NewTREND

NEW integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts

GA No. 680474

Deliverable D1.2:

Report on current design process

Deliverable Version:	D1.2, v.2.0
Document Identifier:	NewTREND_WP1_D1.2_Report_on_current_design_process_v2.0
Preparation Date:	August 12, 2016
Nature of Document:	Report
Document Status:	Delivered
Author(s):	STAM, UCC
Dissemination Level:	PU - Public

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680474

DELIVERABLE SUMMARY SHEET

DELIVERABLE DETAILS	
TYPE OF DOCUMENT:	Deliverable
DOCUMENT REFERENCE #:	D1.2
TITLE:	Report on current design process
VERSION NUMBER:	2.0
PREPARATION DATE:	August 12, 2016
DELIVERY DATE:	August 12, 2016
AUTHOR(S):	STAM, UCC
CONTRIBUTORS:	ABUD, UCD, Sant Cugat
DOCUMENT IDENTIFIER:	NewTREND_WP1_D1.2_Report_on_current_design_process_v1.2
DOCUMENT STATUS:	Delivered
DISSEMINATION LEVEL:	PU - Public
NATURE OF DOCUMENT:	Report

PROJECT DETAILS	
PROJECT ACRONYM:	NewTREND
PROJECT TITLE:	NEW integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts
PROJECT NUMBER:	680474
CALL THEME:	EeB-05-2015: Innovative design tools for refurbishing of buildings at district level
PROJECT COORDINATOR:	01. IES – Integrated Environmental Solutions Limited – United Kingdom
PARTICIPATING PARTNERS:	01. IES – Integrated Environmental Solutions Limited – United Kingdom 02. ABUD – ABUD Mernokiroda KFT – Hungary 03. JER – Uli Jakob – Germany 04. iiSBE IT R&D – International Initiative for a Sustainable Built Environment Italia Research and Development srl – Italy 05. REGENERA – Regenera Levante SL – Spain 06. GO – Granlund Oy – Finland 07. UCC – University College Cork, National University of Ireland, Cork – Ireland 08. NUID UCD – University College Dublin, National University of Ireland, Dublin – Ireland 09. MUAS – Hochschule fur angewandte Wissenschaften Munchen – Germany 10. LBS – London Business School – United Kingdom 11. STAM – Stam srl – Italy 12. Sant Cugat – Ajuntamento de Sant Cugat del Valles – Spain 13. UNIVPM – Università Politecnica delle Marche – Italy
FUNDING SCHEME:	Innovation Action
CONTRACT START DATE:	September 1, 2015
DURATION:	36 Months
PROJECT WEBSITE ADDRESS:	www.NewTREND-project.eu

DELIVERABLE D1.2: SHORT DESCRIPTION
Characterisation of existing design approaches in refurbishment projects.
Keywords: design process; stakeholders; bottlenecks; participatory design; questionnaire; model

DELIVERABLE D1.2: REVISION HISTORY

VERSION:	DATE:	STATUS:	AUTHOR:	COMMENTS:
1.0	29/07/2016	Released	STAM, UCC	
1.1	05/08/2016	Released	STAM, UCC	Reviewed by IES, ABUD, UCD
2.0	12/8/2016	Final	STAM	IES

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Abbreviations and Acronyms

Acronym	Definition
BIM	Building Information Modelling
BREEAM	BRE Environmental Assessment Method
BSRIA	Building Services Research and Information Association (UK()
CIC	Construction Industry Council (UK)
EeB	Energy-efficient buildings
FIDIC	Federation Internationale des Ingenieurs-Conseil
GA	Grant Agreement
HOAI	Honorarordnung für Architekten und Ingenieure (DE)
HVAC	Heating Ventilation and Air-Conditioning
IDR	Integrated Design Roadmap
IA	Innovation Action
ICE	Integrated Concurrent Engineering
KPI	Key performnance indicator
LEED	Leadership in Energy and Environmental Design
NewTREND	NEW integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts
nZEB	low and net zero energy (nZEB)
QAM	Quality Assurance Manual
RIBA	Royal Institute of British Architects
SME	Small and medium-sized enterprises
POE	Post-Occupancy Evaluation
VDC	Virtual Design and Construction
WP	Work Package

EXECUTIVE SUMMARY

This report is the output of Task 1.2 "Analysis of the current design process in refurbishment projects", which comprises an analysis of the design process as it is currently formulated in building refurbishment (including energy retrofit) projects at both the level of individual buildings and in the context of district neighbourhoods.

This analysis combined an extensive literature review, in-depth interviews with stakeholders with experience of the design process, a survey of industry professionals, and a modified Delphi approach to access the views of both academic and industry experts. Based on this work, the report provides an account of the current design process in building refurbishment. It outlines the main phases in the design process and its management; the key stakeholders involved and their levels of interest and influence; the principal models of decision-making; current bottlenecks in the process; the extent to which occupants and users are presently engaged with during design; and the extent to which the district context is taken account of in energy retrofit projects, as well as its challenges and potentials.

The report aims to provide a baseline from which NewTREND can proceed in developing an integrated design methodology and an efficient collaborative design platform that will advance on current best practice in the design process for building refurbishment (including energy retrofit).

Some key conclusions from the research can be found in summary below. These should now be taken forward for further consideration in Work Package 1 'Value Chain and Stakeholder engagement', Work Package 2 'Integrated retrofit design methodology', and Work Package 3 'Life cycle collaborative design platform':

- Although design stages based on the RIBA Plan of Work, provide a fairly accurate representation of the design process, in actual building renovation projects, a standardised design process is often not followed due to factors such as the scale, objectives, stakeholders, the planning process, and the participation of occupants and users.

- Inclusion of an energy audit and post-occupancy review should be considered in any standardised plan of work for the energy renovation sector. Post-occupancy evaluation and measurement is vital and, despite the challenges involved, should be recognised as an integral stage of the design process.

- Early involvement of contractors in the design process can have a significant positive impact.

- Voluntary energy certification systems such as BREEAM, LEED and ITACA are well known and influential in the industry, but there is some disagreement about their effectiveness and no one system is dominant.

- Stakeholders can be assigned to a limited number of project roles (client, design team, contractor, project manager) and stakeholder categories (financier, public and statutory bodies, end-users, occupants, neighbourhood stakeholders, consultants and third parties).

- Building renovation projects are often delivered by complex stakeholder configurations, which vary from project to project. The shape of these configurations impacts on the interests of

stakeholders and the influence they can exert over the design process. Maximum inclusion of all stakeholders, their interests and specific bodies of knowledge in the design process can help achieve the optimal blending of design objectives.

- Participation of building occupants and users should be included in a structured way in standardised models of the design process, however there is a lack of effective techniques to enable the participation of occupants and users as stakeholders in the design process from an early stage. Engagement is usually limited to consultation when the design is already complete, and occupant/ user participation is most effective when they are offered a structured input into the design process.

- Energy efficiency is seldom the only factor determining building design. Comfort, maximising rental value or return on investment, preserving heritage value, aesthetics, accessibility, flexibility, functionality, and saving operational costs were other design principles commonly cited. An effective design process will achieve the optimal blend of different objectives in the same building.

- Common constraints on the design include: heritage restrictions, delays in certification and approval, infrastructure issues, structural issues, skills shortages, return on investment, occupants and neighbours, tender process and funding.

- Incorporation of the district context into building retrofit design was often absent or limited. Where it took place, it usually involved established technologies such as CHP, solar water heating or photovoltaic panels.

1. Introduction

1.1. Background and context

The construction industry faces a long list of challenges, not least the delivery of new low and net zero energy (nZEB) buildings as well as the renovation and retrofitting of existing building stock across Europe in order to increase their lifespan and decrease their energy usage. If this particular challenge is to be met, the professions must address the fact that talented teams still deliver buildings that perform badly both in terms of their energy use and, more fundamentally, as places to live or work. Understanding the causes of this performance gap between design and reality is essential to cutting carbon in the built environment. The reasons for this gap between design and reality are many, ranging from poor design, construction and installation to inadequate control and user training. One thread that weaves its way through from early design to building use is a failure to embrace and manage innovation.

If the environmental challenges laid out by regulation and policy measures are to be met by architects and engineers, accepted and established norms in design practice must change. Innovation comes with risks particularly when it involves an unfamiliar or new technology. Design teams can manage these risks by undertaking research and by discussions with suppliers and manufacturers. Inevitably no matter how diligently this process of knowledge building is undertaken, a true understanding only develops when the innovation is tested in reality.

The risks associated with innovation are compounded by the design process in which decisions have to be made with often limited contextual information. As the design evolves, so the context can change. If decisions are not revisited then solutions can become inappropriate, leading to a mismatch between design expectations and performance in use. Flexibility and adaptability throughout the design process can help capture knowledge while minimising the performance gap. It has the potential to enable the professions to innovate with more confidence and to adopt solutions that are both appropriate and capable of delivering buildings that meet ever-increasing expectations in terms of energy efficiency, performance, and comfort.

1.2. Purpose of the document

The aim of this report is the characterisation of the existing design process in energy efficient building. It seeks to identify the main phases in design and the key stakeholders involved; the dominant approaches to the management of design, as well as the constraints and bottlenecks most commonly encountered; and examine the role currently payed by users and occupants, as well as the extent to which the design process takes account of wider district energy systems or potentials. The report aims to provide a baseline from which NewTREND can proceed in developing an efficient collaborative design platform that takes account of current best practice in the design process for energy efficient refurbishments while aiming to improve on it.

1.3. Methodology

The methodology adopted for the task included both qualitative and quantitative research as well as a literature review and verification and corroboration through a modified Delphi-panel process. The task commenced with an extensive literature review of publications related to the design process in construction, including both academic research and industry standards. Based on this, an interview schedule was developed and semi-structured interviews were conducted with 30 industry stakeholders with experience of the design process in building refurbishments, drawn from across Europe. An online survey of building industry professionals which attracted 60 responses was conducted to provide a wider, quantitative, evidence base which might support or modify the results of the interviews. Finally, the draft conclusions of the research process were verified through a modified Delphi process involving a panel of industry and academic experts.

1.4. Document structure

Section 1 outlines the purpose of the report as well as detailing the methodology applied.

Section 2 comprises the results of the literature review, covering design phases and industry standards, stakeholder theory, decision-making procedures, constraints and bottlenecks in the current design process, participatory design, and the potential for incorporation of building energy systems in their district contexts.

Section 3 provides a more detailed outline of our engagement with stakeholders in the design process for building energy refurbishment. It details the approach taken to the interviews, the data analysis process that was applied, the methodology used for the online survey, and the survey results. Finally, it gives details of the methodology used in the modified Delphi process.

Section 4 summarises our research findings for each of the key topics covered in the literature review.

Section 5 presents our conclusions including a generalised model of the current design process.

2. LITERATURE REVIEW

In order to understand the design process in building refurbishment as it currently stands, both academic studies, national and EU regulations, and industry standards have been investigated. This chapter presents a literature review organised in six thematic areas: the design process and its management; stakeholders in energy retrofit projects; decision-making in energy retrofit design; design bottlenecks; participatory design; and energy retrofit in a district context.

2.1. LITERATURE REVIEW METHOD

A key part of any research study is to explore how the topic has been 'researched, thought about and written about by others' (Matthews & Ross, 2010: 93). The objective of reviewing literature within a research study is become acquainted with this existing body of knowledge and to consider the relevance of prior work to the research being undertaken. For Kumar (1999: 26) this is 'one the essential preliminary tasks' in undertaking a research study, which leads to improved clarity and focus of research problem; improved methodology; and broadened knowledge base on the research area.

Jesson & Lacey (2006) describe a literature review as a narrative account of information currently available, accessible and published, which may be written from a number of differing perspectives to which the review adds an analytical assessment. Fink (2010: 3) defines a literature review as: 'a systematic explicit, and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners'. In other words, as Hammond and Wellington (2013: 99) observe it is an overview of what has been written on a topic, detailing what has been said, who has said it and outlining prevalent theories and associated methodologies on the subject.

Matthews & Ross (2010: 94) posit that literature is not a simple term and given constant change in dissemination methods, they suggest that any definite description would soon be out of date. However they do offer a quite comprehensive list of the 'main components' of literature, which they consider to be books, referred journals, non-referred journals; theses; conference papers; newspapers; TV & radio; 'Grey' literature[1]; official documents; research reports and online sources.

Of course, not all sources are created equal and greater value should be given to those sources which have been subjected to a peer-review process, i.e., scientific literature. Furthermore, Flick (2011, p. 33) observes different categories of scientific literature including primary sources and secondary sources; original works (reporting results for the first time) and reviews (which cover several studies). The objective of the literature review and the nature of the topic will determine which are the more useful sources.

The first step in a literature review is to identify and source appropriate literature pertinent to the study topic. Prior to any searches it is important to establish what are the primary key words or phrases relevant to the study topic, while also determining likely synonyms or alternative phrases. There are a number of resources which can be searched to find relevant literature such as: university library catalogues,

[1] This term typically refers to literature not typically available through usual bibliographic indexes *e.g.,* document produced by or for companies and other private organisations.

subscription based bibliographic databases (e.g., ScienceDirect from Elsevier), open access repositories[2], academic search engines (e.g., Refseek), and general web searches (e.g., Google); etc.

These direct search approaches can then be built upon by snowballing, which explores citation links between publications. This can take two types: backward snowballing is snowballing from reference lists of relevant articles to identify additional relevant articles [and databases] found through the initial keyword search; 'forward snowballing' entails identifying articles that have cited the articles located in the initial keyword search (Jalali & Wohlin, 2012).

Once literature has been sourced it can be reviewed for information of relevance to the study topic – of course these steps should not be considered a linear process, rather the literature reviewing process is inherently iterative. In reviewing the literature, a standardised approach is applied to abstract information from the publications and synthesise the findings.

In the preparation of D1.2, the sources of information that were used to map the available literature and identify the relevant publications were a combination of academic databases and google scholar. There are strengths and weaknesses to all databases, and so it is appropriate to use a cluster of databases in order to access the widest possible tranche of the available literature. Google Scholar has the widest availability, and has the advantage that it can be accessed for free. However, Google Scholar has been subject to considerable critique including that: it has incomplete, inaccurate citations; it includes non-scholarly material; it has multiple versions of single articles, including unofficial, incomplete pre-publishing draft versions of articles; and it lacks clarity about how it selects and ranks material (Jacsó 2010). All things considered, Google Scholar is a powerful tool and was adopted for developing this report, especially in regards to accessing information on industry standards and normative models. However other, subscription-based academic databases were the primary sources consulted for the bulk of the literature review. These included JSTOR, Science Direct and Scopus. In addition, official and government publications (and official government websites) as well as industry and professional publications (and websites) were used. Finally, both forward and backward snowballing techniques were deployed to identify relevant literature which was not listed in the initial database searches using keywords.

2.2. Design process and its management

From a general point of view, the design process can be defined as a decision making process (often iterative) in which the basic sciences, architectural, engineering and systems sciences are applied to convert resources to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation (ABET). The design process, especially in the construction field, is often defined by the professional experiences and background that an architect, an engineer or a company project manager would have developed during his/her career.

National and EU regulations, and transpositions of EU Directives into National Law govern public procurement and the awarding of contracts to designers, builders and providers of services or products, for government and other publicly funded projects. As a result, certain operators, in particular small and medium-sized enterprises (SMEs), may find it more difficult to compete within the internal market and

[2] A directory of open access repositories is available at http://www.opendoar.org

may miss out on important business opportunities where the weighting of tenders primarily concerned with the tender proposing to carry out the work for the lowest cost, with less weighting given to experience, existing working relationships, proven levels of quality and other factors.

In order to overcome these barriers, the EU in 2014, enacted three new Directives to regulate the concession contracts and the required steps that shall be performed during the execution of public constructions (2014/23/UE, 2014/24/UE and 2014/25/UE). A detailed analysis of these norms is performed in 2.2.1.

However, the design process shall be considered in its complexity and going beyond international regulations: it's a creative, iterative and innovative dynamic workflow. In the early creative stages, the architects, engineers and other designers produce options, sketches, models, thoughts and ideas. These processes need to be open and to enable the achievement of best solution (Hansen & Olsson, 2011). The process has an iterative form (Kalsaas & Sacks, 2011) and each iteration contributes to the end value of a project.

In the literature, there are several papers that evidence the complexity of the design process and which model the interdependences of the inputs and outputs of each step. Lawson (1997) defines design problems and design solutions as interdependent. Design problems cannot be comprehensively stated and there are no optimal solutions to design problems, and design solutions are unlimited in number. Controlling and managing the design process can be a significant challenge. The design process can be viewed as an endless reciprocal process; versus the building construction process which is traditionally viewed as a strictly sequential process.

Bølviken et al. (2010) introduce the work of Thompson (1967) to describe the different processes of design and their interdependences. There are pooled interdependence, sequential interdependence and reciprocal interdependence. Bell and Kozolowski (2002) introduced a fourth dimension called intensive interdependence. Processes emerge at different times and at the same time in the design phase. This also needs a form for coordination, which is described as coordination by standardisation, by plan and by mutual adjustment. "Design decision making is often negotiated amongst groups and teams, it is an iterative process" (Kestle & London, 2002). Kalsaas and Sacks (2011) and Andersen (2011) used the same concept in a case study to explain the design process of a hospital project.

Kalsaas and Sacks (2011) argue that it is important to understand dependencies in the design process in order to handle them. Andersen (2011) describes the coordination of the process as involving negotiations, mutual adjustment and opinion based communication. Relationships in the process follow different logics. One of the logics describes an "everlasting movement", where everything is connected to each other (see Figure 1).

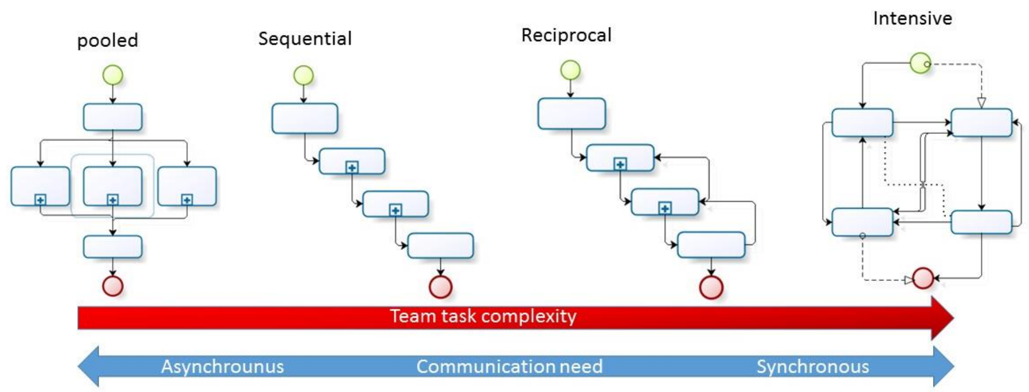


FIGURE 1: TEAM TASK COMPLEXITY (REMAKE OF BELL&KOZLOWSKI, 2002)

To be able to proceed between stages, you must make a decision, regarding an element or structure; if not the process stops or it will not start. A concrete decision might then start a sequential process, yet a decision turning down a solution, might just set of a new reciprocal process. A second logic is to pursue decisions so that they again set off a chain of solutions and new decisions. Knotten et al. (2014) introduce the term reflective logic and sequential logic to describe the logics of the design process. The sequential logic is based on a sequential, linear, closed process. Activity A must be finished before activity B can start. These are the typical processes displayed in a Gant schedule, and they can be planned and managed by the management planning tools (Pinto, 2013; PMI, 2013).

Finally, in order to find out the best approach for merging theoretical models and practical best practice, project management knowledge and creative processes, several national associations and international boards of professionals have defined common plan of works, standards and design processes that could lead to certified level of quality.

An overview of the most common *standardized guidelines* is presented in sub-section 2.2.2.

2.2.1. EU Public contract Directives

In directive 2014/23/UE, 2014/24/UE and 2014/25/UE the new regulations on public contracts are detailed. The European Commission defines three different design phases, according to three levels of successive technical insight; the three steps are **technical and economic feasibility study**, **detailed design** and **construction design.**

This division is aimed at ensuring:

1. the satisfaction of the community needs;
2. the architectural and technical quality and functional relationship in the context of the work;
3. compliance with environmental standards, zoning and protection of cultural heritage and landscape, as well as compliance with the provisions of legislation on health and safety;
4. a limited consumption of land;
5. the respect of hydro-geological, seismic and forestry as well as other existing constraints;
6. energy saving and energy efficiency, as well as evaluation of the life cycle and maintainability of the works;
7. compatibility with archaeological remains;

8. the rationalization of the design and related checks through the progressive use of specific methods and electronic tools such as modelling for the building and infrastructure;
9. compatibility with geological, geomorphological, hydrogeological work;
10. accessibility and adaptability in accordance with current provisions of architectural barriers.

For the design of special importance works in terms of architecture, environmental, landscaping, agronomy and forestry, art-historical, conservation and technology, contracting authorities resort to internal professionals, provided that they possess the necessary skills and knowledge in the subject matter of the project.

The contracting authority, in relation to the specific type and size of the intervention, indicates the features, requirements, and design documents necessary for the definition of each stage of the design.

However, the omission of one or both of the first two levels of design is permitted, as long as the next level contains all the elements provided for the omitted level, safeguarding the quality of the design.

THE TECHNICAL AND ECONOMIC FEASIBILITY STUDY

This identifies, among several solutions, which one offers the best balance between costs and benefits for the community, to meet the specific needs to be met and deliverables. The feasibility study includes all investigations and studies needed for the definition of the matters previously listed, as well as graphic schemes for identifying dimensional, volumetric, typological, functional and technological work to be carried out and their economic estimates, including the choice on the possible subdivision into functional lots. The feasibility study must cover, where necessary, the initiation of expropriation proceedings.

The feasibility study should be prepared based on the conduct of geological and geotechnical investigations, preventive checks of archaeological interest, the preliminary environmental impact studies and highlights, with adequate elaborate cartographic appropriate, the areas involved and the necessary safeguards. It also indicates the performance characteristics, the functional specifications, the demands of compensation and mitigation of the environmental impact, as well as the project budget limit.

THE DETAILED DESIGN

It fully identifies the work to be carried out in compliance with the requirements, criteria, constraints, the guidelines and directions established by the contracting authority and, if present, from the feasibility study. The final draft also contains all the elements necessary for the issue of the necessary authorizations and approvals, as well as the final quantification of the spending limit for the construction and its time schedule, through the use, if any, of the price lists drawn up by the regions and the territorially competent autonomous provinces, in agreement with the territorial divisions of the Ministry of infrastructure and transport.

THE CONSTRUCTION DESIGN

It is prepared in accordance with the final project, determines in every detail the work to be done, its estimated cost, the timetable consistent with that of the final project, and must be developed to a level of definition that each element is identified in form, type, quality, size and price. The final design should be also accompanied by a specific plan for maintenance of the work and its parts in relation to the lifecycle.

The detailed and construction designs are preferably carried out by the same body in order to ensure uniformity and consistency to the process. In a case where there are justified reasons for their being carried out separately, the new designer must accept the project activities carried out previously.

