Mittetulunudusühing Eesti Timmitud Ehituse Tugirühm (Estonia)

Net-Ubiep aims

1. **To increase** energy performance of buildings by stimulating and increasing the use of BIM during the life cycle of a building.

2. **To learn** how to use simulation to find the best solutions on different materials and components.

3. **To use** BIM to decrease the environmental impact throughout the construction, management, maintenance, refurbishment and eventually the demolishment of a building.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Net UBIEP: technologies and people

- To properly introduce BIM for energy performance evaluations, all professionals and technicians which participate in the building process must be aware of their role of collecting, managing and storing all required information.

- Each technician, public officer, designer, constructor, facility manager, supplier, etc, should understand which information they manage could potentially be used by any other actor.

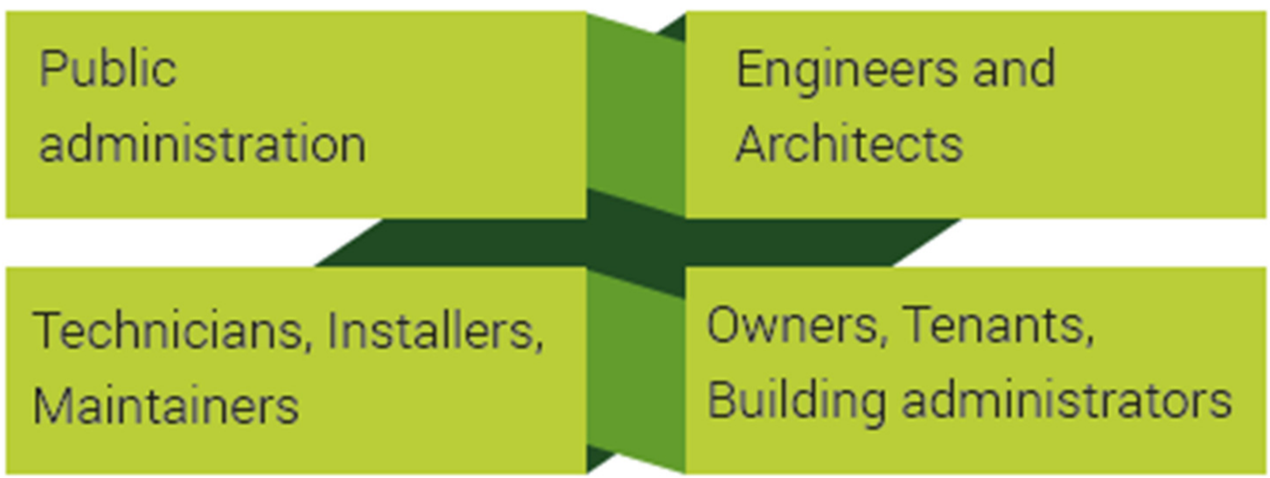
- it is important that all the different actors use the same language, dictionaries and data structures.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Net-UBIEP target groups

Four target groups have been selected according to their role in current building processes,

- Public Administrations,
- Professionals (Engineers/Architects),
- Technicians (Installers/Maintainers),
- Tenants/Owners/Building Administrator



Co-funded by the Intelligent Energy Europe Program of the European Union

Net UBIEP tools

- Three dimensional matrix with the following descriptors:
  - Competences
  - Target groups
  - Phases of the building life cycle.
- BIM Training schemes for the different target groups in each of the seven participating countries.