2.2.2. Standardized guidelines in design process

Several collections of guidelines define work stages in the building design process - each with clear boundaries - detail the tasks and outputs, and provide templates and models, giving the opportunity to create a bespoke organization of work, that at the same time reflects common working methods. The guidelines aim to provide a clear template for the scope of professionals' work through the different phases of a typical project: design, procurement and construction. Typically, every board of professionals in different countries adopts such a template. The following sub-section offers a brief description of the RIBA (Royal Institute of British Architects) plan of work, the FIDIC (Federation Internationale des Ingenieurs-Conseil) guidelines and form of contracts, and the German Fee Schedule for Architects and Engineers HOAI (Honorarordnung für Architekten und Ingenieure).

RIBA plan of work

First developed in 1963 by the Royal Institute of British Architects, for half a century the RIBA Plan of Work[3] has been the definitive UK model for the building design and construction process, also exercising significant influence on an international stage.

The RIBA Plan of Work has been a bedrock document for the architects' profession and the construction industry, providing a shared framework for the organisation and management of building projects that is widely used as both a process map and a management tool, and providing important work stage reference points used in a multitude of contractual and appointment documents and best practice guidance. It has been amended and updated over time to reflect developments in design team organisation, changes in regulatory regimes and innovations in procurement arrangements, although these changes have generally been incremental and reactive to changing circumstances rather than strategically driven.

The RIBA Plan of Work 2013 organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. The content of stages may vary or overlap to suit specific project requirements.

The RIBA Plan of Work 2013 could be used solely as guidance for the preparation of detailed professional services contracts and building contracts; moreover, 2013 version incorporates sustainable design principles, provides the infrastructure to support Building Information Modelling (BIM), promotes integrated working between project team members, including the construction team, and provides the flexibility to match procurement approaches to client needs.

The RIBA Plan of Work 2013:

- acts across the full range of sectors and project sizes
- provides straightforward mapping for all forms of procurement
- integrates sustainable design processes
- maps Building Information Modelling (BIM) processes, and
- provides flexibility in relation to (town) planning procedures.

[3] Official site and documents are available at: www.ribaplanofwork.com

The RIBA Plan of Work 2013 itself is not a contractual document: it directs readers to various tools and supplementary core documents used by a project team, including documents relating to professional services contracts, Schedules of Services and project protocols, which may or may not be contractual, and to the various forms of commonly used Building Contracts.

Buildings are refurbished and reused or demolished and recycled in a continuous cycle. If building outcomes are to improve, better briefing processes will be required. More importantly, feedback from completed projects must be available to inform subsequent projects. The RIBA Plan of Work 2013 recognises the stages that a building project goes through and promotes the importance of recording and disseminating information about completed projects.

The RIBA Plan of Work defines seven process phases:

0 - Strategic definition.
1 - Preparation and brief.
2 - Concept design.
3 - Developed design.
4 - Technical design.
5 - Construction.
6 - Handover and close out.
7 - In use.

RIBA Plan of Work 2013

The RIBA Plan of Work 2013 organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. The content of stages may vary or overlap to suit specific project requirements. The RIBA Plan of Work 2013 should be used solely as guidance for the preparation of detailed professional services contracts and building contracts.

www.ribaplanofwork.com

Tasks ▼ / Stages ►	0 Strategic Definition	1 Preparation and Brief	2 Concept Design	3 Developed Design	4 Technical Design	5 Construction	6 Handover and Close Out	7 In Use
Core Objectives	Identify client's **Business Case** and **Strategic Brief** and other core project requirements.	Develop **Project Objectives**, including **Quality Objectives** and **Project Outcomes**, **Sustainability Aspirations**, **Project Budget**, other parameters or constraints and develop **Initial Project Brief**. Undertake **Feasibility Studies** and review of **Site Information**.	Prepare **Concept Design**, including outline proposals for structural design, building services systems, outline specifications and preliminary **Cost Information** along with relevant **Project Strategies** in accordance with **Design Programme**. Agree alterations to brief and issue **Final Project Brief**.	Prepare **Developed Design**, including coordinated and updated proposals for structural design, building services systems, outline specifications, **Cost Information** and **Project Strategies** in accordance with **Design Programme**.	Prepare **Technical Design** in accordance with **Design Responsibility Matrix** and **Project Strategies** to include all architectural, structural and building services information, specialist subcontractor design and specifications, in accordance with **Design Programme**.	Offsite manufacturing and onsite **Construction** in accordance with **Construction Programme** and resolution of **Design Queries** from site as they arise.	Handover of building and conclusion of **Building Contract**.	Undertake **In Use** services in accordance with **Schedule of Services**.
Procurement *Variable task bar	Initial considerations for assembling the project team.	Prepare **Project Roles Table** and **Contractual Tree** and continue assembling the project team.	<-- The procurement strategy does not fundamentally alter the progression of the design or the level of detail prepared at a given stage. However, **Information Exchanges** will vary depending on the selected procurement route and **Building Contract**. A bespoke **RIBA Plan of Work 2013** will set out the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route. -->			Administration of **Building Contract**, including regular site inspections and review of progress.	Conclude administration of **Building Contract**.	
Programme *Variable task bar	Establish **Project Programme**.	Review **Project Programme**.	Review **Project Programme**.	<-- The procurement route may dictate the **Project Programme** and may result in certain stages overlapping or being undertaken concurrently. A bespoke **RIBA Plan of Work 2013** will clarify the stage overlaps. The **Project Programme** will set out the specific stage dates and detailed programme durations. -->				
(Town) Planning *Variable task bar	Pre-application discussions.	Pre-application discussions.	<-- Planning applications are typically made using the Stage 3 output. A bespoke **RIBA Plan of Work 2013** will identify when the planning application is to be made. -->					
Suggested Key Support Tasks	Review **Feedback** from previous projects.	Prepare **Handover Strategy** and **Risk Assessments**. Agree **Schedule of Services**, **Design Responsibility Matrix** and **Information Exchanges** and prepare **Project Execution Plan** including **Technology** and **Communication Strategies** and consideration of **Common Standards** to be used.	Prepare **Sustainability Strategy**, **Maintenance and Operational Strategy** and review **Handover Strategy** and **Risk Assessments**. Undertake third party consultations as required and any **Research and Development** aspects. Review and update **Project Execution Plan**. Consider **Construction Strategy**, including offsite fabrication, and develop **Health and Safety Strategy**.	Review and update **Sustainability**, **Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Undertake third party consultations as required and conclude **Research and Development** aspects. Review and update **Project Execution Plan**, including **Change Control Procedures**. Review and update **Construction** and **Health and Safety Strategies**.	Review and update **Sustainability**, **Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Prepare and submit Building Regulations submission and any other third party submissions requiring consent. Review and update **Project Execution Plan**. Review **Construction Strategy**, including sequencing, and update **Health and Safety Strategy**.	Review and update **Sustainability Strategy** and implement **Handover Strategy**, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of '**As-constructed' Information**. Update **Construction** and **Health and Safety Strategies**.	Carry out activities listed in **Handover Strategy** including **Feedback** for use during the future life of the building or on future projects. Updating of **Project Information** as required.	Conclude activities listed in **Handover Strategy** including **Post-occupancy Evaluation**, review of **Project Performance**, **Project Outcomes** and **Research and Development** aspects. Updating of **Project Information**, as required, in response to ongoing client **Feedback** until the end of the building's life.
Sustainability Checkpoints	**Sustainability Checkpoint — 0**	**Sustainability Checkpoint — 1**	**Sustainability Checkpoint — 2**	**Sustainability Checkpoint — 3**	**Sustainability Checkpoint — 4**	**Sustainability Checkpoint — 5**	**Sustainability Checkpoint — 6**	**Sustainability Checkpoint — 7**
Information Exchanges (at stage completion)	**Strategic Brief.**	**Initial Project Brief.**	**Concept Design** including outline structural and building services design, associated **Project Strategies**, preliminary **Cost Information** and **Final Project Brief**.	**Developed Design**, including the coordinated architectural, structural and building services design and updated **Cost Information**.	Completed **Technical Design** of the project.	**'As-constructed' Information.**	Updated **'As-constructed' Information.**	**'As-constructed' Information** updated in response to ongoing client **Feedback** and maintenance or operational developments.
UK Government Information Exchanges	Not required.	Required.	Required.	Required.	Not required.	Not required.	Required.	As required.

FIGURE 2: RIBA PLAN OF WORK

Source: RIBA Official Website (https://www.ribaplanofwork.com/Download.aspx)

FIDIC DEFINITION OF SERVICES

FIDIC is an international federation of national member associations of consulting engineers (Federation Internationale des Ingenieurs-Conseil). FIDIC was founded in 1913 with the common objective of promoting professional interest of the member associations. Nowadays FIDIC covers more than 80 countries and encompasses most private practice consulting engineers.

FIDIC provides guidelines for the construction industry, which attempt to consolidate the world's best practice for the definition of engineering services and establish a basis for scoping, executing and benchmarking these services as appropriate.

Through these guidelines for defining services, FIDIC will help clients and their consultants match tasks and desired outcomes with skill sets and required deliverables to improve effectiveness and profitability for both parties.

The adoption of FIDIC guidelines will enable the consultants to define clearly the responsibilities for the outset and communicate these to all parties, define the scope of consultant's work through the different phases of the project; define the level of design services required, benchmark the services the client receives against best-practice standards.

The guidelines identify and define distinct project phases, list work tasks, and design documentation. The latter is the critical tie between all the parties in a construction project, where the thorough coordination of design documents between disciplines is considered to be the single most important issue confronting the construction industry.

According to FIDIC guidelines projects are divided mainly into three categories:

- Building construction projects;
- Infrastructure/civil engineering projects;
- Industrial process plant projects.

The guidelines detail how different types of project services are defined and at the same time they illustrate how the scope of services should be defined.

In the case of a building construction project the phases defined by the FIDIC guidelines are the followings:

1) Scoping of Services Phase (or Engagement/Appointment phase)
2) Pre-Design Phase (or Programming Phase)
3) Schematic Design Phase (or Concept of Preliminary Phase)
4) Developed Design Phase (or design Development Phase)
5) Construction Documentation Phase (or Detailed Design or Working Drawings Phase)
6) Building Permission Application Phase
7) Procurement Phase (or Contract Award/ Bidding/ Negotiation Phase)
8) Construction Phase (or Project Supervision/Construction Monitoring Phase)
9) Post Construction Phase (commissioning/Defects Liability/Project Control Phase)

Per each project phase the guidelines detail the inputs form specialist designers covering the different primary design disciplines (such as: Structural Engineering, Architecture, HVAC, Electrical Engineering, Hydraulics, Fire Safety, Ancillary Services) and the outputs.

Here below, the different project phases, the input and the output for a typical building construction project, according to FIDIC guidelines, are summarized.

Project Phase	**Input/Task**	**Output**
Scoping of Services	Scope of works and services, timing, list of sub-consultants, conditions of engagements, list of information to be supplied by clients, deliverables, definition of team work	Engagement of consultants
Pre-Design	Site evaluation, topological survey, survey of existing structures, preliminary geotechnical study, environmental status assessment, regulatory framework evaluation, list of permits, preliminary estimates	Report, bulk and location sketches, Rough cost estimate
Preliminary Design	EIA, site specific investigation, preliminary design in all disciplines and sizing of key elements, evaluation of alternatives, preliminary review of utility supply capacity, pre-consent application with regulatory authorities, preliminary risk assessment, estimates on a "square metre rate" basis.	Design report, Preliminary Drawings, Estimates, Risk identification Report, Planning/Environmental consent applications.
Developed Design	Design of key elements in all disciplines, detailed review of utilities, detailed risk assessment and preliminary peer review, estimates on element by element basis	Updated design features repot, 60% of drawings, Specifications. List of elements not fully identified elsewhere in the documents, Estimates, Updated risk identification report.
Detailed Design	Final analysis/design in all disciplines of all elements, plans/elevations and details of all elements, full specifications, final peer review, pre-tender estimates, estimates of construction programme	Constructions drawings and specifications, update design report, estimates and risk identification report, technical documentation for tender, documentation for building consent, certificates.

Project Phase	Input/Task	Output
Building Permission Application Phase	Preparation of building permits, submission of drawings, specifications, calculations and design certificates, modification of the design or documentation at the request of the regulatory authority	Building Approval
Procurement Phase	Preparation of contract documents, insurance conditions, construction schedule, quality plan, health and safety plan, short-list of tenderers. calling tenderers, evaluating tenders, negotiation, signing of contract documents	Construction Contract with the successful bidder
Construction Phase	Construction monitoring/review of quality and consistency with design, review of drawings, issuing of variations, and payment certificates, list of defects	Completion of works and Completion Certificate
Post Construction Phase	Settlement of the final account. as-built drawings and operation manuals, obtaining compliance certificate from the regulatory authority, final inspection and sign-off.	Completion of Contract

TABLE 1: FIDIC PROJECT PHASE DEFINITION

The FIDIC guidelines together with the FIDIC suite of contracts covers a wide range of projects and methods of procurement. It is therefore likely that any international contractor or consultant working outside of the UK will frequently encounter FIDIC conditions of contract.

The different forms of contract within the FIDIC suite are organised around the extent of design and other responsibilities assumed by the employer and the contractor. The suite is therefore now aligned with common procurement strategies rather than the nature of the construction works. The FIDIC forms can therefore be applied to a wide range of differing engineering and construction projects; from traditional civil engineering to hi-tech windmills and heavy duty oil and gas process plants.

Here below, the classification of contracts, according to FIDIC, are briefly summarized up:

- Green Book Short Form of Contract;

- Red Book Conditions of Contract for Construction For Building and Engineering works designed by the Employer;
- Red Book (MDB edition) Conditions of Contract for Construction For Building and Engineering works designed by the Employer;
- Yellow Book Conditions of Contract for Plant and Design-Build;
- Orange Book Conditions of Contract for Design-Build and Turnkey;
- Silver Book Conditions of Contract for EPC/Turnkey Projects;
- DBO Contract Conditions of Contract for Design, Build and Operate Projects.

HOAI

According to the German Fee Schedule for Architects and Engineers HOAI (Honorarordnung für Architekten und Ingenieure) there are nine phases of work identifiable in the design process. Here below the nine phases have been grouped into three categories and the related outcomes listed accordingly:

Kick -Off and Identification of Basic Requirements and Draft Planning (HOAI LP 1-3):

Stage 1 - First Consultation, definition of scope of work;

Stage 2 – Concept Design: Sketch plans and drawings, evaluate project feasibility, make a preliminary consultation with the local authorities and first cost estimate;

Stage 3 – Preliminary Design: Construction drawings – scale: 1:100, write the outline specifications and prepare a cost plan.

Main Outcomes:

- Production of requirements profile / specification;
- Concepts: Audio / video / signage / controls / event technology;
- Layout design;
- Operational overview with alternatives;
- Definition of interfaces to other contractors and trades;
- Cost calculations.

Execution and Specification Planning (HOAI LP 4-6)

Stage 4 - Building warrant drawings and preparation of the documents necessary for the building application;

Stage 5 – Detailed Design: scale: 1: 50 drawings;

Stage 6 - Preparation of the tendering stage: e.g., detailed bills of quantities and specifications for each contractor needed on the project.

Main Outcomes:

- Erection and installation plans
- Cable planning
- Block diagrams
- Scheduling

- Detailed cost proposal
- Production of specification documents / bill of quantities
- Tender Dossier

Site Supervision (HOAI LP7-9)

Stage 7 – Tenders Analysis: receipt of tenders, appraisal, tenders shortlist and award;

Stage 8 - Site inspection and work supervision;

Stage 9 - Administration and documentation, work completion.

Main Outcomes:

- Production of qualified tender list
- Receipt and evaluation of quotations
- Tender negotiations
- Assessment and recommendation of tenderers / price list
- Site training
- Preliminary trade work (supervision and execution)
- Supervision of commissioning
- Coordination and supervision of installation work
- Checking for compliance with the bill of quantities
- Technical analysis of documents
- Specialist technical partial and final handover

2.2.3. Overview of guidelines in Energy Retrofitting Projects

The goal of this specific overview is to identify phases/elements that should be also taken into account when establishing the modus operandi of Integrated Design Process (IDP) of a retrofitting project, in the context of buildings/district neighbourhoods. The overview on the subject comprises research articles published in the database of Science Direct[4], national standards and guidelines.

The guidelines were reviewed and compared (Table 2) based on the following aspects: the considered phases in the life cycle of the project development, whether the development is a new construction or a retrofitting, the scale of the development, whether the guideline focuses on a particular area and what aspects are considered in connection with the phases (e.g., inputs, outputs, involved stakeholders, etc.)

The fundamental concept of each roadmap/guideline is similar to RIBA Plan of Work 2013, therefore this has been taken as benchmark. Although the reviewed studies referenced below (Table 2) differentiates various stages of the process similarly to the RIBA Plan of Work, most of the guidelines identified extra steps, such as a political decision phase to set long term national goals (Kanters & Wall, 2016), urban design phase prior to conceptual design stage or the complete tendering process (e.g., German Fee Schedule for Architects and Engineers HOAI §1). Others provide detailed information for what actions should be carried out, such as performing particular analyses (Hou et al., 2016), or are based on expert interviews (Busby et al., 2007) pointing out further actors and identifying stakeholders who should be

[4] Official website is http://www.sciencedirect.com/

involved, and determining the input, output and tools used at a certain phase–in order to produce a more significant result.

The planning process map of Lund University highlights important factors that influence the implementation of renewable energy in urban planning. Political decision phase, financial aspects, environmental aspects, energy-efficiency of buildings, comfort, ambience and environmental protection are in general the elements that this study emphasizes. Particularly regarding retrofitting strategies, the political support and combined national level governance policies with local government policies are presented as the basic stage of the process. In case of energy-efficient intervention, the attendance of different specialist expert teams, as civil engineers with expertise in water and wastewater systems, interior designers, green design specialist, lighting or day lighting specialist and mechanical engineers with expertise in energy analysis and simulation, concerned from the earliest stages or at least from the concept design phase of the project is also important. There are guidelines where the tendering process is more relevant, if referring to the RIBA concept and it is represented as a separate step.

The review revealed that guidelines focusing on energy-efficient retrofitting at the intervention scale of NewTREND, that means a block of some adjacent buildings, are missing. However, there are some process-based roadmaps (e.g., Consortium for Building Energy Innovation of Philadelphia – CBEI – roadmaps) demonstrating the stages of projects with consideration of different scales: from urban design phase to building design phase. The concern of neighbourhood is present in most of the reviewed guidelines. Related to retrofitting of existing buildings, the roadmap of the CBEI identifies four retrofit roadmaps in order to acknowledge interventions with varying levels of scope, professional expertise and available funding: Light Retrofits, Partial Retrofits, Substantial Retrofits, Comprehensive Retrofits. The guideline deals with commercial buildings; however, it could also be applied to other refurbishment projects.

The study of Hou et al. (2016) through the examination of successful pilot projects, revealed the necessity of political participation in refurbishment projects. At the same time, it concludes that the political and financial supporters should be well aware of the needs of the retrofitting. Hence, the condition of existing buildings should be clear; the exact targets of the renovation should be explained to the involved stakeholders as well who will provide financial support. It is also stated that linking the subsidy level proportionally to energy savings is effective to encourage developments to pursue greater energy savings, however subsidies should be paid in two or three instalments linked to the acceptance of the retrofit project into the subsidy program, completion of the retrofit and the successful operation of the retrofitted building.

With highlighting the importance of informing supporters and making the tendering activity an integral component of the process, it will be clearly visible that the development of an adequate form of aid based on the result of previous analyses is needed. Another factor that can be implemented in NewTREND is the gradual reduction in the scale of the design process, that in most cases takes the urban context into account. With defining all the necessary tools, actors to be involved, the required inputs and outputs of each design stage, a more complete methodology can be used to have a positive impact on the final performance of the buildings. Another aspect to be taken into account is pointed out by Cole & Valdebenito (2013), who suggest that a proliferation of building environmental assessment methods has occurred for application within many individual countries' domestic markets. However, the demand for 'brand recognition' in a global market, the desire for international standards and the motivation of the owners of some systems to expand the adoption of their assessment systems abroad are among many of the forces driving toward the increased international use of the two most established methods: BREEAM and LEED.

BREEAM (the BRE Environmental Assessment Method), appeared in 1990. BREEAM has since expanded massively, going from a 19-page BRE report with 27 credits available, to a massive 350-page technical guide (for the office version) with 105 credits (BSRIA, 2009).

The principles of BREEAM have also spread across the world. The US Green Building Council launched its Leadership in Energy and Environmental Design (LEED) in 1998. While similar methods have also sprung up, such as Greenstar in Australia and CASBEE in Japan, BREEAM and LEED are the main methods currently in use.

The main difference between the two methods is the process of certification. BREEAM has trained assessors who assess the evidence against the credit criteria and report it to the BRE, who validate the assessment and issue the certificate.

While LEED does not require training, there is a credit available if an accredited professional (AP) is used. The role of the AP is to help gather the evidence and advise the client. The evidence is then submitted to the US-GBC which does the assessment and issues the certificate.

Both schemes share common components. Early involvement of the assessor or AP at the design stage is beneficial to the project and the final rating. Both schemes drive the market to improve building design. The judging criteria also keep pace with legislative developments and current best practice.

It is very important to note that while LEED is dominated by the American ASHRAE standards, BREEAM takes it cue from European and UK legislation. The regional versions of both schemes flow from those antecedents (e.g., for Italy there are several regional assessment methods, such as Itaca and Casaclima).

The following table aims at providing a synopsis of the roadmaps and assessment methods analysed, detailing their scope, fields of application, inputs, outputs and involved stakeholders.

PROJECT OWNER	TITLE	SOURCE	OVERVIEW	DETERMINED PHASE OF LIFECYCLE	NEW DEVELOPMENT /RENOVATION /RETROFITTING	DESIGN SCALE	SPECIFIC FIELD	DETERMINED INPUT/OUTPUT /WORKFLOW	STAKEHOLDERS
LUND UNIVERSITY, SWEDEN	A planning process map for solar buildings in urban environments	Jouri Kanters, Maria Wall (2016)	A process map defining which decision regarding solar energy needs to be discussed in which design stage, is presented. With the help of this process map, more informed decisions should facilitate the implementation of solar energy in buildings.	whole lifecycle (from political decision phase)	new development or retrofitting	from urban design to buildings	solar energy	for each work stage decisions & actions, tools & documentation and actors are determined	politicians, adviser, non-governmental organisation, industry association, urban planner, building permission dept., real estate developer, real estate owners (e.g., of renovation), architects, engineer, energy planner, product developer, solar map expert, installer
CHINESE GOVERNMENT	Study of commercial building energy-efficiency retrofit policies in four pilot cities in China	Jing Hou et al. (2016)	In 2011 and 2012, the Chinese Government selected four cities-Shanghai, Tianjin, Shenzhen, and Chongqing- to implement pilot commercial building energy efficiency retrofit program. This research conducted a comparative analysis on incentive policies of local city level and examined the implementation process.	implementation procedure (project collection till project acceptance)	retrofitting	building	energy-efficient retrofitting of commercial buildings	workflow, actions and tools are defined + pilot projects, results	building owner, EMC, authorities concerned, construction department, experts committee, third party audit agency, financial department
BC GREEN BUILDING ROUNDTABLE (TORONTO)	Roadmap for the Integrated Design Process	Busby Perkins +Will, Stantec Consulting (2007)	The Roadmap was developed through an extensive literature review of existing best practices, an expert workshop, guidance from the Roundtable, and with input from professionals practicing IDP.	whole lifecycle	new building or renovation	building	-	input, output, actions, tools, documentation and stakeholders are defined in detail + pilot projects	ecologist, occupants' or users' representatives (rep), building program rep., planning/regulatory approvals agencies rep., interior designer, material consultants, lightning or daylightning specialist, soils or geotechnical engineer, electrical engineer, green design specialist, civil engineer, facilities manager or

PROJECT OWNER	TITLE	SOURCE	OVERVIEW	DETERMINED PHASE OF LIFECYCLE	NEW DEVELOPMENT /RENOVATION /RETROFITTING	DESIGN SCALE	SPECIFIC FIELD	DETERMINED INPUT/OUTPUT /WORKFLOW	STAKEHOLDERS
									operations and building maintenance staff rep, cost consultant, landscape architect, general contractor or construction manager, green design specialist, client or owner rep, project manager, architect, IDP facilitator, structural engineer, mechanical engineer with expertise in energy analysis and simulation
GERMAN FEE SCHEDULE FOR ARCHITECTS AND ENGINEERS HOAI §1	macom_ Planning Methods HOAI	German Fee Schedule for Architects and Engineers HOAI §1	A short description of the nine phases of work according to the German Fee Schedule for Architects and	whole lifecycle	unknown	building	-	non-comprehensive list is given for illustrative purpose onlynon-comprehensive list is given for illustrative purpose only	-
CBEI (PHILADELPHIA)	Integrated Design Roadmaps for AER	Franca Trubiano, Kristen Albee, and the Trustees of the University of Pennsylvania (2015)	CBEI developed a set of "roadmaps" describing how to undertake this type of cross-disciplinary collaboration. These guidelines, based on principles of integrated design, are called Integrated Design Roadmaps (IDRs) for AERs.	whole lifecycle	retrofitting	building	energy-efficient retrofitting of commercial buildings	input, output, actions, tools, documentation and stakeholders are defined in detail	occupants, owner, financial investors, facility manager(project manager,operation+management) architecture professionals (landscape architect, urban design, contract documents, specifications, project supervision, LEED certification) engineering

PROJECT OWNER	TITLE	SOURCE	OVERVIEW	DETERMINED PHASE OF LIFECYCLE	NEW DEVELOPMENT /RENOVATION /RETROFITTING	DESIGN SCALE	SPECIFIC FIELD	DETERMINED INPUT/OUTPUT /WORKFLOW	STAKEHOLDERS
									professionals,(structural engineering, MEP engineering, contract documents, specifications, project supervision, energy star certification) construction professionals(general contractor services, subcontracting services, suppliers, construction management)
BSRIA (BUILDING SERVICES RESEARCH AND INFORMATION ASSOCIATION)	BREEAM or LEED - strengths and weaknesses of the two main environmental assessment methods	2009	BREEAM has dominated environmental assessment of UK buildings for nearly 20 years. Now there's a competitor from the US: Leadership in Energy and Environmental Design (LEED). BSRIA delves deep into the inner workings of both schemes to find their strengths and weaknesses.	whole lifecycle	new building or renovation	from urban design to buildings	Water and energy efficiency, materials, environmental quality, innovation in design ,sustainable sites	technical standards and processes, benchmarks.	AP, certifiers, owners, contractors.

TABLE 2: OVERVIEW OF GUIDELINES IN ENERGY RETROFITTING PROJECTS

2.2.4. Management of design process

There is often a marked difference between the designed performance of a building and the actual performance of a building post-occupation. The increasing need to incorporate efficiency and sustainability makes it even more important to reduce the gap between design and performance, and to eliminate deficiencies in the design process. The managing of building design phases might be one of the most challenging forms of management in the AEC industry, i.e. it involves managing both outputs as drawings and harnessing creativity, in other words, design management is about managing people and information (Emmitt & Ruikar, 2013). In this context, the people being managed are the stakeholders in a building project, and the information being managed is the deliverables such as drawings, models etc. Design management is a complex social situation as value can be a socially constructed phenomenon and decision making to that end can be inherently unpredictable.

Management of Design process with Models

The use of Building Information Modelling (BIM) in the construction industry is increasing because this is a powerful tool for asynchronous communication between different professionals during design phase. BIM has become an invaluable tool in the construction industry, particularly on medium to large, and complex building projects. In the UK it will be mandatory to achieve BIM Level 2 on public projects by the end of this year. In order to achieve this, the British Building Standards Institute has introduced PAS1192-2, which specifies the information management process to BIM Level 2 for the delivery of public projects. The steering group for this document included some of the big stakeholders in the construction software industry such as Autodesk and Bently as well as big names in the construction industry; Atkins, Kier and Skanska for example. The requirements of PAS1192-2 are based on BS1192:2007 (Collaborative production of architectural, engineering and construction information – Code of Practice). Both PAS1192 and BS1192 were sponsored by the (UK) Construction Industry Council (CIC), and were informed by the CIC Code of Procedure for the Construction Industry first published in 2003.

Moum (2008) has described how BIM could also be suitable as a tool to use in synchronous communication between stakeholders and participants in ICE (Integrated Concurrent Engineering). He has described the use of collaborative design and the participants' reflection of how a BIM could ease their difficulties, help them to better understand complex problems and find out possible solutions. The benefits of improving communication in the design process are significant (Clemente & Cachadinha, 2013), in terms of increasing the quality of output and reducing the costs throughout the project's evolution. Using this method, the quality of the process is increased by an higher probability of an early clash detection, thus saving much money in projects (Khanzoode et al., 2008).

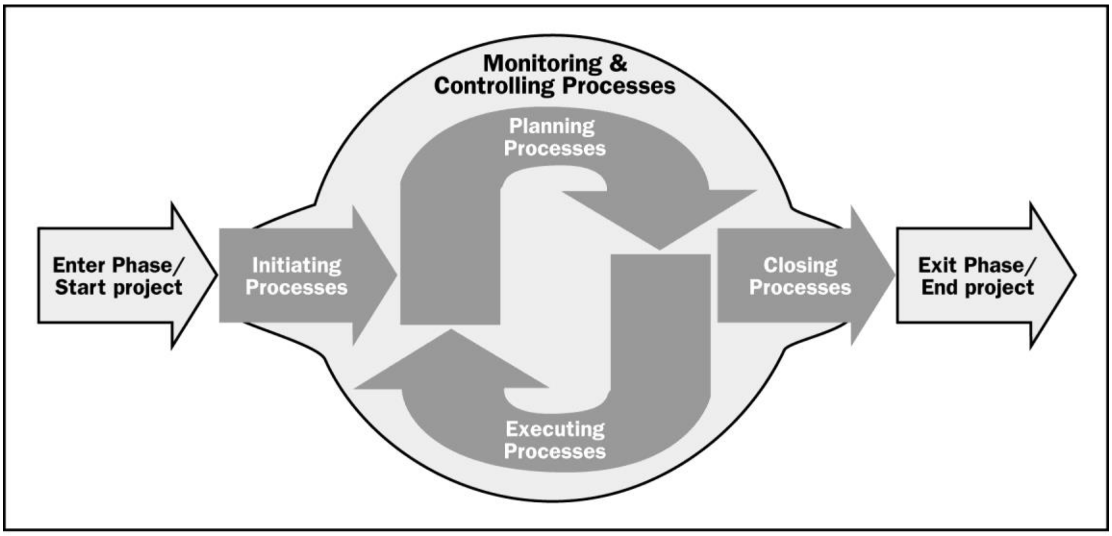


FIGURE 3: PROJECT MANAGEMENT PROCESS GROUPS (PMIS PBOK GUIDE FOURTH EDITION 2008)

In order to properly manage a design process, it is necessary to set up the metrics of the work that should be carried out and to continuously monitor them. The Project Management Institute (PMI) outlines five sets of processes in any project; initiating, planning, executing and closing processes, as well as monitoring and controlling processes which are on-going throughout each of the other four (see Figure 3 above). The PMI also describes a successful project as one that is completed on time, on budget, and meets stakeholder's expectations. These are often referred to as a Project Management Triangle as one cannot be changed without affecting the others, in the way one side of a triangle cannot be changed without changing the other two sides. Inevitably there are trade-offs during the project between the three in order to arrive at the optimal solution. Kristensen (2013) identifies 14 key performance indicators (KPI) that are needed to control design processes. These KPIs are classified as the strategic, tactical and operational metrics. In addition to time, cost, and quality, these metrics includes requests for information, participation and proofing, etc. The need for metrics to improve the design processes is also an active topic debated in several publications (Carvalho et al., 2008; Leong & Tilley, 2008; Succar et al., 2012; Knotten & Svalestuen, 2014) with the final aim of suggesting methods for controlling the quality, the efficiency and the information exchange effectiveness, even if it still remains fundamental to measure the project outcome in terms of time, cost and quality.

It is easier to measure the project outcomes of time and cost, however, it is more difficult, but equally important to set up metrics controlling the quality of design and the exchange of information. Using metrics to follow up the quality and efficiency, e.g., in ICE sessions, is important in order to improve the design process (Knotten & Svalestuen, 2014). Keeping the value perspective in mind, new ways of managing the earliest stages of the building design process might be considered. A comparison with innovation and product design gives alternatives to conduct building design development, e.g., the Innovation Diamond (Darsø, 2011) and IDEO (Best, 2006).

Virtual Design and Construction (VDC) and the Last Planner System (developed by Glenn Ballard and Greg Howell) seem to be the most recent approaches developed to deal with building design management. The VDC project model emphasises those aspects of the project that can be designed and managed, i.e., a product (typically a building or plant), an organisation to define, design, construct and operate it as well as a process that organisation teams follow (Kunz & Fischer, 2009).

VDC using BIM as a tool of communication as well as ICE sessions as a tool to create agreements and solutions are both applicable for design processes with a sequential and reflective logic.

Last Planner is the name for the LCI's (Lean Construction Institute) system of production control. Last Planner is a collaborative short-term production planning of Lean construction that improves the predictability and reliability of construction production. Last Planner manages the relationships, conversations and commitments that together enable program & production planning decisions to be made collaboratively at the lowest possible level in a whole range of one-off production settings — software development, shipbuilding, yacht fit-out, construction and other examples of one-off production. With adaptations, LPS works in new product development and design too. Even if there is no consensus that the Last Planner is an adequate tool for planning building design processes, Hamzeh et al. (2009) have shown the potentials of the method in the planning and re-planning of tasks. This together with the measurement of a process and products enables a design manager to follow up the building design phase. Finally, there are several ongoing successful studies for integrating BIM tools in Last Planner methodology, such as the one described by Garrido (Garrido, 2015).

Management of Design process with Parametric System Modelling

(PSM) is a supplementary technique to parametric geometric modelling (CAD/BIM). The system model represented by the diagrams provides a tool for capturing dependencies concerning non-geometric performance-determining properties and building design interdependencies (Philipp Geyer, 2012).

The technical approach of Building Information Modelling is inherently parametric, because the creation of a digital virtual mock-up of a building project is done by modelling and adjusting parametric objects. Whereas the designer manually models geometric detail in a generic 3D CAD system, BIM software limits the amount of direct modelling, using internal algorithms and embedded knowledge about the construction domain. Someone could argue that the designer models the skeleton of an object in a BIM system, whereas underlying algorithms generate the flesh and skin that will be the realization of the object. To contrast this, in parametric modelling systems, designers develop a recipe for a particular project, which can often be regarded as a composition of geometric entities. Regardless of the chosen technology, they embed and inject mathematic formulas, constraints, calculations and control functions to derive a geometric model from a series of input data. This is usually a combination of both numeric and geometric information, but can be extended with external inputs, such as site conditions, sensor data and even online streams or graphical imagery.

The literature review reveals that the benefit of PSM in building design is the explicit description of the non-geometric reasoning in the design process. This eases the modelling of the physical and technological interdependencies relevant to building performance. Furthermore, it enables a substantiated expert discussion on relevant interdependencies. The PSM technique thus fills the gap between geometry-focused CAD and analytic performance analysis and simulation using an active modelling tool, while making the design synthesis process transparent in its performance. A parametric systems model is the basis for active search and designing well-performing solutions (Philipp Geyer, 2012).

Management of Design process with specific reference to low energy building design

Conventional approaches to energy-efficiency design tend to focus on the provision of computational support to designers via building performance simulation to explore, inform and validate their decisions. "The provision of user-friendly tools for conceptual design and sophisticated building performance simulation tools for detailed design is presupposed to be the panacea to low-energy building design"

(Zapata-Lancaster & Tweed, 2016). However, there are doubts about the effectiveness of the tool-centric approaches to low-energy design where designers rely heavily on building performance simulation for problem solving and decision-making. According Zapata-Lancaster & Tweed, the aspects that affect the use of simulation tools in routine building design can be identified in the followings:

- The predominant use of experiential knowledge to advance the design development;
- Designers' conflicting views about simulation tools and the challenges to incorporate simulation tools in the design process;
- The status of simulation tools as boundary objects in the design process which affects their integration in the design process.

Rules of thumb and experiential knowledge are prevalent methods to inform design problem solving. They enable quick performance appraisals to advance the design development in situations where building performance simulation did not offer immediate results. Rules of thumb and experiential knowledge are also invoked to inform the assumptions embedded in simulation tools and the as-designed estimation models. Reportedly, while designers think that simulation tools helped to quantify performance with more certainty than rules, they also perceived that simulation results are theoretical. The as-designed performance estimation (as opposed to the as-built and measured performance) is considered to be an uncertain representation of the designers' intentions and the simulators assumptions about the building. This perception seems to undermine the credibility and trust in simulation results by the design team members who are not energy specialists.

As a result, the added value of simulation tools to support co-design and knowledge-sharing activities could be affected by the context of the design process: partnership and relationship between design team members, client expectations, drivers of the process and the perceived value of the contribution of different design team members.

Indeed, in the context of routine design problem-solving, a survey conducted by Zapata-Lancaster & Tweed (2016) about the assessment of tools and methods for low-energy building design has shown that simulation tools do not fit smoothly in the design process. In relation to user-friendly tools for early design, the architects' preference is for rules of thumb and heuristics for quick decision-making. In relation to advanced simulation tools for detailed design, the same survey found that the simulation tools used by the energy specialists need to be part of the design dialogue and support the co-design activities of the whole design team. The simulation results are more effectively integrated in the design process if they are a consistent part of the design dialogue at different points of the process: to share knowledge, to outline the assumptions embedded in the simulation models, to negotiate the design strategies, to estimate the as-designed performance. The involvement of the non-energy experts to inform the as-designed estimation scenarios seemed to increase the credibility and legitimation of the simulation results among the non-energy experts.

Different levels of integration of simulation were observed in the design process. In Zapata-Lancaster & Tweed's first case study analysis (Zapata-Lancaster & Tweed, 2016), simulation tools are deployed from RIBA 2 to 5 to inform the design development and support the co-design sessions. Conversely, in other case study simulation tools were used intermittently, mainly to respond to the compliance requirements outlined by planning application and building control.

The simulation tools have the potential to support the design conversations between the energy and non-energy experts and increase the knowledge about energy performance among the design team members.

However, in situations where the simulation results were not part of the design teams' dialogue, the simulation results created conflicts and aggravated the controversies among design team members. If a simulation tool was invoked for compliance purposes only, it could interfere with the way that knowledge about low-energy aspects is shared between the design team members.

2.2.5. Enhancement of Design Process

Post occupancy evaluation as a tool to enhance the Design Process

Recent studies (Gocer et al., 2015) report the improvements in the evaluation of building performance and introduce a new method for Post-Occupancy Evaluation (POE) to complete the missing link in the building design process. Generally, once the building has been completed, and basic snagging works have taken place, both the design and construction team no longer have any 'stake' in the building. There may be a short defects liability period of approximately 1 year in order to complete snagging, but after this period there is no further obligation, contractual or otherwise, and the temporary multi-firm network established for the project is dissolved. The term Soft Landing is used to describe a controlled deceleration and landing. It is often used in economics and other non-vehicular situations also. The UK based Building Services Research and Information Association (BSRIA) have created an approach to construction contracts with a strong focus on post-occupancy, entitled Soft Landings, and a sub-sequent approach entitled Government Soft Landings. Soft Landings core principles are set out in BSRIA (2014) as follows:

1) Adopt the entire process
2) Provide Leadership
3) Set Roles and Responsibilities
4) Ensure Continuity
5) Commit to Aftercare
6) Share Risk and Responsibility
7) Use Feedback to Inform Design
8) Focus on Operational Outcomes
9) Involve the Building Managers
10) Involve the End Users
11) Set Performance Objectives
12) Communicate and Inform

Stakeholders frequently fail to learn straightforward lessons from completed projects and end up repeating mistakes that could easily be avoided. In addition, it is very difficult for designers to evaluate their own designs objectively, formulating the effects of the designed space on their users. With regard to these concerns, there is a mismatch between expectations for energy efficiency and outcomes. In other words, a well-known gap exists between the predicted and actual environmental performances of built infrastructure. There is a current resurgent interest in the use of major feedback loops to narrow this gap. Post-occupancy evaluation (POE) has the potential to lead to a better understanding of how we can complete feedback loops in the building design process. If POE can be completed, it would be possible to do the following:

- enhance continuous improvement in the design process through 'Feed-Forward' in briefing. Real information provided with a proper POE on which to base decisions is key to informing and improving the next project;
- support occupant satisfaction and productivity by validating occupants' real needs, particularly in relation to managing services to suit occupants;

- increase organizational efficiency by reducing ownership/operational expenses and the waste of space and energy; and
- use benchmarking as a platform for sustainable development for future projects through the lesson-learn method.

The evaluation of a building almost immediately, i.e. starting from the day of its occupation, could significantly enhance the quality of user representations in the building. Such evaluation also provides the opportunity for all parties to learn from past mistakes for deficiencies and promote performance improvement for future buildings. Briefly, overlooking POE as a mechanism for linking feedback on buildings with the pre-design decision making process and common problems in the construction sector is caused by the separation of design from production, ownership and use. Considering the impact of these issues, studies are on-going to find possible reasons explaining the missing link of “building performance feedback” and present a spatial mapping method in POE to close the building performance feedback loop in the building design process.

Effectiveness of Design Process Communication Methodology (DPCM)

Research in design process management mainly focuses in finding out efficient communication processes, but with methods that may be too complicated to be adopted in practice. The lack of methods for effective and efficient design process communication manifests as a struggle for Architecture, Engineering, and Construction industry professionals to:

- collaborate within projects;
- share processes between projects;
- understand processes across projects to strategically invest in improvement.

The Design Process Communication Methodology (Senescu at al., 2012) enables effective and efficient design process communication. To test DPCM, previous research mapped the methodology to software features in the Process Integration Platform (PIP). PIP is a cloud application enabling project teams to organize and share files as nodes in an information dependency map that emerges as they work. The capabilities of the cloud enabled the development of PIP and validation of DPCM, increasing the possibility of using design processes for collaboration and process sharing impact, visual and analytically advantageous format for complex systems.

2.3. Stakeholders in Energy Retrofit Projects

2.3.1. Stakeholder Theory

Stakeholder Theory literature generally tends to concern itself with the management and treatment of a business (or firm, or a corporation) entity of its stakeholders. Freeman describes "business" as: "a set of relationships among groups which have a stake in the activities that make up the business. Business is about how customers, suppliers, employees, financiers (stockholders, bondholders, banks, etc.), communities and managers interact and create value." (Freeman, 2010, p7)

Therefore, if business is considered as a set of relationships, stakeholder theory seeks to ensure that the treatment of those involved in those relationships, the stakeholders, is fair and responsible, which has in more recent times been incorporated into Corporate Social Responsibility (CSR). Kaler (2003 & 2006) describes stakeholder theory as a reformist stance toward capitalism, moving in a direction of greater equity, and that it has two main functions, one, to argue for an enhancement of distributive justice and the other to be used as a way to understand CSR, and companies taking on obligations to society beyond those owed to shareholders. Stakeholder theory is also managerial i.e. managing competing stakeholder interests (Harrison & Freeman, 1999). The objectives of Stakeholder Theory are to consider the needs and impacts of various stakeholders (Fassin, 2012), and to understand how value is created and traded (Freeman et al., 2004). The stakes of each stakeholder group are multi-faceted, and inherently connected to each other, "no stakeholder stands alone in the process of value creation" (Freeman, 2010). According to Freeman et al (2004 p364) the focus of stakeholder theory is articulated in two core questions:

- What is the purpose of the firm?
- What responsibility does management have to stakeholders?

Jones and Wicks (1999, p207) elaborate further on this, and describe the essential premises of stakeholder theory in four points:

- The corporation has relationships with many constituent groups ("stakeholders") that affect and are affected by its decisions (Freeman, 1984);
- The theory is concerned with the nature of these relationships in terms of both processes and outcomes for the firm and its stakeholders;
- The interests of all (legitimate) stakeholders' have intrinsic value, and no set of interests is assumed to dominate the others (Clarkson, 1995; Donaldson & Preston, 1995);
- The theory focuses on managerial decision-making (Donaldson & Preston, 1995).

While noting that they do not agree that stakeholder theory fulfils those promises often attributed to it, Orts & Strudler (2009 p605) argue that while it may be useful, claims surrounding stakeholder theory are often overblown. They state that the primary appeal of stakeholder theory is that it promises to help solve large and often morally difficult problems such as:

- How to manage people fairly and efficiently;
- How to determine the extent of a firm's moral responsibilities beyond its obligations to enhance its profits and economic value.

Stakeholder theory can, and is, also applied to projects including construction projects. The construction industry is both corporate and project oriented (Liao et al., 2016). Project managers across the world, especially those that are members of the international and professional project management body Project Manager Institute (PMI), will cite stakeholder identification and management as being crucial to the success of a project. Therefore, the next logical step is to define who or what is a stakeholder. Why should we be concerned with identification of stakeholders? As Svenfelt et al (2011) point out – there is sufficient technical potential to achieve energy saving targets, however, without radical changes to social structures, incentivising actors to act, enhanced communication and feedback, and changes in attitude and behaviour (of stakeholders) targets cannot be met. Corporate Social Responsibility (CSR) already recognises the need to treat stakeholders fairly and increase dialogue and collaboration between them (whether that is applied in practice is of course a different matter).

The Project Management Institute defines a project as a temporary endeavour undertaken to create a unique product, service or result (PMI, in Yang et al., 2011). Building construction and renovation, or retrofitting falls within the scope of this definition, projects that create something unique. In order to do so, various persons, or groups of persons are involved for a finite period of time and for a specific purpose. Thus it can be said that a multi-firm network of stakeholders is involved. However, many stakeholders in this network tend to go un-noticed, according to Berardi (2013), construction companies and project managers seldom conduct surveys into their customer preferences, and prefer instead to hypothesize about them according to previous experience and expectations. The complexity and uniqueness of the organizational structures surrounding construction projects, and the various relationships between stakeholders can also make it more vulnerable to disruption (Genovese et al., 2013).