Co-funded by the Intelligent Energy Europe
Program of the European Union

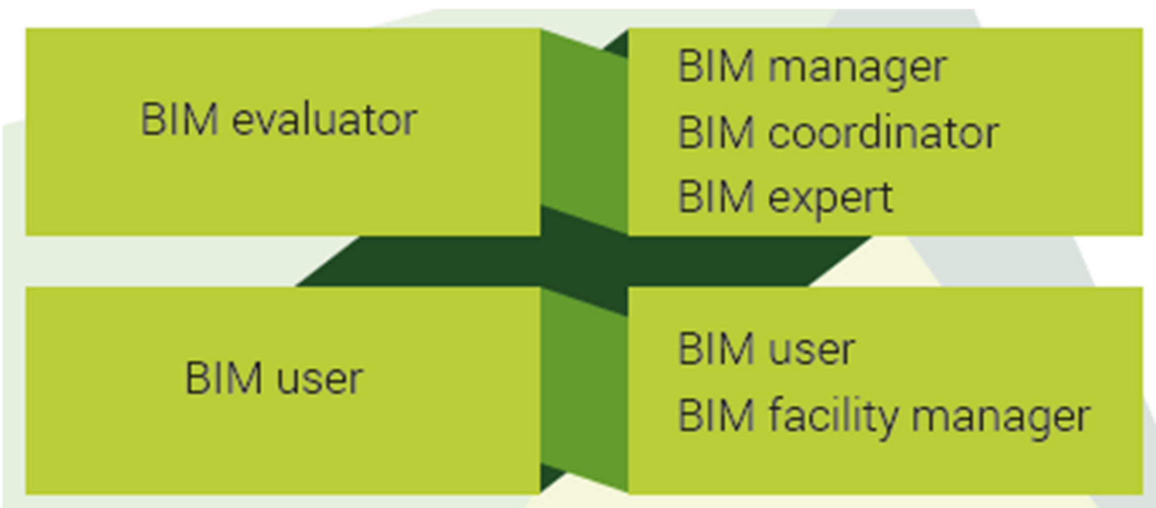
BIM qualification models

- Seminars on BIM implementation strategies
- Classroom courses on energy performance implementation in BIM
- E-learning courses on the use of BIM in the life-time of the building
- Seminars on improved energy performance and plant management using BIM

Co-funded by the Intelligent Energy Europe
Program of the European Union

Net-UBIEP output

- Qualification Models to overcome the gap of energy performance competences in existing building professions. Each BIM Qualification Model will be composed of:
  - BIM Training Scheme
  - BIM Qualification and/or Certification Scheme.
- Development of at least six professional profiles:



Co-funded by the Intelligent Energy Europe Program of the European Union

Why action needed?

- The building sector is the largest consumer of energy in Europe, accounting for nearly 40% of the total consumption (EPBD 2010/31/EU).
- 2030 European Energy [COM(2014)16Final] and Energy Roadmap 2050 [COM(2011) 885 final], strongly requires more focus on the energy efficiency on housing sector.
- The Directive 2014/24/EU on public procurement, requires that all member states introduce electronic means to exchange information and communication in procurement procedures.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Expected results

- To propose the BIM Qualification Models integrated with energy competences, to widespread a better comprehension of energy issues along all the value chain of building industry so that both existing and new building will have better energy performances.
- During the project, the “integrated” BIM Qualification Models will be validated by stakeholders and proposed for standardization to find a broader acceptance at European and international level through regulatory organizations (CEN/ISO).
- The integrated approach of the Net-UBIEP project, based on BIM, integrated with energy performance requirements, will be key to solve all the problems in a more effective and efficient manner.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Methods

Step 1. Identification of target groups

↓

Step 2. Analysis of existing practice and used approaches
Literature review

↓

Step 3. Interviewing of experts and focus groups
Identification of knowledge gaps, prioritization of BIM use cases, mapping of BIM use cases, definition of competence levels

↓

Step 4. Analysis of experience from other projects
Classification systems, mapping of technologies and interdisciplinary competences, structuring of competences

↓

Step 5. Decision tree model
Identification and structuring of competences

↓

Step 6. 3D matrix for mapping competences
Agreed levels of competences mapped by target groups and BIM roles

Co-funded by the Intelligent Energy Europe
Program of the European Union

Methods

- Target groups, or stakeholders, structured and mapped using influence-interest matrix.
- To define the competences and learning outcomes, different data for analysis was gathered by use of direct and indirect observations, interviewing of construction sector experts, and analysis of experience of other related projects.
- Decision tree model was used to structure of specific energy BIM competences for each target group.
- 3D matrix used for mapping of competences.

Presented approach illustrates the process of identification of specific energy BIM competences for each target group needed to implement BIM models during the whole building life cycle.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Mapping of target groups

- Interest groups, or stakeholders, who participate in building life-cycle processes, have different influence on processes. Figure 1 depicts the main key stakeholders on different level participating in building life-cycle processes.