2.3.2. Definition of Stakeholders

There are numerous definitions of stakeholders, and they are for the most part, definitions from a corporate point of view. The most often cited definition of a stakeholder (e.g., Brown, Crane & Ruebottom, Fassin, *etc*.) is Freeman's 1984 definition from his book (p. 25), *Strategic Management: A Stakeholder Approach*, which defined a stakeholder as: "any group or individual who can affect or is affected by the achievement of the organization's objectives" in addition to this, according to Freeman, "the stakeholder approach is about groups and individuals who can affect the organization, and it is about managerial behaviour taken in response to those groups and individuals" (p. 48). In other words, stakeholder theory is concerned with who has input in decision-making, and who benefits from the outcomes of such decisions (Phillips et al., 2003 in Crane & Ruebottom, 2011). Stakeholder fairness, as a principle, as developed by Phillips, recognises the obligations and duties of stakeholders (Fassin, 2012). Reciprocity must also be considered, obligations of fairness are not restricted to just one groups of stakeholders, *e.g.,* the directors of a large company/corporation.

The literature is divided however, on whether stakeholder theory should adopt a strictly anthropocentric viewpoint or not. The big question for many is whether the natural environment should be considered as a stakeholder in its own right. It is not a person, group or organization, and yet it can affect, or be affected. It can also create value. Consider the market value of two houses, one in a particularly bland suburb, and one with extraordinary sea views on a much sought after beach-front location. The buildings are identical and yet it is highly unlikely that the price tags will also be identical, because of the additional value created by the natural environment at each house. Consider also that nature provides the building materials used to build the two houses, the energy used to heat and provide electricity to the houses, and the water used use in the houses (and consequently a place to dump the waste generated by the houses' construction, occupation and future demolition).

If we see the natural environment as a stakeholder in its own right, does that mean that we view it as apart from us as humans? On the other hand, if we do not view it as apart from humans, but instead view humans as part of nature; can the natural environment be said to be sufficiently represented by proxy by the human stakeholders? Considering the current state of environmental degradation, climate change and species extinction there is a strong argument that humans do not currently sufficiently represent the interests of the natural environment. There is also a danger if nature is simply viewed as being everywhere, then being present at all times in all places may lead to it being taken for granted, being invisible, or perhaps being unimportant (Laine, 2010). Starik (in Pajunen, 2010) suggests that human proxies for the non-human environment are necessary, but not sufficient.

Authors such as Nasi, Stead & Stead, and Driscoll & Starik (Laine, 2010) have argued that the Natural Environment / Nature / The Earth should be considered to be a stakeholder in its own right. Others (Phillips & Reichart, Orts & Strudtler, Fineman & Clarke) argue that it should not, lest the entire concept of stakeholder theory be diluted beyond usefulness. Those who argue against giving nature stakeholder status will point to the fact that nature has no voice or opinion – those who argue for say that other stakeholders may also be voiceless, but no less valid, e.g., the homeless, political prisoners, indigenous peoples, minorities etc (Starik in Pajunen 2010). Freeman, the original source, originator and inspiration for so much of stakeholder theory literature describes it in relation to the corporation/firm/business, and as managerial, (terms associated with humans, not with nature) and in more recent decades, in relation to a "names and faces" approach (again, human terms, nature does not have a name or face), i.e. stakeholders have names, faces and children (Freeman, 2004, McVea & Freeman, 2005). This language alone suggests an anthropocentric view, and that only humans can be stakeholders.

2.3.3. Stakeholder Identification

A significant, and important part of successful project management is the identification of stakeholders, as well as their interests, impacts, and ambitions for a project, as well as conflicting and hidden or unseen agendas of stakeholders, which if ignored could lead to project failure, (Menassa & Baer, 2014, Heravi et al., 2015). The diversity of values, opinions, expectations and perspectives of stakeholders needs to be managed carefully to turn it into an asset rather than a liability according to Menassa & Baer (2014). Lack of cooperation and competing agendas can be a major barrier to a project's success (Berardi, 2013). Identification, and subsequent prioritization of stakeholders can be a difficult task. Crane & Ruebottom, (2011) point out that critics of stakeholder theory argue that the "lack of specificity" is a serious obstacle to its development, as this is an issue that has never been fully resolved in the literature, and is at best stakeholder identification and prioritization in the literature is criticized for being vague, ambiguous – to the point of overlapping with the definition of the citizen, and that everyone is essentially a stakeholder when you apply the "can affect or be affected rule" too broadly where stakeholder theory can be made to mean almost anything that you want it to mean. Care must therefore be taken when carrying out this task. Freemans identification of stakeholders in line with his definition of what a stakeholder is from his 1984 publication is shown in Figure 4 below.

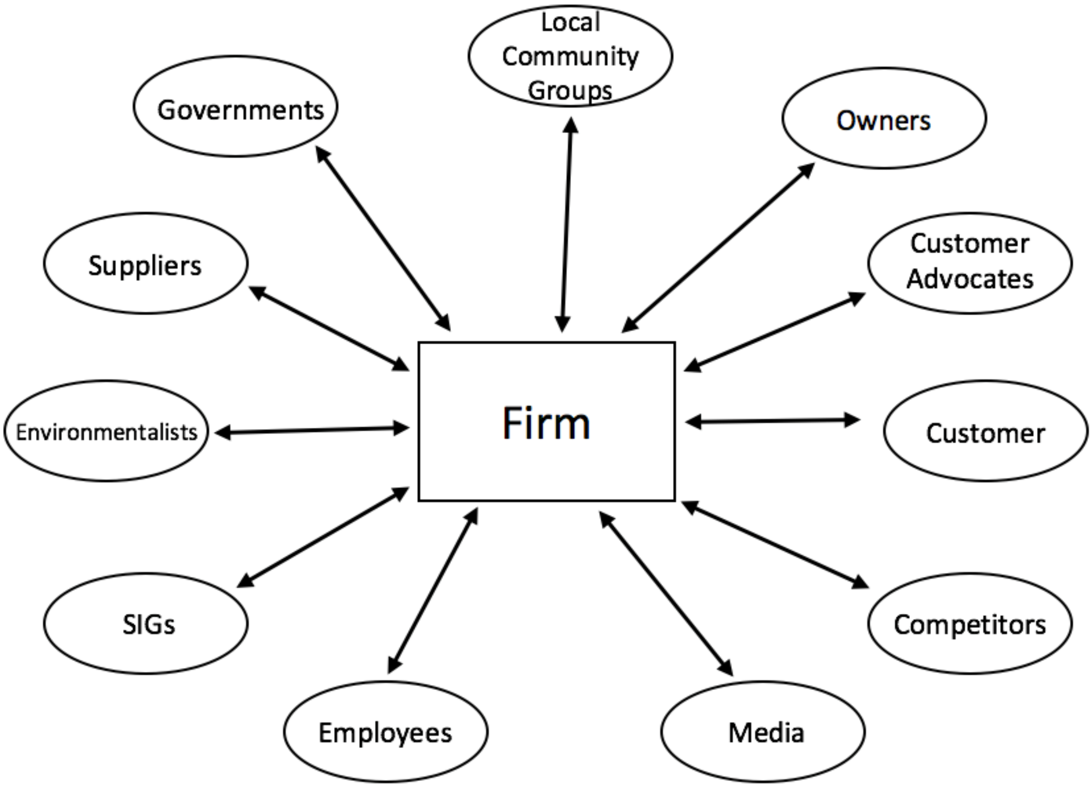


FIGURE 4: STAKEHOLDER VIEW OF THE BUSINESS (FREEMAN, 1984, P25 IN PAJUNEN, 2010)

The social identity of a stakeholder is also important, how the stakeholder views themselves with regards their wider social surroundings, the "*mutual understandings regarding the characteristics that distinguish (members) from non-members*" of a particular social identity (Crane & Ruebottom, 2011 p81). This will require recognizing and understanding the social identities of the stakeholders as social groups as well as individuals. McVea & Freeman (2005) also warn against categorizing stakeholders according to generic groupings opting instead for the more personal "names and faces" method, which will also allow for the possibility of stakeholder migration between groups. It should also be noted that for stakeholder theory to be of any use, the term stakeholder should not be synonymous with "citizen" or "moral agent", the theory is not a comprehensive moral doctrine, and nor is it a theory of political economy (Phillips et al., 2003) (nor should it be synonymous with the term actor which implies a stakeholder actively participating in the project whereas in reality some stakeholders are active, and others are passive). A stakeholder's interaction with a firm (or project) can also change over time, (Santana, 2012), and as a result, their relationships with other stakeholders, their affect, and/or potential to be affected may also change. For example, the building contractor tends to be most involved with a building only after it has been designed, and has received the various planning approvals, and before it is occupied. Different stakeholders are more or less active at different stages in the lifecycle of a building project. Dunphy et al., (2013) identified 6 stages in the lifecycle of a building. These are: upstream activities, initiation & viability, design & planning, construction / implementation, operation & maintenance, end-of-life & downstream – see Figure 5.

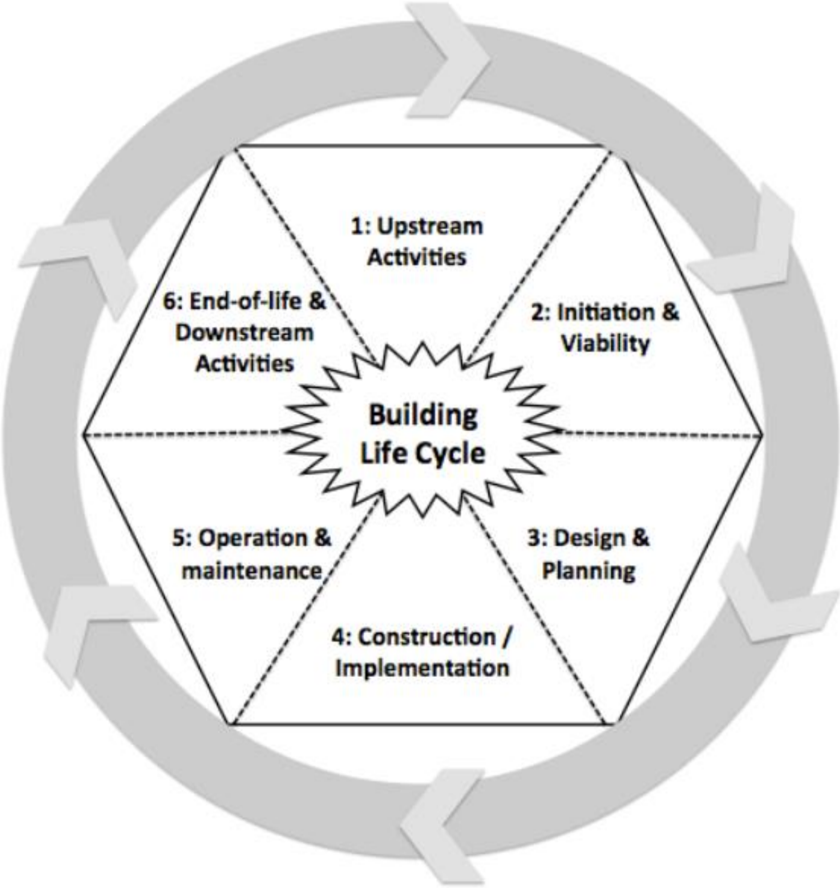


FIGURE 5: STAGES IN THE LIFECYCLE OF A BUILDING (DUNPHY ET AL., 2013)

In the case of a project, the stakeholders are issue-focussed, and more likely to be part of, or in some way associated with a multi-stakeholder network, as opposed to an organization-focussed corporate situation (Roloff, 2008). Participation is often voluntary, and engagement is often deliberative and collaborative.

2.4. Decision-Making in Energy Retrofit Design

2.4.1. Setting The Problem

The decision making process in design tends to follow a relatively standard cycle of setting the problem, analysis, proposed solution and evaluation, and where a case is complex, will include a series of iterations before reaching the final decision (D'Anjou, 2011). Efficient and effective decision-making begins with a clear and unambiguous statement of the problem. Articulating the correct problem is a challenge in itself, as it may actually be but an element, condition, or symptom of a larger problem (Kleindorfer et al., 1993, in Martin, 2015). Therefore, decision-making models can only be as good as the characterisation of the problem to which they are applied (Martin, 2015). Care must be taken to ensure that the perception of the context surrounding the decision, the scopes and objectives are not ill defined, and that the problem is not unrealistic or unsolvable. Uncertainty also arises when the decision makers perceive one or more components to be unpredictable (Siontoru & Batzia, 2012).

2.4.2. Phases of Decision-Making

There are essentially four phases in the basic design cycle for decision-making: analysis, synthesis, simulation and evaluation, (Dorst & Royakkers, 2006, in D'Anjou, 2011). When an absolute best solution cannot be found, D'Anjou suggests that an ethical solution is an approximation – and the phases of ethical decision making differ slightly. They are: moral problem statement, problem analysis, options for actions, ethical judgment, reflection, and morally acceptable action (Van de Poel & Royakkers, 2007 in D'Anjou, 2011). Satisficing may also serve as a decision-making strategy for multiple stakeholders and providing a means to generate learning experience and debate (Dunphy & Morrissey, 2015). This involves searching through the alternatives until an acceptability threshold has been met. The designer is always confronted with design choices regarding materials, specifications, costs, aesthetics, quality and so on as well as decisions regarding energy use, and energy retro-fitting. Decision-making methods that are transparent, and integrate disparate information, perceptions and values tend to be the most useful for problems with a variety of stakeholders that value a variety of different outcomes, (Martin, 2015). In order to mitigate uncertainty, it is common within organisations (public of private) or within projects, that decision-making is aided by check-lists, procedures, technical standards (regulations) and policy documents which act as guides to aid the decision making process (Wu & Pagell, 2011). In the case of building energy projects, for example, the use of building regulations, technical standards, and energy rating tools or building simulation software will aid the decision process by inputting values in certain parameters to provide information regarding different estimated outcomes in line with stakeholder requirements such as meeting regulations and staying within budget.

2.4.3. Decision Drivers

The interview process thus far appears to confirm the findings in the literature that energy improvements are seldom the main deciding factor in whether to go ahead with a building renovation project. Instead, energy is often one of several coinciding needs, such as comfort levels, repairs, modernisation (Steskens et al., 2015), security and so on. Decisions are made throughout the process, although Steskens et al., 2015, identify the main decision-making stage as the selection of specific refurbishment alternatives, i.e. feasibly stage, early in the project, prior to the design stage. Building design, and consequently, energy retro-fit projects, tend to be multi-stakeholder undertakings, (or as Østergård et al., 2016 describe them – multi-collaborator). The feasibility phase may be complete before some of the design team or construction team members are even appointed to the project. In this case, the expertise and experience of these individuals or organisations may not have been available at the time of making certain important decisions about the project, as it is well documented that the decisions that can have the highest impact on energy performance are made very early in the project, (Østergård et al., 2016). Design and construction teams are generally temporary multi-firm configurations, or TMFCs (Dunphy & Morrissey, 2015) that have been assembled for the purpose of a particular project. There are four features of temporary organisations; Time, Task, Team, and Transition (Lundin & Soderholm, 1995 in Dunphy & Morrissey, 2015). Projects by their nature are one-off occurrences. The TMFC is created for a particular period of time, for a particular task. Those involved may or may not have existing relationships or prior experience of working with one another. Multi-objective optimization (Dunphy & Morrissey, 2015) will be required to consider the trade-offs between multiple, and possibly competing objectives within an energy retrofit project, for example the trade-offs between short and long term gains, payback or savings versus initial capital outlays and other costs.

2.4.4. Tools and Models

In order to obtain the optimal solution for the renovation, refurbishment or retrofit project, decision-making models and tools are utilised. Modelling and articulating trade-offs is vital to the decision-maker (Dunphy et al., 2012). The words tools and models, and related terms, (modelling framework, etc.) are often used interchangeably but a model is a simplified representation of a system, whereas tools (or modelling framework etc.), according to Gironès, et al., (2015), are methodologies applied for the development of the model, they refer to interaction between the users and the model.

Failure to account for micro-level decision-making in models can result in resistance to the intended purposes of a system, and understanding and unlocking the human elements of the system is key to adaptive capacity and resilience (Elsawah et al., 2015). *"Explicitly expressing decision making and underlying assumptions, in a transparent way, gives decision makers an opportunity to: reflect on their practices, explicitly link actions and effects, and see the rationale behind other's practices. This fosters individual and group learning, and improves the prospects for communication, negotiation, trust-building, and hence, collective action"* (Pahl- Wostl et al., 2007 in Elsawah et al., 2015).

Mental, or cognitive models are used to understand stakeholder functioning and knowledge. Models help to highlight hierarchies, networks, and relationships. Connections between individuals, and/or groups as well as causal links can be indicated. Models are cognitive constructs that people use when perceiving and interpreting information as a basis for decisions and behaviours, a descriptive decision theory to explain how people make decisions based on how they perceive their surrounding world (Craik, 1943; Johnson-Laird, 1983 in Elsawah et al., 2015). Mental models are subjective, encompass ideas, incomplete, flawed, and sometimes inconsistent, context specific, dynamic, not consciously known by their owners, hard to access because of our limited capacity to verbalise our mental models, and not inclusive of elements such as emotion (Elsawah et al., 2015). Cognitive mapping is a technique used to create a visual representation of a mental model. The term has been in use since the 1940s, and was originally used in order to understand decision-making.

One example of such a technique would Fuzzy-Logic Cognitive Mapping, (FCM). Gray et al., (2012) use FCM to develop stakeholder and community cognitive maps, individual representations of the concepts and causal relationships in social and ecological systems, showing how they operate based on defined components and the causal links between them, where the components can be either quantifiable constructs like temperature or abstract constructs such as satisfaction. Cognitive mapping can be used in the following four ways (Ackerman and Eden, 2010 in Elsawah et al., 2015):

1. *"to elicit, represent, and sometimes compare, individual mental models (e.g., Hjortsø, 2004);*

2. *to support a group working on strategy development or analyse a complex issue (e.g., Eden and Ackermann, 2004);*
3. *to inform quantitative model building (e.g., El Sawah et al., 2011; Giordano et al., 2013);*
4. *to support the structural analysis of large maps. This paper uses cognitive mapping to elicit and represent individual mental models as a basis for developing numerical Agent-based Models."*

2.4.5. Stakeholder Knowledge and Perspectives

Integrating stakeholder knowledge adds flexibility to social-ecological systems because diversity reduces rigidity, represents multiple perspectives and promotes adaptability in decision-making. Knowledge is not a static resource – it is linked to the organisations and individuals who use it (Girodon et al., (2015). A knowledge system refers to a coherent set of mental constructs, cognitions, and practices held by individuals within a particular community (Richards, 1985 in Gray et al., 2012). Knowledge is often divided loosely into Local Knowledge and Scientific Knowledge, though all stakeholders possess both types to different extents. Local knowledge includes individual experiences, non-expert, localised information as well as traditional, indigenous and lay knowledge mediated by personal or cultural experiences. Care must be taken however, not to assume that the integration of stakeholder knowledge is a panacea, Gray et al., (2012). The term informal learning is another form of stakeholder knowledge referred to in the literature. According to García-Peñalvo & Conde, (2014) informal learning is an essential element in the decision-making process that takes place in the context of everyday experiences. Elsawah et al., (2015) provide a five-step method for integrating stakeholder knowledge and perceptions (qualitative) into formal simulation models (quantitative) with the ultimate goal of improving understanding and communication about decision making in complex socio-ecological systems.

These five steps are as follows:

1. Interviews (to elicit mental models)
2. Cognitive Mapping (to represent the models)
3. Time-sequence diagrams (to chronologically structure the decision making process)
4. All-encompassing model of decision making
5. Computational models

Stranzali & Aravossis (2016) point out that the energy sector affects so many actors, that it is now not social acceptable to suggest, or implement policies regarding energy without taking into account the interests of the multiple factors and multiple affected parties. The built environment also requires multi-criteria decision-making. Multi-criteria Decision analysis (MCDA) techniques, popular in sustainable energy management, help to provide solutions to the problems involving conflicting and multiple objectives, and is often used in combination with Fuzzy methodologies. Kollmuss & Agyeman, (2002), point out that modelling behaviour is so complex that not only can it not be visualised in one single framework or diagram, but that developing a model that tries to incorporate *all* factors may be neither feasible nor useful – it can help to illuminate this complex field.

Multi-Level Perspective (MLP) frameworks can also be used as an aid to decision making. This combines various methods and tools from the fields of foresight, impact assessment, simulation modelling, and societal embedding, (Auvinen, et al., 2015). The notion of transitions in socio-technical systems is central to their approach, where a socio-technical system consists of the following elements: production, distributions (consisting of markets, networks and infrastructure), the use of artefacts, and the resources to endorse them, like knowledge, capital, labour and cultural meaning. The MLP has three levels; the niche level (new innovations), the socio-technical regime level (stability of existing systems) and socio-technical landscape (exogenous macro-developments). The decision making process begins with identification of the decision-making situation, followed by an analysis of the socio-technical system. Changes and drivers to the system are then identified, and modelling and simulations are carried out. Iterations are likely to be required.

2.4.6. Types of Decision-Making

Decision-making can be deliberative/analytical or intuitive/emotional. Menzel (2013) differentiates between emotions and intuition, where emotions relate to affective states, such as anger, fear or joy in relation to something whereas intuition is more strongly related to decision making and it's often cited when decisions are made that appear quick and without interference of thought, observation or reason (Johnson-Laird, 2006, in Menzel, 2013). The dominance of analytical thinking and deliberative decision-making is prominent in many models despite evidence for emotion and intuition in decision-making. Menzel, (2013) feels that policy advice based on a rationalist perspective to foster sustainable behaviour has approached its limits, and that alternatives to the rationalist models of human-decision making behaviour are needed to question *'why do we often knowingly behave unsustainably, even though we consider it important to act otherwise?'* This is a question that has been dealt with extensively in academic literature; the phenomenon is generally referred to as The Value Action gap. It is not intended, therefore, to discuss this in detail here, but instead to focus on how it relates to decision-making (and vice versa). Dual models that examine both the deliberative and intuitive decision making processes should therefore be considered.

These systems are explored in the concept of Brain Modulatory in Neuroscience (Brocas & Carrillo, 2014). Two emerging and related fields also engaged in attempting to understand decision-making processes are Neuroeconomics and Neuromarketing (Sebastian, 2014). These fields highlight the links between decision-making processes and parts of the brain (studied with imaging technologies), often for the purpose of examining consumer behavior, and why people decide to buy a particular product. Multi-process theories rely on the existence of several brain systems interacting with each other in order to perform tasks such as decision-making. Dual system theories, or dual system models presume that the human brain employs two different computational principles, or processes in decision-making, and that there is no unitary reasoning system in the brain (Menzel, 2013). The two systems are referred to as System 1 (the affective, associative or experiential system) and System 2 (the deliberative or analytical system). System 1 works quickly and automatically, performing intuitive decision making, while System 2, processes information, symbols, logic and analytical thinking (Metcalfe and Mischel, 1999; Osman, 2004; Slovic et al., 2004 in Menzel, 2013). Although described as functionally separate roles in Dual System Theory, it has also been suggested that decision-making is actually a complicated composite of both analysis and intuition, and that analytical processes cannot be completely separated from emotion because emotional involvement is necessary to motivate analytical thought, and that mental processes fall along a continuum stretching from fully automated to fully controlled (Phelps, 2009, Goodenough & Prehn, 2004, and Evans 2011 in Menzel, 2013). Emotions and intuition (System 1) are as essential to decision-making as analysis and deliberation (System 2).

2.4.7. Decision-Making and Behaviour

Early models of pro-environmental behaviour assumed that increasing environmental knowledge, led to an increase in environmental attitudes and as a consequence, pro-environmental behaviour. These models are known as the information deficit models (Kollmuss & Agyeman, 2002). Information deficit models persist although they have been proven to be wrong. Other barriers between environmental concerns (aside from lack of knowledge) have been identified, such as Individuality, Responsibility and

Practicality (Blake, 1999 in Kollmuss & Agyeman, 2002). The responsibility barrier is closely associated with the locus of control, people who make certain decisions to behave in a certain way according to the amount of control or responsibility they have over a particular choice. The "Locus of Control" of the decision maker is cited in the literature as having a very strong influence on decision-making. Dumitriu et al. (2014) examine the influence of the locus of control of leaders on the decision-making capacity of their leadership style which examines the theory of locus of control, or internal versus external control of reinforcement introduced in the 1650s and 60s. Stenmark & Mumford, (2011) cite various studies that also point to the importance of situational influences on leaders' decision making. These situational variables include performance pressure, interpersonal conflict, threats to self-efficacy, decision-making autonomy, types of ethical issue, and level of authority. Although Stenmark and Mumford do not list locus of control, it is related to several of the variables, such as autonomy and authority. Groups or teams of people can carry out decision-making, as well individuals. The group or team (or household for example) may make their decisions based on a general consensus between the members of team, or at least the most powerful members of the team, or based on the opinions of an official or unofficial leader of the team whose decisions they will follow. Certain research on team performance suggests that teams are more effective at decision-making than individuals, and teams with a high individual participation; minority opinions encourage creativity. Whereas other research indicates that while consensus increases "buy-in" from the individual team members, decisions can be "watered-down" (and slow) in order to reach consensus, and that there is a danger of "groupthink" and sticking with the team decision even if an individual privately disagrees with it, for the sake of keeping the team cohesion (Yang, 2010). Team coherence and a shared perspective will have a significant effect on decision-making. Social networks are also an important consideration, and as an extension to that, social media networks. Studies indicate that tastes for products, services and behaviours can be contagious and spread through social networks (Chorus, 2015), this is evident in they way products, services and behaviours can go "viral", and is an entire field of study in itself.

2.4.8. Influencing Factors

People who believe that they can influence outcomes through their own efforts, skills, and characteristics are designated as having a strong internal locus of control, whereas those who perceive that outcomes are determined by external factors such as luck, chance, fate or the power of others are designated "externals" (Millet, 2005 in Dumitriu et al., 2014). The former are seen to be preferable for successful leadership, but also for pro-environmental behavior, or in this case, pro-energy saving behavior. The "externals" might assume that there is no point in carrying out an energy retro-fit because their actions cannot amount to much the overall context of global warming, or that the actions of one person cannot make any difference. Studies have shown that employees with greater degrees of autonomy tend to be more internally motivated to perform their job, which in turn improves their job satisfaction, creativity and performance. However, when it comes to decision-making the relationship is complex, as both too much, and too little autonomy can lead to poor decision-making (Stenmark & Mumford, 2011). The make-up of the teams directly involved in the project will also be relevant. For example, the TMFCs loyalties will inevitably be divided between the ultimate goals of the project, and the ultimate goals of their organization, and this will be reflected in their decision-making.

In addition to internal factors such as locus of control, knowledge, awareness, motivation, emotional involvement (or investment) and values/value-chain analysis (an important driver for behavior according to Martin, 2015), external factors also influence environmental attitude and pro-environmental behavior. Demographics factors, in particular gender and length of time in education, have been shown to have an effect on environmental decision-making. Other external factors, such as institutional factors (or infrastructural factors e.g., public transport), economic factors, and social and cultural factors affect decision-making and behavior (Kollmuss & Ageyman, 2002). Chorus, 2015, describes (in this case moral) decision-making as socially endogenous, where behavior, as well as the norms from which it originates, are to a large extent determined by the perceived or expected behaviours of others (which are in turn based on the same social processes). Most decisions involve other people, either directly, or indirectly. These other people could be family, friends, colleagues and persons known to the decision maker, or total strangers, future generations, or society at large. Culture may also be a factor – for example, paying a mortgage in some cultures is not only the norm, but also something of an aspiration, while in other cultures it would be completely immoral to accrue such a debt, and then to have to pay interest on that debt (Bucciarelli et al., 2008 in Chorus, 2015).

2.5. Design bottlenecks

2.5.1. Assessment of Bottlenecks in Design Process

According to design literature, there is a common apprehension that the overall performance of the AEC industry has not evolved with other industries and that there still are too many quality errors. A finger is pointed towards building design as a major factor of low performance. Moreover, it has been proven that these problems influence building projects as a whole negatively in terms of increased costs or reduced productivity (Baldwin et al., 1999). Similarly, failures to fully understand clients' requirements and value, influence the value of buildings negatively in a form of clients not getting what they really need and want (Thyssen et al.,2010).

Many projects are not able to realise their value potential and this is argued to be due to managerial problems in the design phase (e.g., Hamzeh et al., 2009; Hansen & Olsson, 2011). One of the reasons for this is the complexity of the design phase, and especially the early design phase where iterations are essential for value creation (Ballard, 2000). The management of a mass production factory can always be planned sequentially, where activity A must be completed before activity B can start. This is seldom the case for building design management, where several iterations are meant to generate value, consequently making the early stages of the design phase a complex process to manage. The understanding of the nature of processes is necessary to manage building design. The nature of processes is complex and consists of many types of interdependencies that need to be addressed differently in design phases. Allowing iterative processes to run as long as necessary can be beneficial to the value of a project, but if they run too long they can have serious implications for a project, concerning time and cost. Acknowledging how this logic influences the design process is the first step to improve the way we manage the process.

In the paper "Critical Success factors of partnering in the building design process" (Dogan et al 2015), bottlenecks in the design process deriving from stakeholders' interactions are analysed. As a matter of fact, the building design process typically involves the participation of architects, engineers (structural, mechanical, electrical, and environmental engineers) and material suppliers. In some project delivery systems, contractors are also involved in the design process. The lack of effective coordination among different disciplines in the building design process may affect not only the design but also the construction processes and the final product, creating problems related to schedule, quality, manpower, materials used, and cost. The interaction of the project participants is vital for the success of the project. The multi-dimensional fragmentation in the building design process presents special challenges to design participants. The successful management of these challenges requires the harmonious regulation of the demands of the various disciplines involved in the design phase. Partnering is a process that is expected to reconcile the conflicting demands of the participants in performing design tasks.

2.5.2. Bottlenecks in Design Process derived from the use of simulation tool

Testing is a critical part of the design process, no matter how complex or simple, every design must be vetted to ensure it works as intended. Typically powerful software tools can simulate how a design would work enabling virtual tests to be carried out long before time-intensive and costly physical and thermal model are made.

When the goal is to offer time-efficient design services for construction industries, simulation software integrated into CAD software shortens the learning curve because of the similar workflows in these programs.

Despite the benefits of using building performance simulation being widely recognised in AEC industry, it is increasingly clear that there are difficulties in incorporating building performance simulation in standard design process, especially for low-budget projects. Simulation techniques have been widely documented, although their level of usage in industry varies. Incorporating building performance simulation in the design process is challenging because the design thinking and problem-solving paradigms of designers and simulators differ in terms of knowledge and praxis (de Souza, 2012).

Existing approaches to offer support for low-energy design tend to overemphasise the provision of computational support for design problem-solving. Thus, these perspectives tend to incentivate the straightforward application of robust simulation techniques and ignoring the designers' problem-solving preferences and the context of the process.

In general terms, Zapata-Lancaster & Tweed (2016) reported that respondents perceived that it was difficult to identify the time to start using simulation tools in the design process. Furthermore, the case study in the paper reports the simulation as a tool that aggravates conflicts. The second case study presented shows that even if a simulation tool was invoked during the design process progression (due to regulatory framework) for site analysis and evaluation of passive design strategies in RIBA Workstage 2, the design decisions were based on rules of thumb and experiential knowledge, because the tool did not inform the design conversations. Reportedly, simulation tools miss to inform the design development and to support the co-design and knowledge-sharing activities between design team members. The results of the study report that in the light of discrepancies, the credibility of the simulation results was questioned by the design team members.

2.5.3. Specific bottlenecks of Green Building Design Process

Specific bottlenecks where identified during the development of a green-building project following a specific reference standard such as LEED. These standards are reported to bring new conditions and restrains for all subjects involved in the process (Orsi, 2016). Such changes affect technicians, owners, bureaucracy and also the management tasks either during design or construction phases. The summarized categories of issues identified are:

- Misunderstanding of Commissioning Authority's tasks and process;
- Lack of appropriate clauses in bid documentation;
- Systematic cuts to budget due to change-orders and delays;
- Lack of knowledge about energy modelling role and process;
- Lack of project management role supervising the whole project.

The results of the research clearly identify three types of waste, namely: delays in project completion; money spent over budget; and non-achievement of sustainability points. The estimations reported considerable "waste" in terms of money (26,5% of the initial project budget for the design) and, in terms of project scheduling, the application of green-building practices on that particular case-study led to more than 3 years of delay, for the issues cited above and the duration of bureaucracy-related activities.

2.6. Participatory Design

Participatory design refers to family of approaches that attempt to widen participation in design and integrate the perspectives of end-users in the design process. Participation in this context is not just a matter of consultation or conducting research into end-users' habits or opinions. It involves a fundamental transformation of the user's role 'from being merely informants to being legitimate and acknowledged participants in the design process' (Robertson & Simonsen, 2013: 5). Participatory design can also have the potential to bring researchers and end-users closer through dialogue and continuous learning (Svenfelt et al., 2011). The literature on participatory design derives from research in a wide range of areas including information and communication technologies, consumer goods, planning and urban development, and architecture and building design. It should be noted that participatory design is not a new concept; it dates back several decades (Woolley, 1985). This section offers a thematic review of the literature, summarizing the state of the art on key issues in participatory design and identifying gaps and potential for further research.

2.6.1. What is participatory design?

Participatory design (also referred to as co-design) emerged as a backlash against what was perceived as the overly rationalist and top-down approach embodied in the design science movement of the 1960s. Much of the initial impetus came from Norway, Denmark and Sweden, and was focused around the design of new computer technologies in the workplace (Sanders & Stappers, 2008). These were seen as having the potential to fundamentally change the nature of work, the design process, and their associated power structures. A critical moment came in 1971, when the Design Research Society held a conference in Manchester on the theme of 'design participation' (Sanders & Stappers, 2008). In an indication of the potential scope of participatory design, Robert Jungk wrote in the closing comments to the resulting publication, *Design Participation*: 'we could talk not (only) about participation at the moment of decision but about participation at the moment of idea generation' (quoted in Sanders & Stappers, 2008).

The participatory design movement was influenced by existing trends in user-centred design, largely emanating from the United States, where designers sought to learn about the needs of the user. However, while in user-centred design the user is not really part of the team, but is spoken for by the researcher, in participatory design the user becomes a critical component of the process (Sanders, 2002). From the 1980s onwards, design firms began including the social sciences in the design process to help find ways of more effectively incorporating user perspectives (Sanders, 2002). Since then participatory design has grown to become an established field of practice and research, with its techniques applied in a variety of areas from software development to urban planning (Dalsgaard, 2012).

Around the same time as participatory design emerged in the area of computing and information technology, some architects and town planners began to look for ways to involve people in the design of various aspects of their everyday built environments (Sanoff, 1978). Top-down, 'scientific' approaches to urban renewal and planning began to be challenged by more inclusive and participatory approaches where a variety of social actors are given the chance to speak and be listened to (Ferilli et al., 2015). Key contributions to the literature around participation in urban planning, as summarised in Ferilli et al., 2015, have included Arnstein's (1969) famous 'ladder of participation', Sandercock's (2000) argument on the role of civil society and diversity, and Fainstein's (2010) comprehensive analysis of social justice and inclusion issues in urban development, while Sarkissian and Bunjamin-Mau (2009) have developed a comprehensive, hands-on approach to participatory public debate and deliberation. Design for sustainability has also begun to integrate ideas from the participatory design movement into architecture and planning (Sanders & Stappers, 2008: 16).

Participatory design promotes the active involvement of stakeholders, such as citizens, employees, customers and end users, who are not usually afforded a central role in the design process (Cross, 1993). Robertson & Simonsen (2012) describe it as comprising 'the direct involvement of people in the co-design of tools, products, environments, businesses, and social institutions'. They see the participatory design approach as 'a process of investigating, understanding, reflecting upon, establishing, developing, and supporting mutual learning between multiple participants' (2013: 2). Users move from being passive informants to having an active design role that is acknowledged by other stakeholders as both legitimate and valuable (Robertson & Simonsen, 2013). They are recognised as experts on their own experience, and consequently play a large role in offering knowledge, generating ideas and in concept development (Sanders & Stappers, 2008). The design professional supports the user by providing tools for ideation and expression. Participatory design is therefore a two-way process of mutual learning for both designers and users (Robertson & Simonsen, 2013). On the one hand it seeks to enable those who will use a technology or product to have a voice in its design; on the other, it involves design professionals helping people who may not have technical knowledge define what they want from the design process, and understand what is technically possible. Designers seek to understand how a building works from the users' perspective, while users attempt to give expression to their desired outcomes. 'Designers need insight into practice, users need insight into technological potentials, and the best way of developing this reciprocal knowledge is collaboratively through joint, practice-based experiments' (Dalsgaard, 2012: 44). This exchange of information and views is very much a social process. 'Participatory design is driven by social interaction as users and designers learn together to create, develop, express and evaluate their ideas and visions' (Robertson & Simonsen, 2013: 8).

To date, however, participatory design has tended to be deployed on smaller-scale projects rather than on large-scale developments (Dalsgaard, 2012). User involvement 'remains a vague concept and a highly varied practice' while 'design discourse has merely scratched the surface in unpacking meanings about participation and the ways these meanings affect design outcomes' (Winschiers-Theophilius et al., 2012). In urban regeneration and planning, in particular, there is often a profound contradiction between the declared intention of participatory processes and their actual achievement in terms of community involvement and impact on project outcomes (Ferilli et al., 2015). While inclusivity is acknowledged as a key component of new approaches to building design such as integrated design process, there is still no consensus on how to achieve it.

2.6.2. From rationalist to practice-led design

Participatory design gives a voice to occupants and end users and in this way marks a clear move away from top-down models of design. From the beginning it voiced a critique of the cultural, political and economic values inherent in formalised models of human activities, which were explicitly connected with the rationalist tradition of western philosophy (Greenbaum & Kyng, 1991). In an important early critique of rationalist approaches to technology design, Winograd & Flores (1986) argued that traditional design practices characterise situations in terms of identifiable objects with well-defined properties; find general rules that apply to situations in terms of these objects and properties; and then apply the rules logically to the situation of concern in order to draw conclusions about what should be done. The effect is a top-down, formalised perspective which renders invisible the social, embodied and contingent nature of everyday practices. Contesting such rationalised accounts of human behaviour, participatory design emphasises both the concrete contexts of human action and people's right to participate in shaping the worlds in which they act.

In line with this philosophical orientation participatory design adopts a socio-technical approach which takes account of the context in which a product will be used and the everyday practices of the users (Robertson & Simonsen, 2013: 7). Practice plays a central epistemological[5] role in participatory design (*ibid.*). Social practices are routinized behaviours shaped by their technical, social and historical context (Barr & Prillwitz, 2014: 7). Practices are performed by individuals but shaped and sustained by collective conventions and contexts (Gram-Hanssen, 2011). These include technical infrastructures, institutional arrangements, systems of governance, and the norms and values of social groups. The practice approach is therefore neither purely individualistic nor rigidly structural but takes account of the wide variety of factors shaping everyday behaviour (Crivits & Paredis, 2013: 308). Consumption settings, infrastructures, technologies, materials and land-use not only influence individual behaviour but produce conventions or prevailing standards or expectations of conduct which shape people's routines (Barr & Prillwitz, 2014; Seyfang & Smith, 2007).

Such concrete and embodied practices are often very different from the formalized ways in which people's behaviour might be described by others or depicted in schematic models. Practitioners of participatory design adopt a practice-led approach, in which they strive to learn about the practices and contexts of those who will use their designs, at the same time as end-users and other participants learn about possible technological options. They conceive their activities explicitly 'in terms of an ongoing, active process of designing (a verb), which is typically iterative and involves testing various ideas and prototypes before settling on the final design (a noun)' (Romme and Endenburg 2006). Because of this, there is a cross-over between participatory design and ethnography[6]. 'Rich accounts of practice and the understandings they enabled were considered early in the development of Participatory Design as alternatives to the formal diagrams and abstracted work procedures that had guided so much early technology design' (Robertson & Simonsen, 2013: 7). Mutual learning throughout the process provides all participants with increased knowledge and understanding (Robertson & Simonsen, 2012: 5). 'Practice plays a central epistemological role in Participatory Design that complements its rejection of technology-driven formalisms and rationalist models of both work and design...practice is understood as a social activity' (Robertson & Simonsen, 2012: 5).

2.6.3. Benefits and challenges of user participation

---

[5] Epistemology is the branch of philosophy which deals with questions of what we can know and how we know it. In social science, epistemological questions are central to debates on methodology. For any given method, a researcher needs to be aware of issues like what kind of knowledge of social life the approach offers, how it provides this knowledge and what are its limitations. For example, in assessing the drivers of residential energy use in buildings, quantitative methods may provide readily comparable data on a large number of users which will allow us grasp overarching patterns and reach generalizable conclusions - but at the cost of abstracting from the actual experience of particular users. Qualitative methods like semi-structured interviews or participant observation, on the other hand, can afford the kind of detailed, fine-grained picture that will allow us 'get inside people's heads' and understand why they behave as they do. However it may be more difficult to reach generalizable conclusions.

[6] Ethnography is a social science methodology which uses participant observation to construct detailed accounts of human behaviour in a specific social or cultural context.

There is increasing recognition in the literature of the benefits of inclusive, collaborative approaches to building design. In particular, the involvement of occupants and other end-users in the design process has important advantages for building energy retrofit projects. At the same time, effective implementation of participatory design encounters a number of challenges.

One benefit of participatory design, which has been touched on already, is that building occupants and users are by definition the experts on their own lives. By actively involving them, the design process benefits from a uniquely informed perspective on their needs and requirements. This provides for a better design fit and for retrofit solutions that are more appropriate for the occupants' needs. Moreover, early engagement with building occupants, which incorporates their needs and desires in the design process is the most effective way of avoiding conflict – and the delays, cost-overruns and planning difficulties which often accompany it. It is widely acknowledged in the literature that occupant and user participants in the design process bring new information, motivation to address problems, and new ways of understanding issues to the design process. These can be used to generate better projects and policies, secure buy-in for decisions, and limit delays, mistakes, and lawsuits. The process of participation may enhance trust, build social capital, and generate infrastructure for ongoing community action (Bryson et al., 2013).

Occupants also have a key influence on the successful operation of energy retrofit solutions. This is particularly important given that studies show household behaviour affects residential energy use to the same extent as equipment and appliances (Lindén, Carlsson-Kanyama, & Eriksson, 2006). Even where buildings have been retrofitted to high thermal standards or incorporate energy-efficient technologies, ingrained patterns of behaviour mean that many households continue to consume more energy than expected (Galvin, 2013; Gram-Hanssen, 2011). Crosbie & Baker (2010) observe that technological improvements cannot be effective without the cooperation of building occupants. If occupants are not willing or able to engage with the installation and utilisation of energy efficient retrofit solutions effectively, then the expected efficiencies cannot be achieved, regardless of how much energy these measures could hypothetically save. Woolner (2009) suggests occupant involvement at an early stage affords designers access to user experiences, knowledge and desires, which can assist in the selection of appropriate retrofit solutions. It also contributes to the building of relationships and trust, which can assist in post-occupancy communication on the optimal use of the selected retrofit solutions. By ensuring occupant buy–in, and tailoring energy-saving measures to occupants' lifestyles and needs, participatory design can help avoid many of the problems which can negatively impact on the performance of retrofitted buildings.

In conclusion, while participatory processes are increasingly being turned to as a tool for addressing user behaviour in buildings (Doyle & Davies, 2013), and ensuring the most effective use of energy-saving technologies, the benefits are not confined to this. They include better functionality, improved design, greater occupant and user satisfaction, and the minimisation of conflict – in addition to empowering occupants and end-users to co-design the environments they will inhabit.

On the other hand, the successful implementation of participatory design – especially in a large-scale project – can face significant challenges. Some of these are identified by Simonsen & Hertzum (2012). They include securing the appropriate conditions to employ participatory design; managing a multitude of stakeholders and managing stepwise implementation processes. Dalsgaard (2012: 42) notes that while many early participatory design projects were undertaken in workplace settings, in which the stakeholders could be readily identified, in other kinds of projects – such as public buildings – the pool of potential future users may be diffuse and highly heterogeneous. Moreover, while an important strand of participatory design involves engagement with local communities (for example in urban regeneration projects), their interests are typically fragmented, diverse and often contradictory (Ferilli et al., 2015). In such cases participation can often be a rhetoric used to simulate a social consultation when decisions have already been taken in advance (Ferilli et al., 2015).

2.6.4. Depth of participation

A key issue is the depth of participation, which must be matched to the nature of the project, the needs of the stakeholders, and the goals of the project itself. For example, in retrofitting an apartment block occupied by long-term residents, a strongly participatory process with the incorporation of occupants' perspectives in the design will be indispensable. On the other hand, in retrofitting an office building, which has been emptied of tenants, participatory methods will be less important – although there might still be benefits in talking to potential tenants and taking account of their needs, expectations, and everyday practices in the design.

Arnstein (1969) forwarded an useful taxonomy of citizen participation, which she divided into three broad categories, namely non-participation, tokenism and citizen power. She further divided these into subcategories which she presented as rungs on a ladder, intended to differentiate between 'empty rituals of participation' at the bottom of the ladder and 'real power to affect the outcome of the process' towards the top.

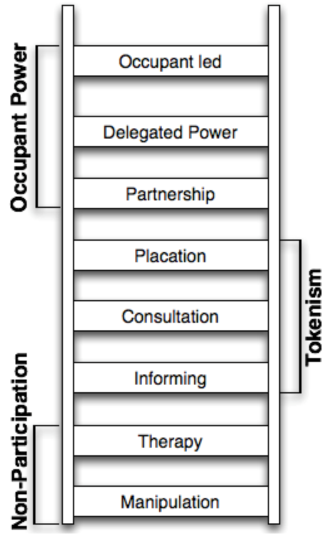


FIGURE 6: LADDER OF PARTICIPATION, ADAPTED FROM ARNSTEIN (1969)

Where the aim is merely to meet legal requirements or communicate some information to the public, this may be achieved by a relatively shallow consultation process, involving traditional public notices and meetings (Bryson et al., 2013). On the other hand, deeper participation may be required in order to enhance understanding of a problem and explore and generate potential solutions, or to improve the quality of a project (Bryson et al., 2013). In this case a more far-reaching engagement involving deliberative approaches and small-group formats would be appropriate (Bryson et al., 2013). The participatory design process requires moving beyond tokenism to afford occupants a degree of actual power as conceptualised in the upper rungs of Arnstein's 'ladder of participation'.