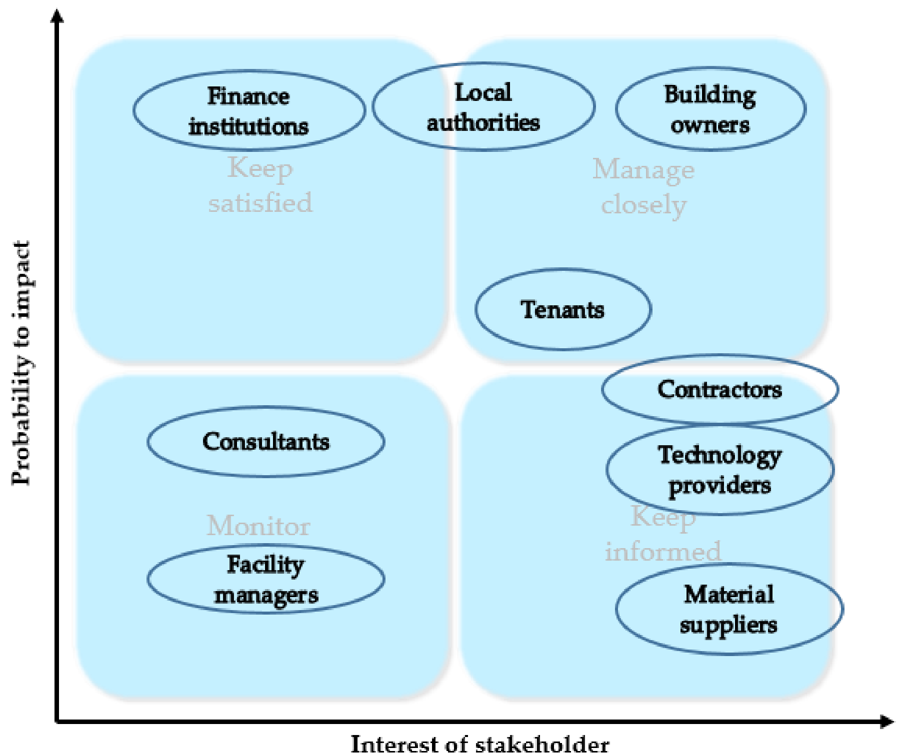


Figure 1. Mapping of key stakeholders.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Mapping of target groups

The research of Risholtn and Berker [12] revealed that private building owners are a key group to increase the building energy efficiency rates. The analysis of the effect of domestic occupancy profiles on the energy performance revealed that type and size of household have influence on the energy demand [11]. Building owners if are conscious consumers or have knowledge succeed in saving energy, therefore relevant and reliable advice is crucial and can get homeowners to realize energy savings.

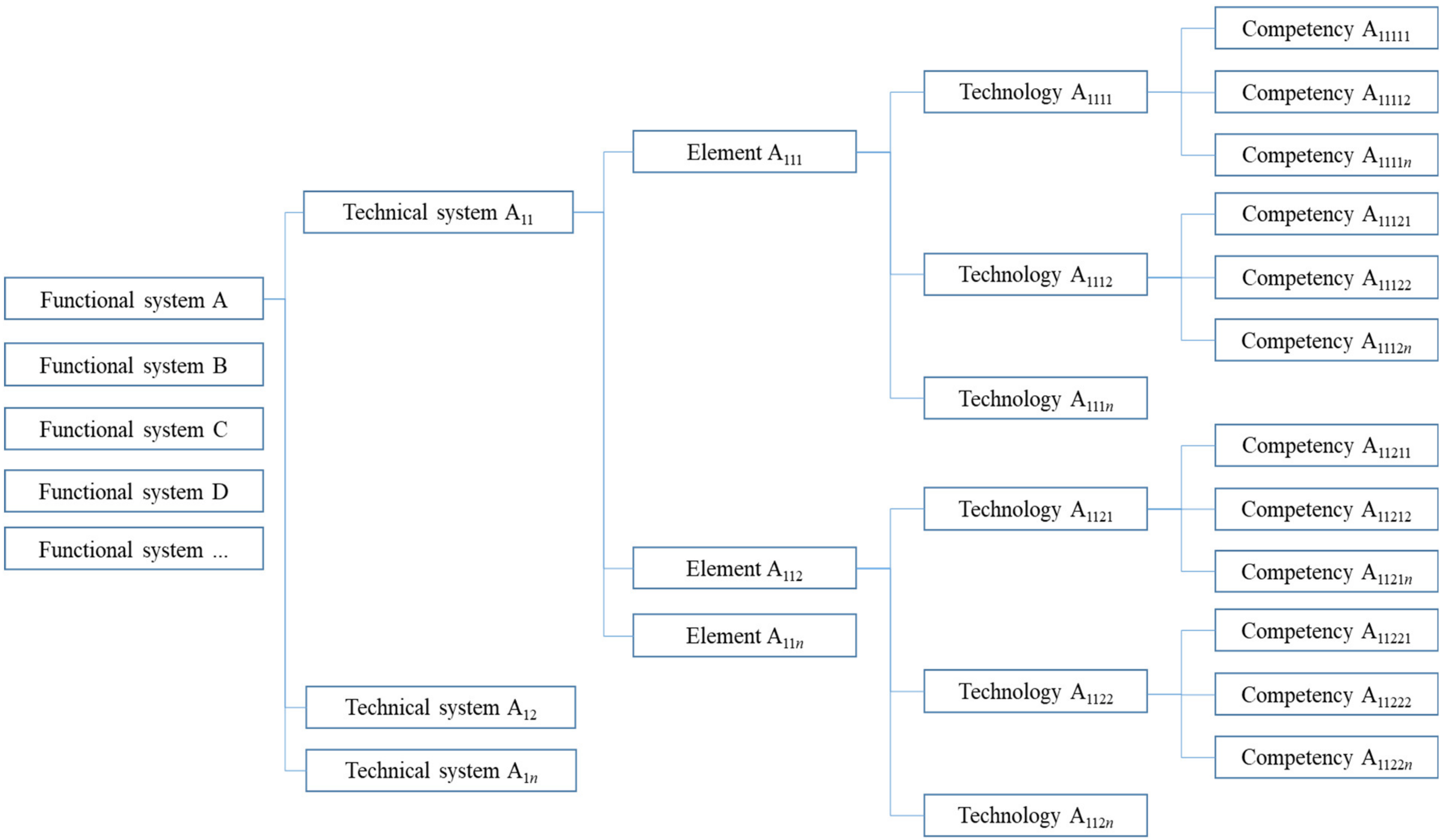
Co-funded by the Intelligent Energy Europe
Program of the European Union

Definition of priority BIM use cases

BIM Use Cases	Priorities							
	LT	IT	NL	ES	EE	HR	SK	Agreed priorities
1 **Economic / quantity take off and cost calculations**	1							
2 **Development of current conditions model**	1							
3 **Planning project stages**	x							
4 **Land plot analysis**	1							
5 **Functional, volumetric and planing layouts development (S2)**	1							
6 **Project visualization and reviews**	1							
7 **Design / Modeling (S3-S4)**	1							
8 **Engineering calculations and analysis**	x							
9 **Energy analysis**	1							
10 Sustainability Assessment	2							
11 **Structural analysis and design**	x							
12 Lighting Analysis	2							
13 **Analysis of engineering systems**	1							
14 Other cases of analysis								
15 Conformity assessment / project expertise	1							
16 3D coordination	1							
17 **Planning a building site (building site plan)**	1							
18 Health and safety planning	2							
19 Structural-technological analysis	x							
20 Construction Technologies (Technological Schemes) and simulation of the installation process	2							

Co-funded by the Intelligent Energy Europe
Program of the European Union

The structure of the decision tree model



Co-funded by the Intelligent Energy Europe
Program of the European Union

The structure of the decision tree model

The extract from the decision tree model

Model tree levels				Competences		
Level 1	Level 2	Level 3	Level 4	Reference to PROF / TRAC D2.3 structure		
Functional systems	Technical systems	Element	Technology	Code	Name	Technology groups
Ground system						
	AB Foundation construction					
		? *Insulation element*				
			? *Insulation technology*	ER1	Insulation (floor, wall, roof, thermal bridges)	Energy Reduction of constr.
				ER2	Air tightness building	Energy Reduction of constr.
		BB Foundation structure				
	AC Slab construction					
		BC Slab structure				
		BG Ceiling structure				
		BF Floor structure				
Wall system						
	AD Wall construction					
		? *Insulation and façade finishing*				
			? *Ventilated facades installation*	ER1	Insulation (floor, wall, roof, thermal bridges)	Energy Reduction of constr.
				ER4	Envelope systems	Energy Reduction of constr.
				ER2	Air tightness building	Energy Reduction of constr.
			? *ETIC fasades installation*	ER1	Insulation (floor, wall, roof, thermal bridges)	Energy Reduction of constr.
				ER4	Envelope systems	Energy Reduction of constr.
				ER2	Air tightness building	Energy Reduction of constr.
		BD Wall structure				
		QQA Windows				
			QQAn Windows installation	ER4	Envelope systems	Energy Reduction of constr.