Arnstein's 'ladder' reminds us that, in the words of Robertson and Simonsen (2013: 3), 'Participatory Design is also a political process'. Participatory design threatens existing power structures by requiring that control over the design of a project be relinquished and given to potential customers, consumers or end-users (Ferilli et al., 2015; Sanders & Stappers, 2008). This has significant – and potentially challenging – implications for stakeholders such as architects and engineers, who have traditionally dominated the design process, as well as building owners and commissioning bodies such as public authorities. An important strand within the literature concerns the political orientation of participatory design, which is one of empowering citizens and communities. 'The political rationale for genuine participation in design reflects a commitment to ensuring that the voices of marginalised groups and communities are heard in decision-making processes that will affect them. The motivation was and remains democratic and emancipatory' (Robertson & Simonsen, 2013: 6).

Creating the space for genuine engagement can involve the use of deliberative approaches and small-group formats to enhance understanding of the occupants' perspectives and needs; build trust and resolve potential problems as they arise; explore how occupants currently use energy and how they might be willing to change these practices; generate potential design solutions and ideas; and increase quality of outcome by taking advantage of the stakeholders' relevant knowledge and experience (Quick & Feldman, 2011).

Another issue touched on by Sanders & Stappers (2008) is the stage of design process at which users become involved. Some occupants and users may be motivated to act as co-designers throughout, while others may not. 'It depends on level of expertise, passion, and creativity of the 'user'' (Sanders & Stappers, 2008). People with a high level of knowledge and expertise in a particular domain are more likely to be both willing and able to take on the role of co-designer – for example, healthcare professionals in the design of a new hospital or clinic. Different approaches can be used for involving future users into the design development process based on their different levels of interest and creativity: 'It is not always the case that we want to push people beyond their level of interest, passion and creativity' (Sanders & Stappers, 2008). It is important to bring people into the design process in the way most conducive to their ability to participate. At the same time, it has been argued that to create an effective participatory design event, stakeholders need to be included throughout the design process, in order to build both a collective knowledge base and confidence in their collective decision-making ability (Smith, 2012: 3). Moreover, if users are involved early on in the design process, there is more scope for participants to grow in knowledge and confidence through the process itself, and for the facilitators to take steps to overcome any barriers of knowledge and expertise which may restrict participation.

Matching the intensity and timing of the engagement to the character of the project and the overall goals of the participatory design process is crucial to establishing its legitimacy with both internal and external stakeholders Developing a shared understanding amongst stakeholders of the nature and objectives of participation is a crucial initial step. Furthermore, the nature of the engagement and the tools and techniques chosen need to match the objectives. This should act to prevent conflicts arising about the authenticity and legitimacy of the participation, which may otherwise result from differing expectations of what the process is about. In short, legitimacy can be established by letting stakeholders know from the outset what is the purpose of the process, how it will be conducted and how their participation will influence outcomes (Bryson et al., 2013).

2.6.5. Inclusivity in participatory design

Alongside the depth of a participatory process, the other key factor is its inclusivity. Processes can vary widely in the number and range of stakeholders involved and the methods of engagement used, and where inclusivity is important, care and attention needs to be taken in designing the process to facilitate this. In the case of building occupants and surrounding communities, the readiness of people to engage in a participatory design process can differ markedly, with a variety of socio-economic factors having an important impact. This includes length of residence, type of tenure and sense of place: 'the way in which residents regard participation depends on a complex set of factors, and primarily on their personal level of identification with, and commitment to, their neighbourhood' (Ferilli et al., 2015: 2). Those residents who are better endowed, in terms of both material resources and education and skills, are often both readier and better equipped to engage in participatory processes. Bryson et al. (2013) observe: 'All too often, supposedly participatory processes end up including the "usual suspects," people who are easily recruited, vocal, and reasonably comfortable in public arenas'. There is therefore a case for utilising the technique of 'informed deliberation' (Fujiwara & Wantchekon, 2013) in an attempt to at least partially equalise participants' capacity to take part.

Kensing (1983) (cited in Dalsgaard, 2012) identifies three key requirements for participation in design: access to relevant information, the possibility of taking an independent position on the problems, and participation in decision-making. The demographics and social composition of a building's occupants and users, including factors like gender, income and education levels and the level of social investment they have in the building or neighbourhood, need to be taken into account in designing a participatory design process. These factors will not only influence the quality of the deliberation, but have a significant impact on the willingness or ability of occupants to participate. Emphasis should be placed on increasing the accessibility of the process to ensure a more diverse input. This might include: ensuring it is advertised widely, and through a variety of media; offering child care and transportation assistance; providing translation facilities for those who need them; and ensuring convenient meeting times and accessible meeting locations (Bryson et al., 2013).

Inclusivity also means managing the power dynamics within the consultation process to ensure that everyone gets the chance of meaningful participation, can exchange ideas, and influence the outcome of the process. Shifting from formal public hearings, which tend to be dominated by a small number of individuals comfortable with that format, to one-on-one interactions between public managers and residents, is one way of ensuring this. Another way to share power more evenly among participants is to engage them in co-producing the agenda and agreeing the criteria for making decisions (Bryson et al., 2013).

The importance of leadership within a participation process and the most effective strategies for leaders to follow are widely covered in the literature. Designing and implementing public participation clearly requires effective leadership — and increasingly so as the level of public participation increases (Bryson et al., 2013: 27). Three kinds of leadership roles are particularly important: sponsors, champions, and facilitators. Sponsors are people with formal authority that can be used to legitimize and underwrite a participation process, such as local authorities, building owners, or academic institutions. Champions are individuals responsible for actually managing the participation effort, by generating enthusiasm, building the support of sponsors, and sustaining the effort through setbacks. Facilitators structure the participation processes, maintain neutrality, deal with conflict, and help groups work together productively (Bryson et al., 2013: 28). Effective facilitators can play an important role in moving a participatory process towards the higher rungs of Arnstein's ladder, ensuring it is both deep and inclusive, and gives those involved a genuine role in shaping the final design.

2.6.6. Tools and techniques

In order to take on the role of co-designers, users need to be given the appropriate tools to express themselves (Sanders & Stappers, 2008). There are an immense variety of methods for engaging people in participatory design described in the literature, of which only a selection can be touched on here

Participatory design can include traditional forms of engagement like public meetings, as well as deliberative assemblies or one-to-one consultations. However it can also incorporate more innovative and accessible modes of communication, including mock-ups, scenarios, prototypes, design games, or even storytelling (Ferilli et al., 2015). Examples offered by Sanders & Stappers (2008: 13-14) include a presentation technique with a carftoonesque TV-frame to help shy people express their opinions more readily, and a three-dimensional tool-kit for generative prototyping of buildings. Generative design tools are tools which help one look forward to the possible future of people who will be living, working and playing in a building (Sanders & Stappers, 2013: 15).

Researchers involved in the design of Mediaspace, a large-scale project to develop a shared building for the municipal library and Citizens' Service Department in Aarhus, Denmark deployed a technique called 'living blueprints' to enhance participation (Dalsgaard, 2012). This is aimed at overcoming the difficulty of potential future users visualising what a future building will look like. It is a workshop based technique in which participants take on the role of a cardboard character and move themselves through the building to bring the future environment alive.

The Make Tools are described as a 'design language for users' which is 'built upon an aesthetics of experience rather than an aesthetics of form' (Sanders, 2002). Emotional toolkits allow people make artefacts such as collages or toolkits which express their stories or dreams, and allow access to their unspoken feelings and emotional states, while cognitive toolkits enable them to make artefacts such as maps, 3-D models, diagrams of relationships and flowcharts of processes (Sanders, 2002).

Information technology has opened up new vistas for involving building occupants and users in the design process. These technologies include public participation geographic information systems, computer generated visualizations, interactive Web sites, keypad voting, and strategy mapping tools. Technology can be particularly effective in providing technical information and enhancing understanding of context, providing public access to information typically available only to experts, and gathering real-time feedback from participants (Bryson et al., 2013). Visualization and other technologies can also help build shared understanding and facilitate interaction among users, as well as with the information provided (Bryson et al. 2013: 30). Social media (Dalsgaard, 2012) and community informatics (Ferilli et al., 2015) can help engage a wider community in the design process.

Design charrettes are a workshop-based framework used to gather a range of project stakeholders to set goals and identify strategies for achieving desired outcomes. To date they have largely remained aligned with the traditional building design process, with the participants typically drawn from the professionals working on the project (Smith, 2012). One source describes a charrette as 'A fast-paced intensive workshop with key client, design, engineering, and building participants…Charrettes provide a framework for achieving significant production and meaningful agreement among participants in relatively brief amounts of time' (Enterprise, 2011). The aim is to facilitate rapid and open discussion between major stakeholders of a development project. While such a process can in theory result in 'co-creation', this is not always the case nor is it always the objective.

Charrettes have also been used as a consultant tool for engaging the community in participatory workshops on potentially controversial developments (Smith, 2012). 'In the mid-1980s in a nod to the creative activity of the architecture students, community development planners adopted the name [charrette] to describe interactive, multiday community planning sessions' (Lennertz and Lutzenhiser 2003, 4). The charrette differs from other planning processes in many ways, particularly in the predominant use of maps, graphics and place-related tools as opposed to policy documents (Lennertz and Lutzenhiser 2003, 8). Other types of visualisation tools are used alongside sketches to explore project development. These include printed maps, plans, sections, perspectives, aerial views and elevation images, photomontage, PowerPoint, video, Skype and social networking media also help to convey information in a non-verbal form (Smith, 2012: 5).

2.6.7. Conclusion

As a movement, participatory design emerged from debates and experiments around the design of information technology in the workplace in Scandinavia. It combined a rejection of top-down rationalist and formalist approaches with a focus on the lived practices of individuals in their everyday environment and a commitment to the participation of users as experts in their own experience. Its subsequent development has continued to be strongly associated with information and communication technologies. Concurrently, another stream of practice and research has developed around the participation of communities in large-scale building projects, typically in the context of urban regeneration. However participatory design has not been widely applied to construction outside the context of urban regeneration. In particular, despite its potential benefits in terms of improving occupant and user engagement with new technologies, participatory design has not been integrated into the area of building energy retrofit. There is accordingly a dearth of research and literature in this area. Overall, the field has often seemed to be characterized by a variety of experiments rather than a systematic clarification of issues and accumulation of knowledge. Critical areas for further study include: how to effectively incorporate rich, practice-based studies of occupants' and users' everyday energy usage into the design of building retrofits; how the depth and inclusivity of occupant and user participation intersects with the objectives of building retrofit and the interests of other stakeholders across different types of building projects; and the comparison of different techniques of engagement in terms of depth of participation, inclusivity, cost and time required.

2.7. Energy retrofit in a district context

The need to substantially reduce carbon emissions, along with issues of resource availability and energy security, requires a substantial rethinking of established energy systems. This is especially important in urban areas, where the majority of Europe's energy is consumed but where there are also substantial opportunities to improve energy efficiency, and where there are benefits to be had from co-ordinated works and economies of scale. This is the background to the growing interest in energy retrofit in a district context. In line sustainable development, urban planning authorities require a comprehensive view of cost- effective opportunities to improve the performance of buildings at the neighborhood and district scale (Fonseca 2016). These measures can be implemented at building-scale (envelope and systems) and at distributed generation schemes (thermal and/or electrical micro-grids) or they can be on-site exploitation of renewable resources. The optimal deployment and integration of multiple locally available energy resources on a district or neighbourhood level can help improve energy efficiency and reduce carbon emissions (Mancarella, 2013). For example, distributed multi-generation involves the simultaneous production of electricity, hot water, space heating, cooling power, etc. from one or more fuel sources to serve a number of different buildings (*ibid*.). In additional to fuels like natural gas, local renewable energy sources such as solar, geothermal, wind or biomass can be incorporated into the network. In essence, distributed multi-generation is an expanded form of CHP, which can be applied outside the industrial or large institutional contexts to which CHP has traditionally been confined. Including multiple buildings in such a network not only allows the deployment of larger generation plants with resulting economies of scale, but more efficient use of the system through balancing out different heating and cooling needs, or peaks in demand and supply. Consequently, rather than considering the energy use of a building in isolation, future retrofits increasingly need to consider the district context through greater involvement of community stakeholders (see the previous section on participatory design), increasing the energy efficiency of the building stock, and enhancing the energy infrastructure through the inclusion of renewable energy systems, upgrading for efficiency or installing district energy services where they did not exist previously.

2.7.1. Advantages and challenges

The integration of a building's energy system into the wider district context offers an array of advantages, but also comes with many challenges. Considering an urban district as a single energy unit creates the potential for improved efficiencies through the implementation of centralised heating or cooling systems. It opens up opportunities for the exploitation of different slopes and tiles for solar technologies, as well as for the utilisation of common and public spaces for the installation of renewable energy technologies (Garcia-Fuentes et al., 2014). Where local renewable energy generation can be integrated into existing building structures, there is the advantage of requiring no additional land or material use (Allegrini *et al.*, 2015: 1394). District energy systems can also lead to a reduction in grid transmission losses and grid congestion issues. Consequently, determining the potential of renewables in an urban environment is important for the design of future urban areas and the retrofit of existing structures. Accurate modelling is essential to achieve this (Allegrini *et al.*, 2015: 1394).

In 2013, the United Nations Environment Programme (UNEP) surveyed low-carbon cities worldwide to identify the key factors underlying their success in scaling up energy efficiency and renewable energy. District energy systems emerged as a best practice approach for providing a local, affordable and low-carbon energy supply. District energy systems also offer potential for integrating energy efficiency and renewable energy technologies (UNEP, 2015). Linking the heat and electricity sectors through district energy infrastructure and utilizing low-grade energy sources, such as waste heat or free cooling, can greatly improve the energy efficiency of new or existing buildings. In mixed-use urban areas, networked renewable energy and storage systems which include interconnection between buildings that allows energy to be shared has proven a viable option, evening out imbalances between supply and demand (Allegrini *et al.*, 2015). It is therefore desirable for energy solutions at district level to incorporate bi-directional connection of energy systems in buildings, in the case of both electrical grids and thermal networks. On the district level, large ground- or water-based seasonal storage solutions can also be economically feasible. These allow seasonal balancing of heating and cooling and include water, gravel water pits, boreholes and aquifers (Pavlov et al., 2012; Bauer et al., 2010).

As the energy efficiency in a building improves, connecting to a district energy system can be more cost effective than a full retrofit, as Frankfurt, Germany, discovered when evaluating its 12,000 buildings with historic façades (UNEP, 2015). Experience in Rotterdam, the Netherlands, has similarly shown that above a certain threshold of energy efficiency, district energy is more cost-effective than retrofits. CHP plants can also operate at very high levels of energy efficiency – for example those in Helsinki use up to 93 per cent of the energy in their fuel source to produce electricity and heat. And in many cities – such as Dubai in the United Arab Emirates – district cooling can result in 50 per cent reductions in electricity use compared to other forms of cooling (UNEP. 2015: 12). However exploiting the potential of district energy requires the intelligent use of synergies, flexibility in demand, and both short- and long-term energy storage solutions, as well as new approaches to governance (UNEP, 2015).

While section 2.5 dealt with bottlenecks in the design process, there are a number of challenges associated with renovations and retrofits within a district context. Mismatch between supply and demand for example, is a key issue with renewable energy systems and district energy networks, requiring extensive network or storage solutions (Allegrini *et al.*, 2015). The current design method lack a comprehensive perspective assessing trade-offs between demand and supply interventions. Due to the fact that the decision making techniques do not include modelling to consider energy supply and demand simultaneously (Best, 2015).

For thermal energy, the greatest mismatch is between space heating demands in winter and solar availability in summer, leading to the need for very large-scale storage solutions to balance this seasonal disparity (Allegrini *et al.*, 2015). The socio-technical terrain into which a district energy system is incorporated also needs to be taken into account. This will usually be complex and space-specific, encompassing the physical characteristics and ownership of land and buildings, existing building heating technologies, established energy contracts, user practices and expectations, and interfaces with other energy systems (Hawkey *et al.*, 2013). Windows of opportunity for retrofitting, created by urban regeneration or the development of new infrastructure, may not suit the timescales of actors such as building owners and developers. Moreover, social constraints, such as the willingness of subscribers to connect to DHC, can be more difficult and time consuming to resolve than physical constraints (Hawkey *et al.*, 2013).

The discussion of district scale retrofitting has mostly focused on the technical implications of integrating net-zero energy developments or on the contrary social issues were in the focus. However it is clear that a holistic methodological framework is needed to address energy and sustainability retrofitting interventions both at building and district level.

2.7.2. Increase System efficiency

Environmental context: Urban microclimate

The energy demand for heating, cooling and lighting buildings, as well as the potential for solar and wind energy generation, is strongly dependent on the local microclimate of the urban district and even the building location. The microclimate in urban areas differs from rural areas: the air temperatures are higher due to the urban heat island effect, local wind speeds are lower due to wind sheltering by buildings, and solar radiation is influenced by shadowing effects and reflections from neighbouring buildings. The complex morphologies of urban areas also cause variations of the local climate on a very small scale (Allegrini et al., 2015). Therefore, it is important to account for the local microclimate and the effect of neighbouring buildings when conducting energy simulations.

The urban microclimate of a district has significant effects on the design process due to the limitations or constraints on retrofit options available for certain urban buildings. Due to the urban heat island effect, for example, the amount of energy for heating requirements may be lower, on the other hand energy required for ventilation and cooling will be far higher than a similar building in a sub-urban or rural setting. Passive solar gain may not be possible even on South facing facades due to shading from neighbouring buildings and structures. Natural ventilation for cooling in higher urban temperatures may not be desirable due to outdoor humidity, noise and pollution levels. Due to a lack in permeable surfaces and natural surface and storm water attenuation areas, climate change, and the likelihood of an urban area being adjacent to a large body of water (rivers, estuaries, sea etc.) flood prevention may dictate design choices, as might seismic design in earthquake prone areas (although the latter is not strictly a micro-climate issue).

District networks

Central to the development of energy efficiency and renewable energy generation at the district level are the characteristics of the networks that tie groups of buildings and energy systems together. A number of reviews of the different options available have been undertaken in the academic literature. Chicco and Mancarella (2009) conducted a review of relevant concepts regarding small-scale distributed multi-generation, including virtual power plants, micro-grids, integrated energy systems, energy hubs and intelligent power grids. Mancarella (2014) provides an overview of multi-energy systems. Rezaie and Rosen (2012) give an overview of district heating and cooling technologies. Harvey (2012) details many aspects of low-energy buildings and also addresses districts. Heier et al. (2015) review thermal energy storage in buildings. Energy networks, hubs and multi-energy grids are all key enabling technologies in achieving greater integration at district level and increased levels of renewable energy penetration, as balancing demand and supply between disparate building types can greatly improve load matching and resource utilisation. Optimisation approaches such as the energy hub concept are applicable at different scales: having been conceived to address dispatch problems in national electricity grids, they are now being widely applied to district and building-scale problems (Allegrini et al., 2015: 1401).

A simple concept to manage energy flows by regulating conversion, storage and distribution is the energy hub. This is a single entity containing all conversion and storage technologies, which supplies electricity, heating and cooling at the output ports of the hub (Allegrini et al., 2015). It can be used to manage energy flows within a large building as well to regulate systems ranging in size from neighbourhood to national level (Allegrini et al., 2015). Academic studies of the operation of energy hubs include studies of energy hubs in Baden Dätwil, Switzerland (Schulze et al., 2008) and in Waterloo, Canada (Parisio, 2012). The technologies involved in these instances were centralised systems based on gas and electricity. Energy hubs for multiple discrete buildings are rarely addressed in literature. An exception is provided by Orehounig et al. (2015), who describe a method for integrating decentralised energy systems at neighbourhood scale based on the energy hub concept. The original energy hub concept is developed in the paper to include decentralised and local energy technologies such as photovoltaics, biomass, or small hydropower, together with district heating systems, building and district conversion and storage technologies at neighbourhood level. This will be further explored in D2.3 *Models to assess the building-neighbourhood relationships and synergies*.

Separately, there is a long history of research into district heating networks, especially in the Nordic countries (Allegrini et al., 2015). District heating is an important source of domestic heat for a number of EU Member States, and is often praised as an efficient, clean and cheap technology with significant potential for carbon emissions mitigation (Herrero & Urge-Vorsatz, 2011). Many energy system analysts identify district heating networks as a critical prerequisite for cost-effectively integrating the zero- and low-emissions energy technologies necessary to meet GHG reduction goals (Baber and Damecour, 2008; Chow, 2009; Lund et al., 2010; Østergaard et al., 2010; Østergaard and Lund, 2011; Voss and Thorsen, 2012). District heating networks aggregate loads and provide economies of scale for a wide variety of heating and cooling supply streams. They also provide balancing capabilities for the electric system when integrated with technologies such as combined heat and power (CHP) (Chittum & Østergaard, 2014). The aggregating capabilities of district heating systems reduce costs per customer and make certain resources economical which would not be cost-effective on an individual customer scale. This is because the costs of new heat resources, such as drilling a geothermal well, are the same whether the resource serves one house or many, and district heating helps spread those costs amongst a larger group of customers. Maximizing the heat delivered, targeting areas of high heat demand, can also reduce the lifetime costs of a heating system using CHP and recruiting users with diverse daily and seasonal heat demand profiles (Hawkey et al., 2013).

In Central and Eastern Europe, on the other hand, aging district heating systems inherited from the communist era often perform poorly because of inefficient design, and heat costs are a burden on the household budgets of domestic users. In that context, significant energy cost savings and additional co-benefits can be realised through a large scale, deep retrofit of buildings connected to district heating, especially if the district heating itself can be made more efficient. In the long-term, however, the economic viability of district heating may be re-evaluated if nearly-zero energy buildings become the norm, as presently legislated in the EU, and the demand for domestic heat is drastically reduced (Herrero & Urge-Vorsatz, 2011).

Another method that can be used to connect buildings in a district is a low temperature network. A low temperature network allows demand for heating on one building to be balanced with waste heat from process and space cooling in buildings near at hand. Such networks are often linked to large seasonal storage facilities, such as borehole fields (Allegrini et al., 2015). Such networks provide a low-temperature source that can be used via decentralised heat pumps for heating, directly for free cooling, or indirectly as a low-temperature source for chillers. De Carli et al. (2014) studied the energetic and economic performance of a small low-temperature district heating and cooling network in Italy. Other studies of this form of district network include Ruesch (2013) and Molyneaux et al. (2010).

Renewable energy generation

Urban areas can be particularly suitable for renewable energy systems – not least the because of the close proximity of where the energy is to be used – reducing distribution and transmission losses substantially.

Renovation at the district scale lends itself to the implementation of various novel complementary technologies including for example: microgrids (Perea, 2008), smart grids (Clastres, 2011) decentralised energy systems (Orehounig et al., 2015) and facilitates the adoption of community energy business models (Gordon et al. 2007).