Co-funded by the Intelligent Energy Europe
Program of the European Union

Mapping of technologies and interdisciplinary competences

ER	ENERGY REDUCTION
ER1	Insulation
ER2	Air tightness building
ER3	Micro climates
ER4	Envelope systems
ER5	Hot water systems
ER6	Window and/or glazing systems
ER7	Heating and cooling emission systems
ER8	Electric heating systems
ER9	Artificial lighting systems
ER10	Ventilation systems

EP	ENERGY PRODUCTION (on-site and nearby renewable energy production and off-site renewable energy)
EP0	Heating and Cooling GENERAL
EP1	Geothermal energy systems
EP2	Biomass energy production
EP3	Biogas energy production
EP4	District heating and cooling
EP5	Planning and design of heat pump installations
EP6	Solar power systems for electricity generation
EP7	Solar absorption cooling
EP8	Solar thermal energy systems for domestic hot water and/or heating generation
EP9	Mini wind power generation
EP10	Combined Heat and Power (CHP) generation

IS	INTERDISCIPLINARY competencies
IS1	Communication
IS2	Information management
IS3	Collaboration
IS4	Quality assurance
IS10	Economics
IS11	Procurement

IS	SUSTAINABLE INTEGRATED DESIGN
IS5	Sustainable architectural design
IS6	Integrated design
IS7	Sustainable building materials
IS8	Sustainable installation materials
IS9	Environmental (indoor) quality

Co-funded by the Intelligent Energy Europe
Program of the European Union

Mapping of BIM use cases with competences

BIM Use Cases with D 2.3. Mapping with PROF / TRAC	Competences										
	IS5	IS6	IS7	IS8	IS9	IS1	IS2	IS3	IS4	IS10	IS11
	Sustainable architectural design	Integrated design	Sustainable building materials	Sustainable installation materials	Environmental (indoor) quality	Communication	Information management	Collaboration	Quality assurance	Economics	Procurement
1 **Economic / quantity take off and cost calculations**	+	+	+	+		+	+	+		+	
2 **Development of current conditions model**	+	+				+	+	+			
3 **Planning project stages**						+	+	+		+	
4 **Land plot analysis**	+	+				+	+	+		+	
5 **Functional, volumetric and planing layouts development (S2)**	+	+	+	+		+	+	+		+	
6 **Project visualization and reviews**	+	+	+	+		+	+	+			
7 **Design / Modeling (S3-S4)**	+	+	+	+		+	+	+		+	
8 **Engineering calculations and analysis**						+	+	+			
9 **Energy analysis**	+	+	+	+	+	+	+	+		+	
10 Sustainability Assessment			+	+	+	+	+	+		+	
11 **Structural analysis and design**						+	+	+			
12 Lighting Analysis						+	+	+		+	
13 **Analysis of engineering systems**	+	+	+	+	+	+	+	+		+	
14 Other cases of analysis						+		+			
15 Conformity assessment / project expertise	+	+	+	+	+	+	+	+		+	
16 3D coordination	+	+				+	+	+	+		
17 **Planning a building site (building site plan)**	+	+				+	+	+			
18 Health and safety planning			+	+	+	+	+	+			
19 Structural-technological analysis						+	+	+			
20 Construction Technologies (Technological Schemes) and simulation of the installation process						+	+	+			
21 Building Logistics Planning (including procurement)	+	+	+	+		+	+	+		+	+
22 **Modeling and management of construction processes**	+	+	+	+		+	+	+		+	+
23 Digital Production			+	+		+	+	+	+	+	+

Co-funded by the Intelligent Energy Europe
Program of the European Union

Definition of the competence levels

Competencies on energy performance are mapped to the defined target groups, public administration, professionals, technicians and owners. To do so, NET-UBIEP uses the earlier work of the PROF/TRAC-project. In PROF/TRAC for each NZEB technology a qualification scheme is developed, which describes needed competencies that are needed in NZEB projects. The technologies and interdisciplinary competencies are based on the outcomes of the competencies mapping, performed in PROF/TRAC. Also, the needed competencies levels for each work field are based on the outcomes of the competencies mappings by experts. Based on the minimum required competencies level for a work field, the corresponding competencies can be found in the table of each technology.

0	Not applicable / no knowledge and competencies required
1	Has little knowledge and competencies with respect to the relevant field / technology (mostly outside the own field of expertise). Understands basic principles and is able to take part in project team discussions
2	Understands basic knowledge and has practical competencies within the field / technology, is able to solve simple problems by selecting and applying basic methods, tools, materials and information (mostly outside the own field of expertise)
3	Has comprehensive, factual and theoretical knowledge and competencies within the field / technology, is capable of solving standard problems within the field
4	Has advanced knowledge involving a critical understanding of theories and principles and competencies, required to solve complex and unpredictable problems in the field and is aware of the boundaries
5	Has specialized knowledge and problem-solving competencies, partly at the forefront of knowledge in the field, in order to develop new knowledge and procedures and to integrate knowledge from different fields

Co-funded by the Intelligent Energy Europe
Program of the European Union

Defining competency levels for target groups

Expert assessment

PRC

D2.4

	TARGET GROUP	BIM Manager	BIM Coördinator	BIM Expert	BIM Expert user	BIM Evaluator	BIM Facility manager	BIM user (unaware)
ER		ENERGY REDUCTION of construction						
ER1	Insulation	1	2	3	2	1	1	0
ER2	Air tightness building	2	2	3	2	2	2	1
ER3	Micro climates	2	3	4	3	2	2	1
ER4	Envelope systems	2	3	4	3	2	2	0
ER6	Window and/or glazing systems	1	2	3	2	2	2	1
ER		ENERGY REDUCTION of installations						
ER5	Hot water systems	1	2	3	3	2	2	1
ER7	Heating and cooling emission systems	1	2	3	3	2	2	0
ER8	Electric heating systems	1	2	3	3	2	2	0
ER9	Artificial lighting systems	2	3	4	3	2	2	1
ER10	Ventilation systems	2	3	4	3	2	2	1
IS		SUSTAINABLE INTEGRATED DESIGN						
IS5	Sustainable architectural design	2	3	4	3	2	2	1
IS6	Integrated design	2	3	4	3	3	3	1
IS7	Sustainable building materials	2	3	4	3	3	3	0
IS8	Sustainable installation materials	2	3	4	3	3	3	0

Co-funded by the Intelligent Energy Europe
Program of the European Union

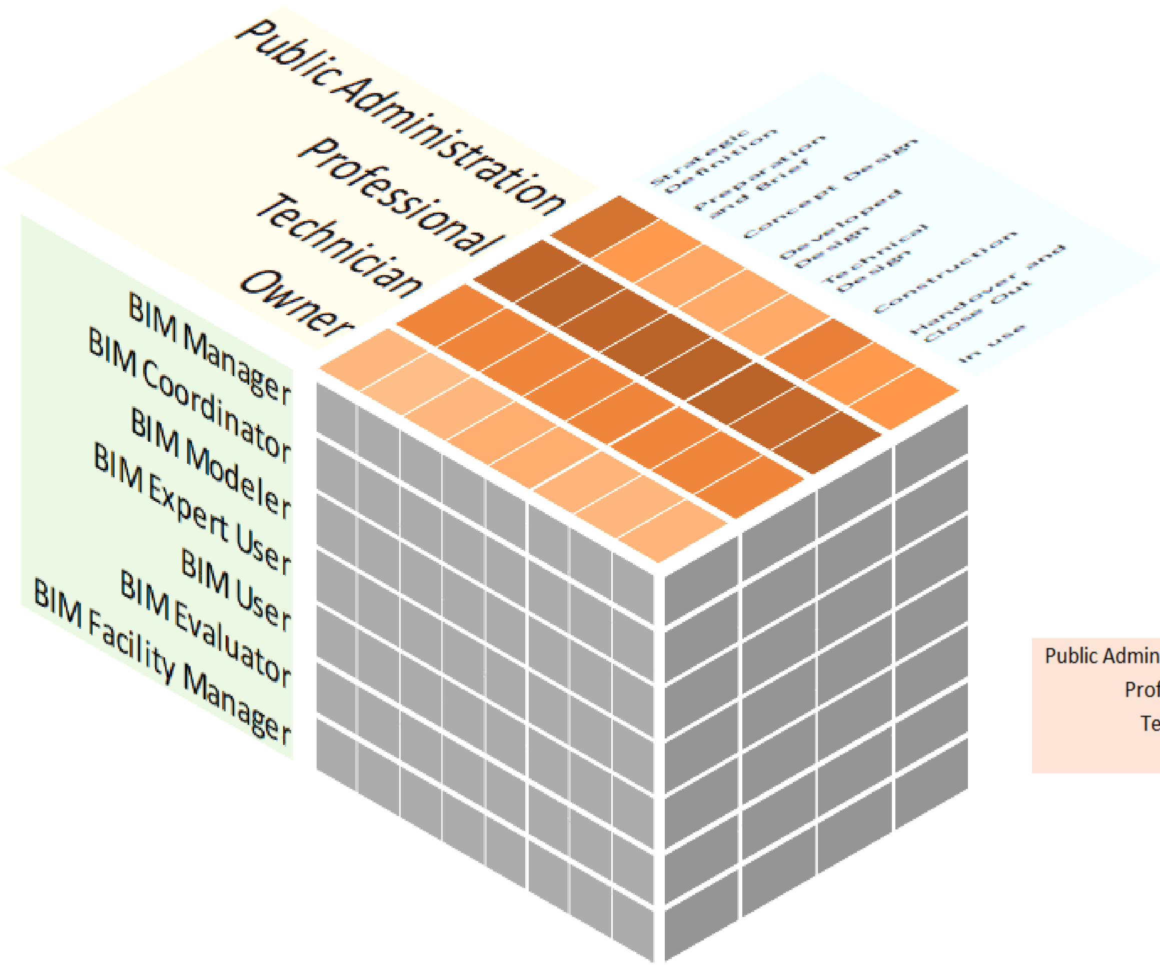
Agreed levels of competences

Back to "EU minimum competence levels"