Solar technologies offer great potential for urban energy generation due to the availability of multiple surfaces on buildings as well as the maturity of the technologies themselves. On the other hand, urban morphologies make it difficult to assess the levels of solar radiation compared to open areas, due to complex shading patterns caused by different building heights, built densities and varying roof slopes (Allegrini et al., 2015).

The exploitation of the solar irradiation in urban zones has to be considered in the early design phase of the project. Methods should be used to quantify the potential of facades and roofs located in urban areas for active and passive solar heating, photovoltaic electricity production and daylighting (Compagon, 2004). Therefore, modelling is the main way to obtain solar radiation data on an urban scale (Jonsson et al., 2012).

Bioenergy sources can be used to produce heat and power in the urban environment using a variety of technologies, depending on the fuel type. Fuels are usually sourced from outside the city; sometimes biomass from tree pruning or similar activities can be exploited, but is not suitable for large-scale use (Allegrini et al., 2015). However, in the literature dealing with determining the potential for bioenergy in the urban environment, the lack of modelling is evident. Most studies are based on interviews, inventory analyses or green censuses (Allegrini et al., 2015). The local availability of bioenergy should also be considered. For example, biomass that can be used for energy purposes, in most cases has to be transported from the surroundings into the city which cause additional environmental impacts.

Even though wind energy is seen mainly as a national-scale energy resource, building-mounted wind turbines can also be used for micro-generation. Regarding the modelling of urban energy wind resources, Walker (2011) comprehensively reviewed the calculation of urban wind speeds as well as urban wind power production.

The design of multi-energy systems is becoming an important topic, driven in part by the need to integrate distributed energy sources. The integration of renewables, waste heat and local storage into complex systems requires models for bi-directional, closed-circuit and transient networks (Allegrini et al., 2015). Effective integration requires the balancing of demand and supply in geographic and temporal terms, which can be aided by computational methods (Allegrini et al., 2015).

2.7.3. Social and economic aspects

The development of district energy renovations is not just a matter of finding technical solutions. Social and economic issues must be addressed as well. District renovation projects are inherently complex, involving for example a very large number of stakeholders, multiple owners (and ownership models), and a diverse range of building types and uses. Retrofitting strategies often present the decision makers a multi-objective optimization problem. This complexity raises a number of challenges, three themes in particular bulk large in the literature: identifying appropriate business models to develop district scale energy systems and large-scale urban retrofits; the role of local government in facilitating and supporting district energy systems; and the inter-relation between district-scale building retrofits and the socio-economic characteristics of the local population. District scale retrofitting also means the technical harmonization of different building types, which can be a challenge as well. Moreover (deep) energy retrofitting often results in socio-economic drawbacks, such as increased rents (Mangold, 2016).

A study by Michelsen et al. (2015) found that large housing companies achieve economies of scale in green refurbishments of apartment buildings compared to private landlords. The authors suggest incentives should be created for private landlords in a neighbourhood to develop integrated refurbishment concepts for their properties and benefit from these scale economies. In Britain, the Sustainable Housing Action Partnership (SHAP) and Homes and Communities Agency (HCA) have produced a 'Community Green Deal' as a model for community-scale delivery of whole house retrofit, which aims to aggregate programmes for communities of between 750 and 3,000 homes that would achieve CO2 emissions reductions of 80%. The report sets out the building blocks for a framework to support delivery of whole house retrofit at an area-wide scale and includes financing models and supply chain opportunities (Coyne). Paiho et al. (2015) conducted an analysis of the potential for district-level building renovation in Russia, where district heating covers nearly 70% of the residential heating market in urban areas, and conclude that a modified ESCO model would provide the most suitable business model to implement these renovations.

The United Nations Environment Programme (UNEP) also undertook a detailed study of business models for district energy in their 2015 report. They concluded that the most appropriate business models would be those which ensure that all of the players involved – including investors, owners, operators, utilities/suppliers, end-consumers and municipalities – can achieve financial returns, in addition to any wider economic benefits that they seek. By evaluating the innovative business approaches being used elsewhere, planners can make better-informed decisions for developing and financially structuring systems in their own cities. The majority of business models for district energy involve the public sector; they range from fully publicly owned systems, to cooperative models and public-private partnerships, to privately owned and developed systems (UNEP, 2015: 14).

Other authors have also emphasised the importance of the public sector in promoting or supporting the development of district energy. Hawkey et al. (2013) analyse the different forms of governance of alternative local energy infrastructures – specifically CHP – in the UK, and the important role of social capital in supporting their development. Greenov (2010) emphasises that while the techniques to implement sustainable district refurbishment are available, local authorities need to play a role as generators and funders of exemplary actions.

Public policy is also an important factor for establishing the context for investment. For example, when the policy of giving grants for one-off retrofits proved not as successful as hoped, the Dutch government initiated an initiative (Energiesprong) to stimulate multiple-unit projects. The initiative brings the various stakeholders together with the aim to deliver net-zero energy retrofit projects within one week, and with no intrusion on the occupant. This was achieved through the use of new off-site manufactured energy efficient building envelopes (Antonelli, 2016; Cole, 2014). Energiesprong also focuses heavily on attractiveness, so the project must not only be "green" but must look good too (Cole, 2014). This is an idea that is likely to appeal to many of the interviewees who expressed strong views on the aesthetics of buildings.

Deakin et al., 2012 conducted a detailed study of the socio-economic impact of a proposed mass retrofit in a residential area of Hackbridge, London. They found that the benefits generated would not be spread equally amongst all residents. The most income- and employment-deprived residents lived in social rented accommodation which already exceeded national standards in terms of energy performance. On the other hand, the least deprived members of the community tended to live in either the owner-occupied or private-rented accommodation which was typified by older, less energy efficient and high carbon-emitting dwellings. Hence the more deprived tenants would receive few benefits in terms of energy savings, while their better-off neighbours would benefit most. The authors concluded that tenure should not be used as the basis for the retrofit, but the type, age, rates of energy consumption and levels of carbon emissions of buildings (Deakin et al., 2012: 200). Garcia-Fuentes et al. (2014) offer a planning methodology for district retrofitting in which energy and comfort conditions are evaluated while social, economic and urban aspects are defined in order to establish the main targets and goals to be achieved as well as likely challenges. For example, where a high proportion of a district's inhabitants are low-income residents like pensioners or the unemployed, this may place barriers to retrofitting (Garcia-Fuentes, 2014).

Often the retrofitting of buildings has high economic constraints and decisions are based on maximum budget availability, while the interests of local community is not involved. Decision support systems that are able to reveal retrofitting alternatives adaptable to the needs of the local stakeholders could enable the integration of both aspects (Fonesca, 2016).

In the context of local community involvement in retrofitting initiatives, neighbourhood is a more relevant scale. Even though, neighbourhood has less official status in most countries, it can be understood as a community that can use its existing social networks to support the retrofitting solutions (Koch, 2012). This view is in line with the planning perspective that neighbourhood is the basic building block of city extensions (Albers, 1983). A neighbourhood often has a number of relatively homogenous buildings which can also ease the implementation of energy retrofitting measures. Regarding the process of neighbourhood scale, energy retrofitting strategies adapted to an integrated understanding of neighbourhoods could enable a transition from objects of planning (e.g. a spatially defined area) towards projects as an active entity in the urban planning process (Koch, 2012).

3. Stakeholder engagement methodology

The research for this report involved a combination of methods, including interviews with design professionals with experience in building energy refurbishment, a supplementary questionnaire, and validation of the results using a modified Delphi-panel approach. This offered the opportunity for a two-step validation of the initial conclusions, with the results of the interviews being elaborated or qualified first by those of the survey and secondly by the experts involved in the Delphi process. It also facilitated the use of both qualitative and quantitative evidence. While qualitative data provides information on what is happening and how and why it is happening, quantitative data indicates how much of it is happening (Sunikka-Blank & Galvin, 2015). This section of the report details the stakeholder engagement carried out through three main research methods: semi-structured interviews, survey questionnaire, and a modified Delphi-panel approach.

3.1. Interview details

Information on the design process involved in building energy renovation was collected through 30 semi-structured interviews carried out with individuals with experience in the design of refurbishment projects in a variety of European countries. Semi-structured interviews using pre-formed open-ended questions were adopted as the most suitable method, given that interviewees came from across Europe and there would be only one opportunity to talk to each of them. The questions focused on four areas:

- Professional background of the interviewee and detail of a specific energy renovation project they had been involved in;
- Outline of the design process involved, including bottlenecks and integration with the district context;
- Stakeholder interactions in the project, especially during the design process;
- Occupant and user participation in the design process.

A first draft of the interview schedule was trialled in the course of a scoping exercise carried out on a large-scale district renovation project in Cork, Ireland. The questions were then refined and a more developed schedule deployed in the interviews across Europe. The questions were relatively short and simple, to facilitate the interviewee in understanding them, especially where there was a language barrier. An effort was made to avoid using jargon, unexplained acronyms, and complex industry or profession-specific terminology. The full interview schedule is included as an appendix to this report.

The interviews were semi-structured, meaning they aimed to stimulate a relatively free-flowing conversation rather than a series of punctuated questions as though the interviewee were undergoing an examination. Interviewees were allowed the freedom to digress, elaborate on their answers, and introduce anecdotes and opinions of their own in response to the questions. Interviewers could ask supplementary questions and follow up on particular lines of enquiry suggested by the discussion where they felt it appropriate. This kind of semi-structured interview format allows respondents present their opinions, expertise, or experience in their own terms. Questions were presented neutrally so as to avoid steering the interviewees, or showing personal bias towards a particular desired answer.

All interviews were recorded, with note-taking also allowed, insofar as it did not interfere with the natural flow of the conversation or the interviewee's train of thought. Audio recording was judged sufficient, as video recording might cause discomfort to the interviewee and detract from the process. The recording device was placed discreetly between interviewer and interviewee. At the beginning of each interview the interviewer was required to obtain verbal or written consent to the interview as well as gain the interviewee's permission to record it. When interviewing stakeholders with a professional interest in the project, it was stressed that what they were asked to outline was not a best practice scenario, but the actual design process and stakeholder interactions involved in a project.

Interviewees were identified through the professional networks of the partners involved in NewTREND, as well as by directly contacting participants in selected large-scale building energy renovation projects. Professionals directly involved in the design process of such projects were targeted for interview. Those recruited included architects, engineers, project managers, clients and academic consultants, among others. A breakdown of the professional background of interviewees is provided in Figure 7 and in Annex 1:

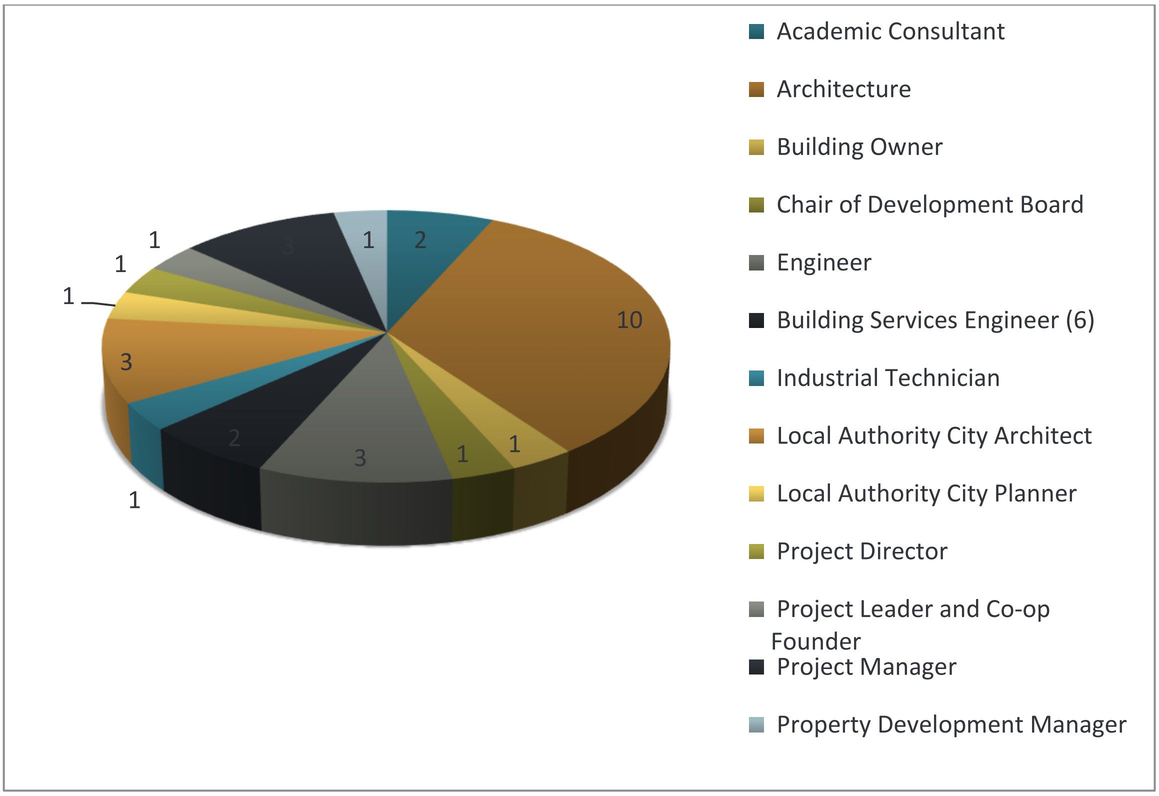


FIGURE 7: PROFESSIONAL BACKGROUND OF INTERVIEWEES

A wide variety of projects were discussed in the interviews, including the renovation of public housing, government offices, commercial office buildings, university buildings and residential complexes. A breakdown of the projects discussed in the interviews, and the countries in which they are located, is provided in Figure 8 and Annex 2:

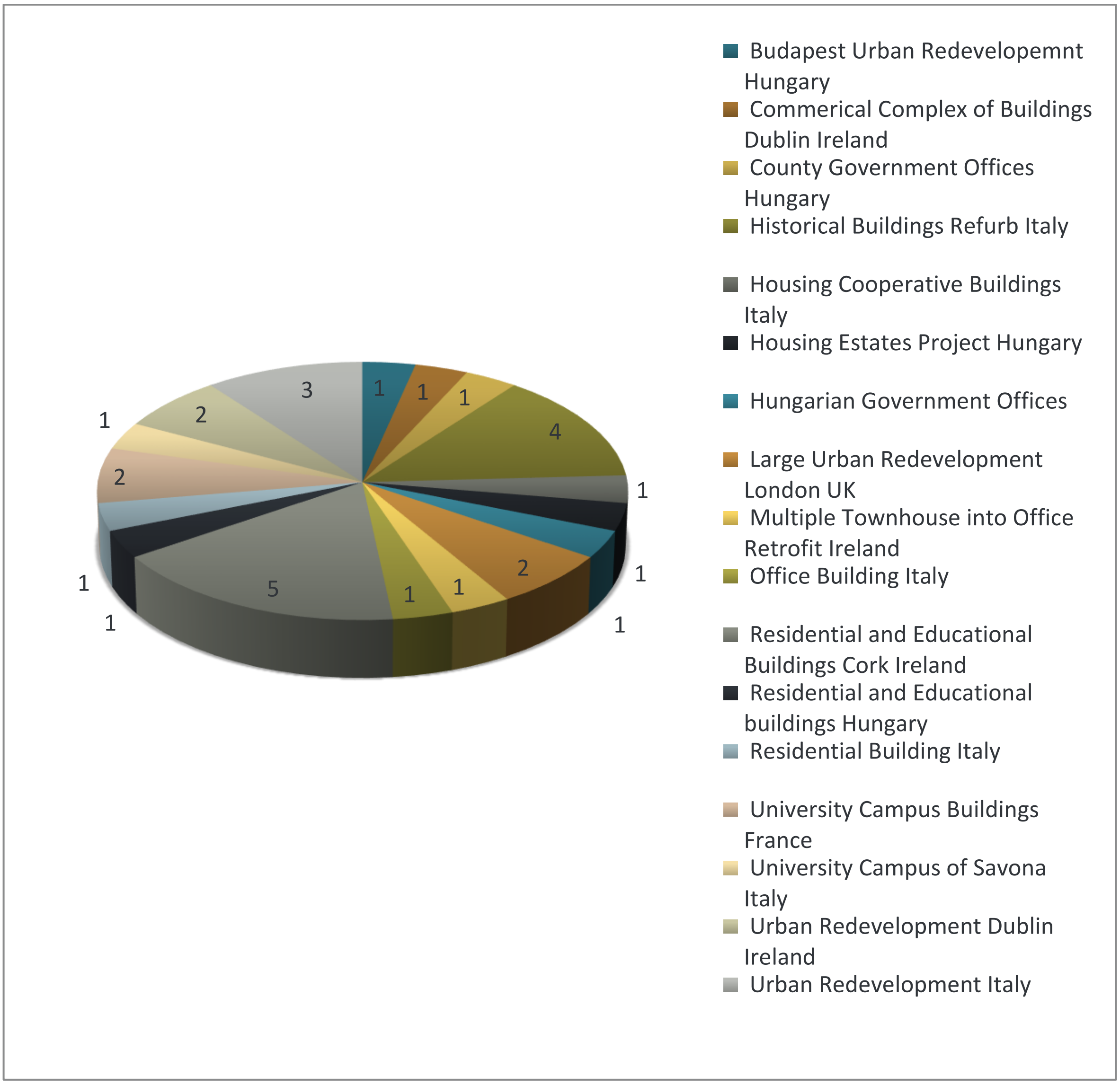


FIGURE 8: BREAKDOWN OF PROJECTS DISCUSSED IN INTERVIEWS

3.2. Data analysis process

The analysis of the transcripts from the interviews adopted a 'realist' approach, as outlined by Sunikka-Blank & Galvin (2015). A realist approach was viewed as more appropriate to NewTREND than the classical grounded theory approach, in which the researcher would ideally analyse the interview transcripts without any preconceived ideas as to what the content and emphasis might be (i.e. identifying these from the ground up). In NewTREND on the other hand, the needs of the project required us to approach the data with particular themes and emphases in mind.

The interviews were analysed using NVivo software, which facilitates coding, organising, linking and cross-referencing of material. NVivo supports both qualitative and mixed methods research, and is designed to help organise, analyse, and find insights in unstructured, or qualitative data like interviews, open-ended survey responses, articles, social media and web content (QSR, 2015). Interviews were coded using the 'template method' as described by Walker et al (2014). This involves producing a template consisting of a list of codes representing themes identified in the textual data. A code in qualitative inquiry is "most often a word or short phrase that symbolically assigns a summative, salient, essence - capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldana, 2013). The initial list was developed from a combination of the key research questions reflected in the interview schedule, and themes identified through an initial reading of the transcripts. This coding template was subsequently refined and developed in the course of coding the transcripts - i.e. assigning segments of text to one or more of a set of thematic 'coding nodes'.

The final list of coding nodes was as follows:

- Interviewee
    - About
        - About the Interview
        - About the Interviewee
    - Anecdotes and Examples
    - Suggestions, Comments, Complaints

- Project
    - Background Information
    - Project Constraints and Bottlenecks
    - Project Parameters
        - Certification or Accreditation
        - Design Brief and Principles
        - District Context
        - Energy
        - Materials and Technologies
        - Money
        - Quality Control and Inspection

- Project Stages
    - Construction Process
    - Design Process
    - Feasibility and Opportunity
    - Project Timelines
    - Tender Process

- Stakeholders
    - Personal Commitment
    - Stakeholder management
        - Attitudes Beliefs and Perspectives
        - Drivers Champions and Influences
        - Relationships
        - Stakeholder Engagement
    - Stakeholder Types
        - Regulators and Authorities
        - Stakeholder Roles
        - Team or Partner Selection
        - User & Occupant Considerations

As coding advanced, relationships and hierarchies between the coding nodes became apparent. When coding was completed, a summary of each coding node written up, highlighting key points from the interviews, supported with quotes. The material was then organised under six headings drawn from the literature review. Finally, the results of the analysis were written up as a report and a series of initial findings identified.

3.3. Questionnaire

The interviews with members of project design teams were supplemented by a questionnaire survey targeting a wider group of industry professionals across Europe with experience of large scale energy retrofits. This offered a number of advantages, including a more diverse geographical reach and a larger pool of respondents against whose response the conclusions drawn from the interviews could be tested.

3.3.1. Questionnaire strategies and planning

A questionnaire is a set of questions for gathering information from individuals. It is possible to administer questionnaires by mail, telephone, using face-to-face interviews, as handouts, or electronically (i.e., by e-mail or through Web-based questionnaires). The first thing to do is to carefully plan the structure and questions, keeping in mind that the time and resources needed to design, implement and analyse a questionnaire should not be underestimated. The layout and the kinds of questions affect greatly the quality of the data that is gathered through the answers: the structure has to be as simple and intuitive as possible, and the questions should be precise, to avoid confusion.

First, the objectives of the survey have to be outlined and identified. The most critical part of developing a questionnaire is defining what is wanted from it and how the information to answer the questions will be used. By taking the time to define purpose and objectives, the likelihood of gathering unusable or unwanted information will be reduced.

Then, the number and type of participants to the questionnaire has to be identified: selecting the type of participants to be included is part of determining the objectives.

The questions need to be simple and easy to understand and it has to be clear and easy to complete because no interviewer is available to assist the respondent. They have to clearly communicate what the author wants to know, by using clear and simple wording written at the reading level of the participants. Abbreviations, jargon, or colloquial phrases should be avoided. It should be noted that the length of the questionnaire influences the response rate: the shorter the questionnaire, the higher the response rate will likely be, because it is often discouraging to answer to endless questions that take a long time to fulfil.

These considerations informed our development of the questionnaire used in this report. The objectives were to test, refine and validate the findings of the interviews. An initial set of questions was drawn up based on a combination of the original interview schedule and the results of our analysis of the transcripts. These were then simplified and pruned down to a final list of 25 questions, divided into two sections, creating an online survey which was easy and convenient for the target audience to complete in less than 10 minutes. With the exception of one open question at the end, closed or multiple choice questions were used, reflecting both the purpose of the survey (to validate or refine the interview findings) and in order to reduce the time required to complete it. A brief introduction was appended, introducing the project and summarising the purpose of the questionnaire. The target audience, finally, were identified as professionals in the area of building energy renovations, with a particular focus on those involved in the design process.

3.3.2. Types of questions

Below is a brief analysis of the different types of questions and their structure (Improvement Skills Consulting, 2009). Visual examples from the NewTREND web questionnaire are included.

The following categories were used in the project questionnaire:

- Multiple choice
- Rating
- Ranking
- Open
- Closed

1) ***Multiple choice.*** The respondent chooses one or more options from a list, for example:

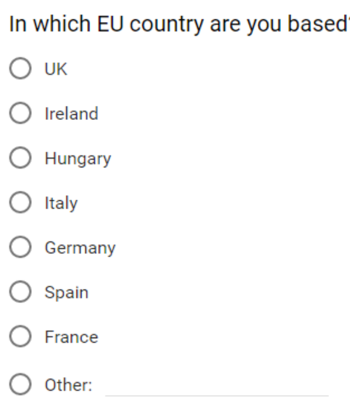


FIGURE 9: MULTIPLE CHOICE QUESTION (NEWTREND ONLINE QUESTIONNAIRE)

It should be made clear whether people are allowed to select more than one option, and they should be given the choice of adding an alternative to those on the list (in case the list does not contain all of the possible choices). If you only want people to select one item, ensure the list contains mutually exclusive choices. This option should be used if there are a few specific alternatives amongst which to choose.