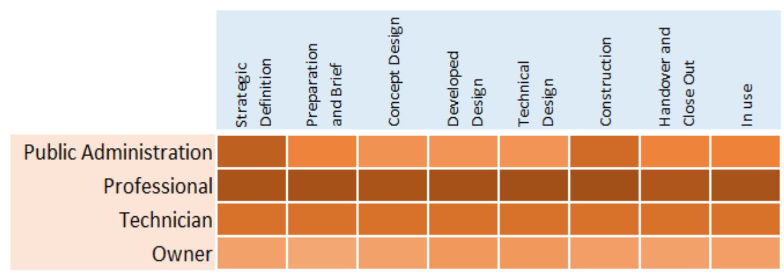
Technology Nr.							
ER1		Insulation  Thermal insulations of ground floors, walls, roofs, thermal bridges					
Project phase (if applicable)	Short description	Detailed description of competencies	for competence level(s)				
			1	2	3	4	5
General	Understand the importance of insulation in relation to nZEB	Has general knowledge on insulation. Understands the basic concept of energy conservation, is able to take part in discussions within a project. Is aware of constraints and boundary conditions (regulations, construction)					
Preparation	Determine the insulation concept within a nZEB project	Understands the concept of energy conservation (reduction of losses) in terms of building shape, zoning of rooms, insulation, airtightness etc. Understands the nature of the thermal bridge. Can discuss and, to some extend evaluate, possible solutions for the thermal bridge problem. Can determine the effect of application of different types of construction elements for the energy performance of the building.					
Design	Engineer the insulation concept and thermal bridges	Detailed engineering of insulation and solutions for thermal bridges					
Construction	Specify the insulation concept in tender documents	Specification of building insulation for contracting purpose. Is able to select products that fit specifications and demands on given quality aspects. Make detailed descriptions and drawings of the design					
Construction	Quality assurance of building insulation	Can manage, instruct and audit contractors on construction site, on critical points. Has knowledge on methodologies to measure quality, e.g. thermography.					
Construction	Commission building insulation	Knows how to measure and evaluate the insulation of the building and its effect on building energy performance					

Co-funded by the Intelligent Energy Europe Program of the European Union

3D matrix used for mapping of competences



competence's level 1
competence's level 2
competence's level 3
competence's level 4
competence's level 5



Co-funded by the Intelligent Energy Europe
Program of the European Union

Vaccination is a significant control measure for airborne infectious diseases such as measles. With resurgences of measles outbreaks, there is a need to find optimal (or at least improved) vaccination strategies, especially in the context of constrained health care resources, as is the case in Tanzania. We apply Operational Research techniques within a public health setting to this end. We use a SEIR (Susceptible, Exposed, Infected, Recovered) vaccination model allowing vaccination of a proportion of the population before or at any point during an outbreak of measles. We apply a social contact network epidemiological modelling approach to examine what vaccination strategies (e.g., mass or targeted) can effectively control measles. Vaccination of individuals against an infectious disease corresponds to the removal of vertices in a contact network. The social contact networks of individuals in Tanzanian villages are generated based on demographic, age, time use and other data. Computer simulations are used to study the spread of disease in various vaccination scenarios. Our findings suggest using a targeted vaccination strategy, particularly in vaccinating children of 6 months to 15 years of age, but also in vaccinating older age groups who were born before or missed the second dose schedule. Our conclusions apply to measles' vaccination theory, practice and policy not only in Tanzania but also in other developing countries that face constrained health care resources.

4 - Efficiency assessment of smart sustainable cities based on network data envelopment analysis

Sadiye Sadanoglu

City performance assessment methods are beneficial to provide support for decision making in urban development. The fast growth of urbanisation creates concerns about the sustainability of cities. The smart city frameworks are mainly focusing on modern technologies and smartness in the smart city rather than urban sustainability. Moreover, the urban sustainability frameworks focus environmental sustainability. Therefore, smart city frameworks are lack of environmental indicators while focusing on mainly economic and social aspects. However, the focus of smart cities is to improve sustainability with the support of technology. Hence there is a gap between smart city and sustainable city frameworks. To overcome this gap, we propose a framework which can explain smart sustainable city from three main perspectives: economic, social and environmental. To assess the efficiency of urban sustainability and smart city efficiencies the traditional Data Envelopment Analysis (DEA) used. However, the traditional DEA treats Decision Making Units (DMUs) as a black box by only considering initial inputs consumed and final outputs produced by them. Therefore, the traditional DEA models cannot sufficiently characterize the performance of cities. Apart from the need for a new framework, there is also a lack of understanding of how cities main three sub-systems: environment, economy, resources, and energy should be assessed, considered and their impact on the efficiency of urban sustainability.

■ MB-51

Monday, 10:30-12:00 - 4D UPV 1.2

OR for Sustainable Built Environment

Stream: OR for Sustainable Development
Chair: *Tatjana Vilutiene*

1 - Optimum design of bridges considering long-term criteria

Tatiana Garcia-segura, Víctor Yepes, Eugenio Pellicer, Laura María Montalbán Domingo

Multi-objective optimization is a commonly used tool to find multiple trade-off solutions. However, a large computational time is needed to check the solutions to certain structural problem. This communication presents a meta-model assisted multi-objective optimization to optimize bridges under multiple objectives. Artificial neural networks (ANNs) are integrated in the multi-objective optimization to reduce the high computational cost required to evaluate the constraints of a real bridge optimization problem. ANNs are trained to predict the structural response in terms of the limit states based on the design variables, without analyzing the bridge response. This methodology is applied to a continuous post-tensioned concrete box-girder road bridges formed by 34 variables regarding the geometry, the concrete grade and the reinforcing and prestressing steel. The objective is to find the optimal bridge design so that the cost of the deck is minimized and the overall safety factor with respect to the ultimate limit states and the corrosion initiation time due to chloride is maximized. The corrosion initiation time and safety criteria are included as objective functions for further deepening in the durability and safety requirements with the aim of designing for longevity and reduced long-term impacts.

2 - Integrated advanced technologies for sustainable BIM-based building refurbishment

Jovita Starynina, Leonas Ustinovichius, Mantas Vaisnoras

Building Information Modelling (BIM) is a collaborative way of working, supported by digital technologies. Computer model that has several 'dimensions' can be used for effective management of information throughout a project lifecycle - from the earliest concept of operation. BIM-based processes are 'mainstream' for new buildings and infrastructure and have potential in sustainable refurbishment projects when complementary workflows such as building scanning. Despite the fast development and spreading standards, challenging research opportunities arise from process automation and BIM adaptation for existing buildings' requirements. To aid decision-making, building simulation is widely used in the late design stages, but its application is still limited in the early stages in which design decisions have a major impact on final building performance. Using building scanning visualization in early design stage helps fully assess the environment of the future, accept design solutions, prevent mistakes and provides rapid changes of the design. 3D scanning technology is simply an incremental technological advancement of surveying, providing a safer, richer and more rapid method of spatial data acquisition for surveying applications. 3D laser scanning or 3D reality meshes from photographs data brings myriad opportunities to project managers, and engineers to monitor, assess, and analyse physical data captured from the existing environment.

3 - Empirical study of BIM-based building life cycle: case of Net-UBIEP project

Tatjana Vilutiene, Arvydas Kiaulakis

The building sector is the largest consumer of energy in Europe, accounting for nearly 40% of the total consumption (EPBD 2010/31/EU). 2030 European Energy [COM(2014)16Final] and Energy Roadmap 2050 [COM(2011) 885 final], strongly requires more focus on the energy efficiency on housing sector. The Directive 2014/24/EU on public procurement, requires that all member states introduce electronic means to exchange information and communication in procurement procedures. The integrated approach of the Net-UBIEP project, based on BIM, integrated with energy performance requirements, will be key to solve all the problems in a more effective and efficient manner. The project proposes BIM Qualification Models integrated with energy competences, to widespread a better comprehension of energy issues along all the value chain of building industry so that both existing and new building will have better energy performances. Article presents the process of identification of specific energy BIM competences for each target group needed to implement BIM models during the whole building life cycle. Data for analysis was gathered by use of direct and indirect observation and experiences of construction sector experts. During the project the "integrated" BIM Qualification Models will be validated by stakeholders and proposed for standardization to find a broader acceptance at European and international level through regulatory organizations (CEN/ISO).

■ MB-52

Monday, 10:30-12:00 - 4D UPV 1.3

Health Care Modelling (ORAHS) I

Stream: OR for Health and Care I
Chair: *Sally Brailsford*

NET UBIEP

Co-funded by the Intelligent Energy Europe Program of the European Union