The NewTREND questionnaire is mainly characterised by this kind of multiple choice question.

2) ***Rating questions.*** The respondent is asked to rate a statement by selecting one point on a rating scale: the opposites are “strong agreement” or “total disagreement”, with some nuances in between. The intermediate options can be explicitly labelled (for example the middle one as ‘’neutral’’, and the others as partly agree and partly disagree), as shown in figure below. The respondent will tick a box according to his or her feelings on the subject.

	None	Low	Medium	High
EU regulation	○	○	○	○
Regional Regulation	○	○	○	○
Municipality regulation	○	○	○	○
RIBA plan of work	○	○	○	○
FIDIC guidelines	○	○	○	○
HOAI	○	○	○	○

FIGURE 10: MIDDLE LABELLED OPTIONS (NEWTREND ONLINE QUESTIONNAIRE)

An alternative to middle labelled option questions are the so called middle unlabelled option questions, as shown in the following example:

Strongly Disagree 1	2	3	4	Strongly Agree 5
○	○	○	○	○

FIGURE 11: MIDDLE UNLABELLED OPTIONS (ARCHIVE)

There is endless debate about whether rating scales should have even or odd numbers of choices and there's probably no right answer. The middle option of a rating scale often attracts a substantial number of respondents who are unsure of their opinion. It is good practice to allow also "Don't Know" or "Not Applicable" responses. The scale can have the various options either marked with a number (usually from 1 to 5) or unnumbered.

It can also be possible to make two sentences with the exact opposite meaning (e.g., "It is easy to find information on refurbishing on the internet" and "It is not easy to find information on refurbishing on the internet") face each other, with some radio buttons or numbers between them as a scale, and make the respondent choose the value or position on the scale that is closer to his or her opinion.

Other types of questions are:

3) ***Ranking questions.*** Respondents are asked to place a number of options in their order of preference: it should be stated whether to put first the most or the least preferred option. Those should be no more than 7-8, to avoid confusion. Ranking questions can be quite difficult to analyse and present results, because several combinations are possible.

4) ***Open questions.*** Those questions ask for a free response: enough space should be left so that the respondent can write freely. It should be kept in mind that these are hard to analyse, but can give some useful insights into the reasons behind responses to the other types of question. It is advised not to have too many because the time to analyse each one of them is quite long and therefore takes up a great amount of resources. In the NewTREND questionnaire only one question is open, and it is aimed at gathering suggestion about possible enhancements or changes in the proposed design process model.

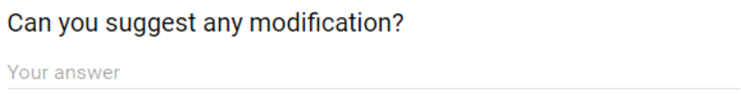


FIGURE 12: OPEN QUESTIONS EXAMPLE NEWTREND ONLINE QUESTIONNAIRE)

5) ***Closed questions.*** This kind of questions are used to get “yes” or “no” answers, as shown in figure below.

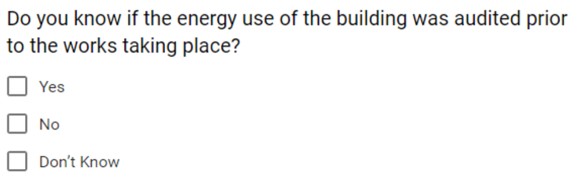


FIGURE 13: CLOSED QUESTIONS EXAMPLE NEWTREND ONLINE QUESTIONNAIRE)

3.3.3. Methods of administration

Once the questionnaire is ready, it should be decided how it is to be administrated to the recipient, according to factors such as time, resources and recipient’s preferences. The main ways of conducting a survey are via email, via web or via traditional mail: the best way is often a combination of those methods.

1) ***Mail questionnaires***. In this method, the questionnaires are directly mailed at the respondent’s address, in paper format. Questions that are difficult to ask on the telephone or in face-to-face interviews can be asked in a postal questionnaire. For example, personally sensitive information is best requested in a way that saves the respondent the embarrassment of facing a stranger and reporting something they may feel awkward about. A serious problem with postal surveys is that response rates are usually lower than with interview surveys.

2) ***Email questionnaires.*** This method involves sending questions in the text of an email, or as an attachment, which respondents fill in and send back. These surveys are both very economical and very fast. It is much cheaper than traditional mail, because there is no need for printing, paper and postage, and also faster, being email is delivered almost instantly at any time of the day. Email surveys should be used carefully, being often nowadays increasingly associated with spam, and there is a diffuse impatience with the flood of unwanted and irrelevant mail that most people have to wade through every day. For this reason, many people dislike unsolicited mail: the response rate increases dramatically if there has been a previous contact or relationship between the sender and the receiver. Moreover, the mails should be personalized and not contain any trace of spam, for example by complying with the various Spam Acts.

3) ***Web-based questionnaires.*** Web surveys can be conducted by Internet or Intranet and are rapidly gaining popularity. They involve sending people a link to a web page containing a questionnaire that is filled in online. Web-based formats make it faster and easier for the respondent to complete the questionnaire (for example by implementing a script that makes them skip a question according to a previous answer instead of writing “if you have answered yes to the previous question then go to the next one”). The questionnaire can be much more colourful and attractive than its emailed counterpart, which has to rely on simple font and structure. It is also very cheap, the only costs being web hosting and setting up the questionnaire, which may require the help of an IT specialist. This kind of survey is very interesting, because it is fast to complete and people tend to give longer answers to open questions compared to other kinds of questionnaires. On the other hand, those who do not have access to the internet cannot

complete this kind of questionnaire, and without some protection, there is no way to guarantee that it will not be completed multiple times by the same person. It is good practice to put the survey on a page that can be accessed only through a specific link, provided via mail. Another downside is that someone might close the questionnaire before it is done, losing the completed questions, something that is less likely to happen in a one-to-one interview.

Taking into account the strengths and drawbacks of the different methods of distribution, and our target audience of building industry professionals, it was decided that for the NewTREND project the questionnaire would be conducted by internet. The format chosen is the very popular Google Forms. This system responds to any need in terms of simplicity, quickness and effectiveness, merged with an attractive layout.

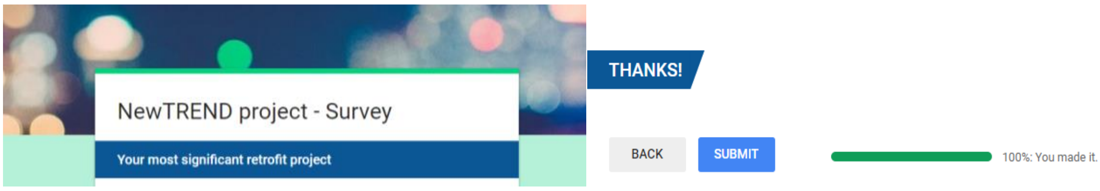


FIGURE 14: NEWTREND ONLINE QUESTIONNAIRE USER INTERFACE

3.4. THE RESULTS FROM THE QUESTIONNAIRE

The online survey was composed by 25 questions and disseminated broadly, thanks to the collaboration of all partners, via professional networks and a mailing list of professional associations. In two weeks hundreds of professionals have been asked by email to fill in the questionnaire: 60 responses were collected from participants based in many different countries.

The following section provides a statistic analysis of the responses for each question.

3.4.1. GENERAL INFORMATION ON RESPONDENTS

1. **In which EU country are you based?**

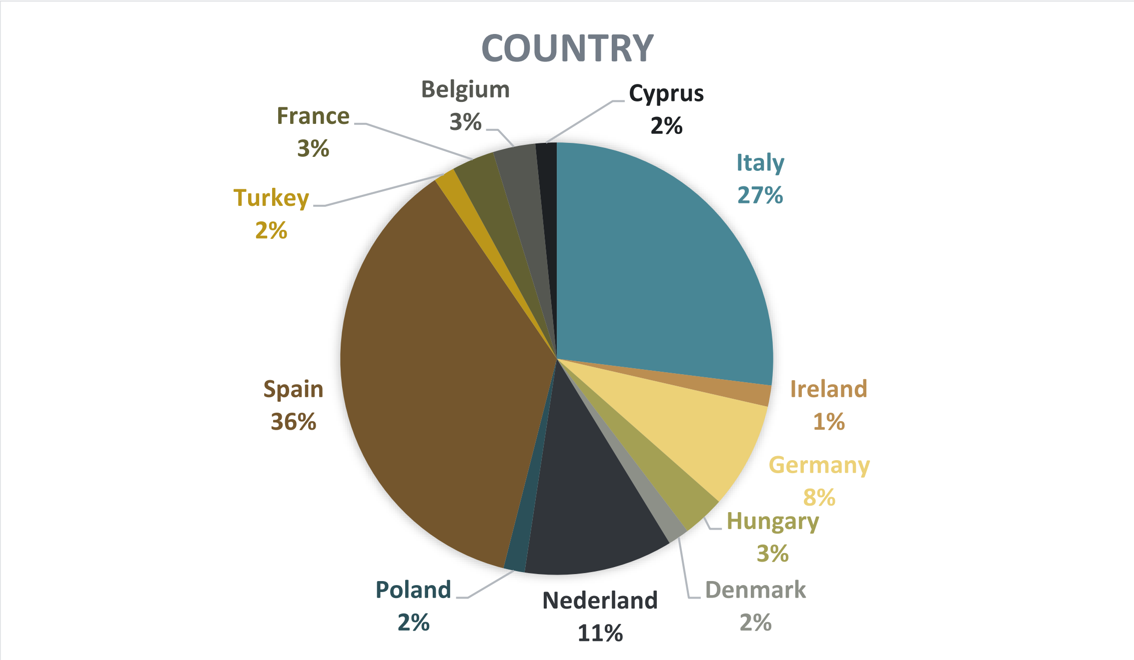


FIGURE 15: SURVEY - EU COUNTRY COVERED BY THE SURVEY

An important aim of this survey was to cover as many different countries as possible, in order to have a wide overview of the European retrofit industry. Twelve countries have been covered (Figure 15).

2. How many years of experience do you have gained in building retrofitting projects?

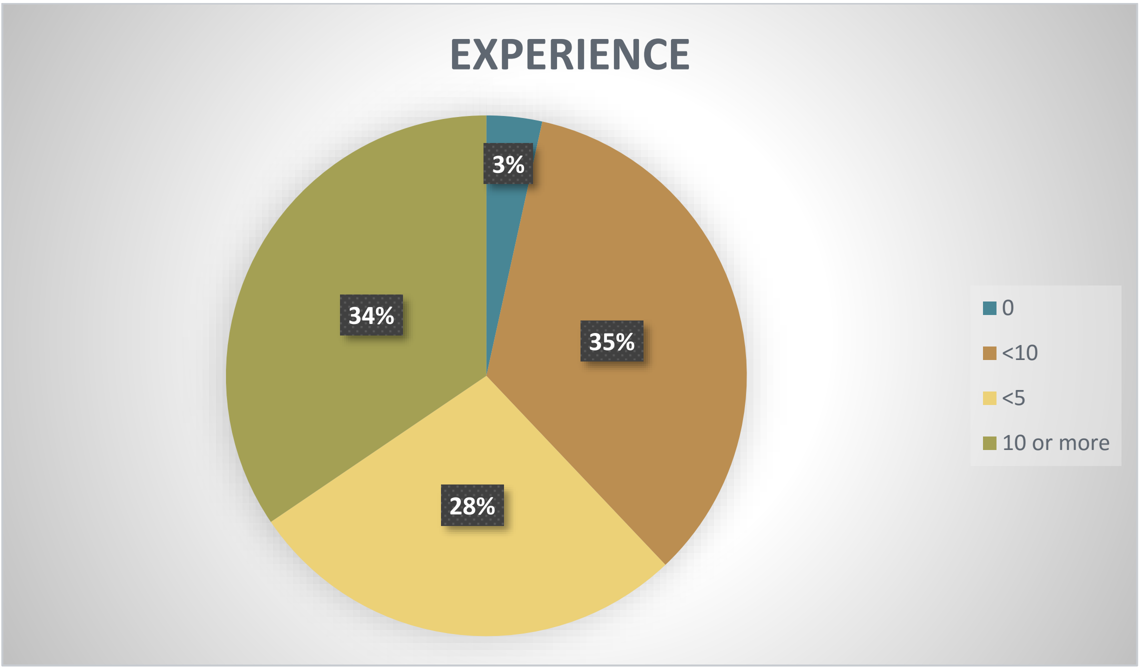


FIGURE 16: SURVEY - YEARS OF EXPERIENCE OF THE RESPONDENTS

The quality of this survey is validated by the involvement of experts with several years of experience in building retrofitting and energy efficiency in the construction field: 70% of those involved have more than 5 years of experience in this sector and almost 34% have more than 10 years.

3.4.2. Investigation of one large-scale retrofit project

The first round of questions was focused on the analysis of one retrofit project that the professional considered significant for the survey and representative of his/her experience. The questions have been based on the previous information from the face-to-face interviews, and tailored for gaining confirmation or negation of the preliminary results.

3. What was your role within the project?

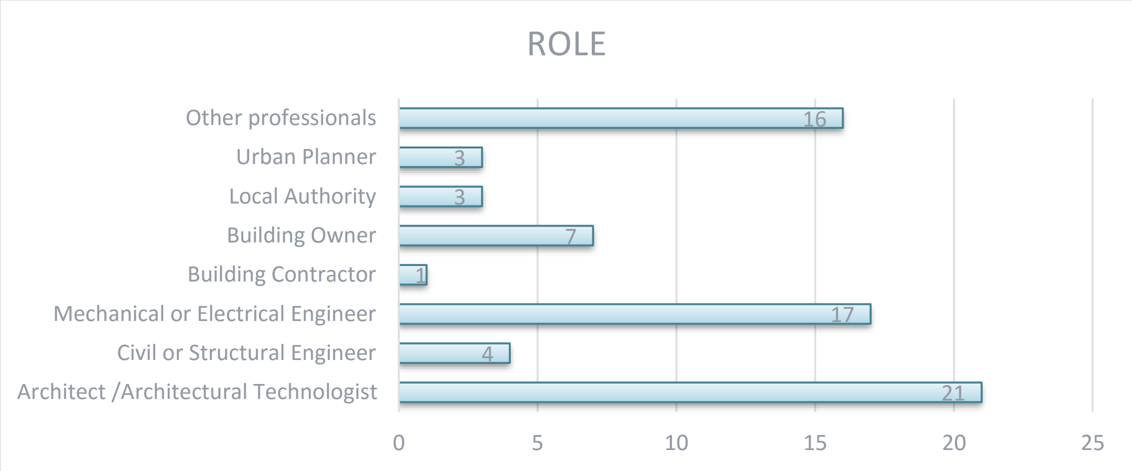


FIGURE 17: SURVEY - ROLE OF THE RESPONDENTS IN THE PROJECT

This chart confirms that the goal of interviewing technical experts is achieved: the majority are architects and engineers.

4. What other people or organisations were involved in the design process?

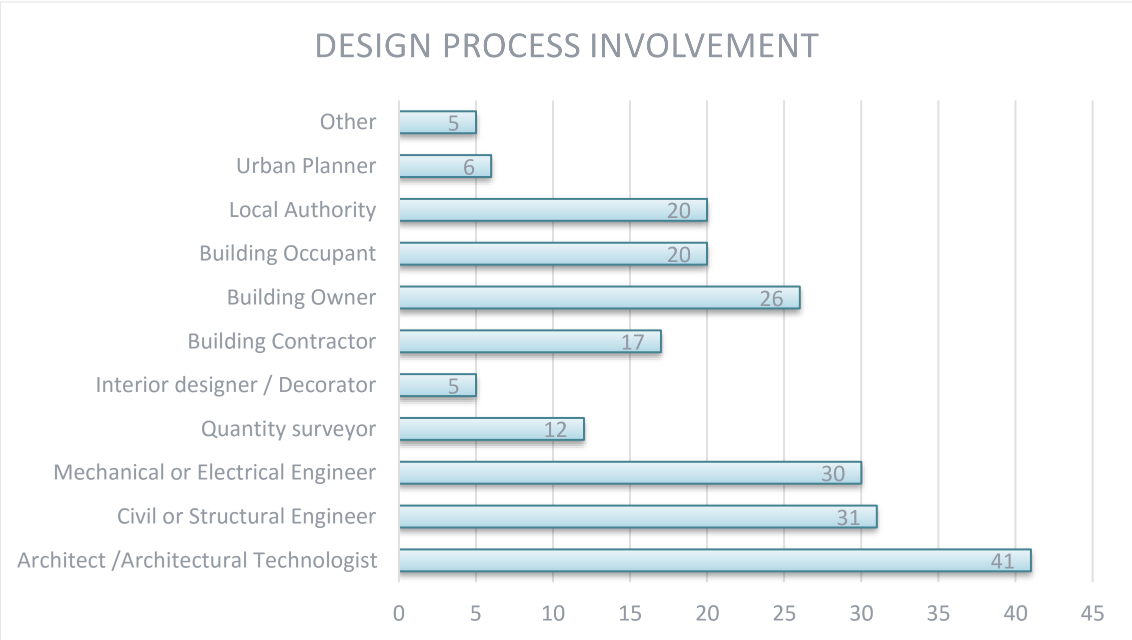


FIGURE 18: SURVEY - PROFESSIONALS AND ORGANISATIONS INVOLVED IN THE PROJECT

The answers to this question show that while professional figures have a constant and predominant role in the design process, 45% of the time there are other non-professional stakeholders actively involved, such as building occupants and owners.

5. **Who would you say were the other stakeholders in the project if the definition of a stakeholder is taken to be "anyone who can affect or be affected" by a project?**

FIGURE 19: SURVEY - STAKEHOLDERS INVOLVED IN THE PROJECT

Almost all the people interviewed recognize that the final occupants of the building and their neighbours are key stakeholders in the project, while the other institutions, associations and organisations listed are not widely so considered.

6. **What impact did the participation of building occupants and users have on the final design?**

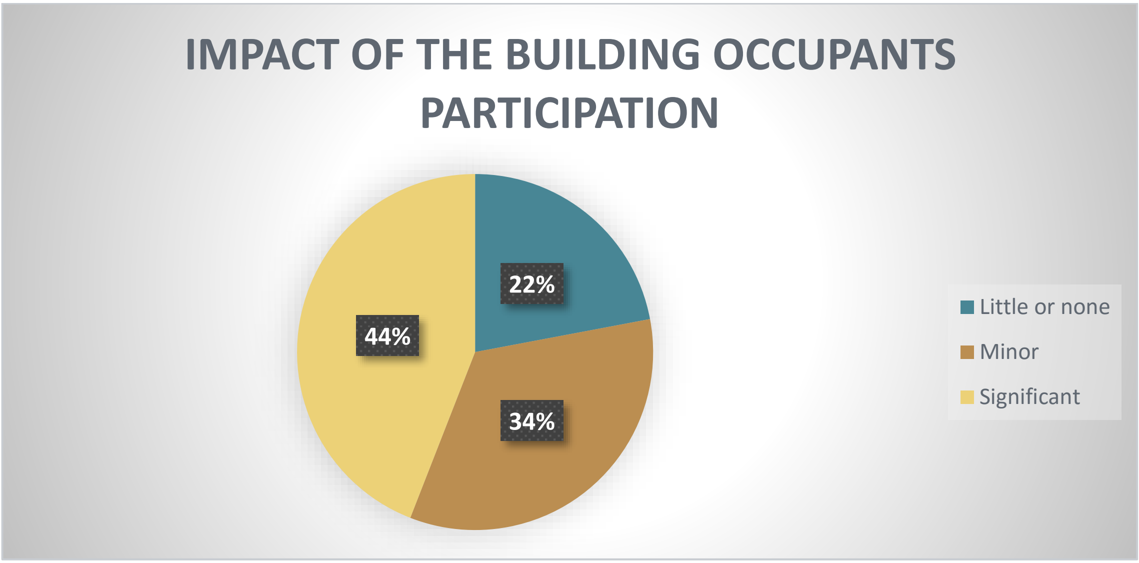


FIGURE 20: SURVEY - IMPACT OF OCCUPANTS AND USERS ON THE FINAL DESIGN

Even if the previous point underlines the importance of the final end users and occupants on the project, this chart shows that only 44% of respondents considered their participation in the design to strongly affect it.

7. **Were there any specific procedures regarding collaboration and stakeholder management?**

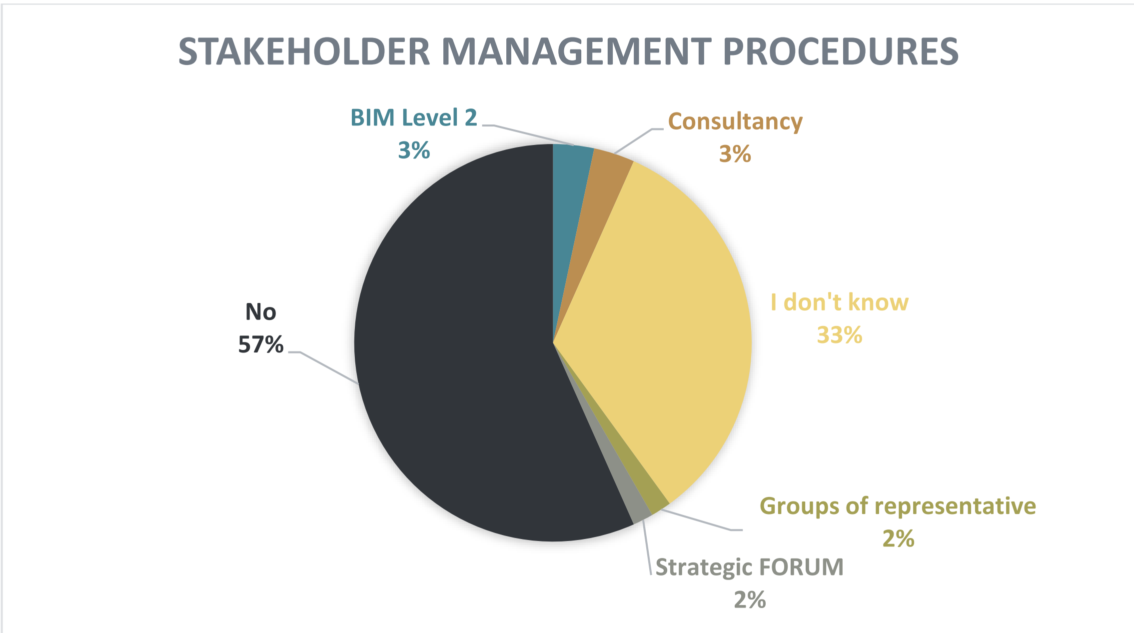


FIGURE 21: SURVEY - STAKEHOLDERS MANAGEMENT PROCEDURES

From this chart is clear that stakeholder management is an open topic for which no standard procedure is applied and which is not even clearly understood by those working in the construction field at present: 57% stated they did not adopt any defined method and 33% didn't know what to answer.

8. **How was the design team selected?**

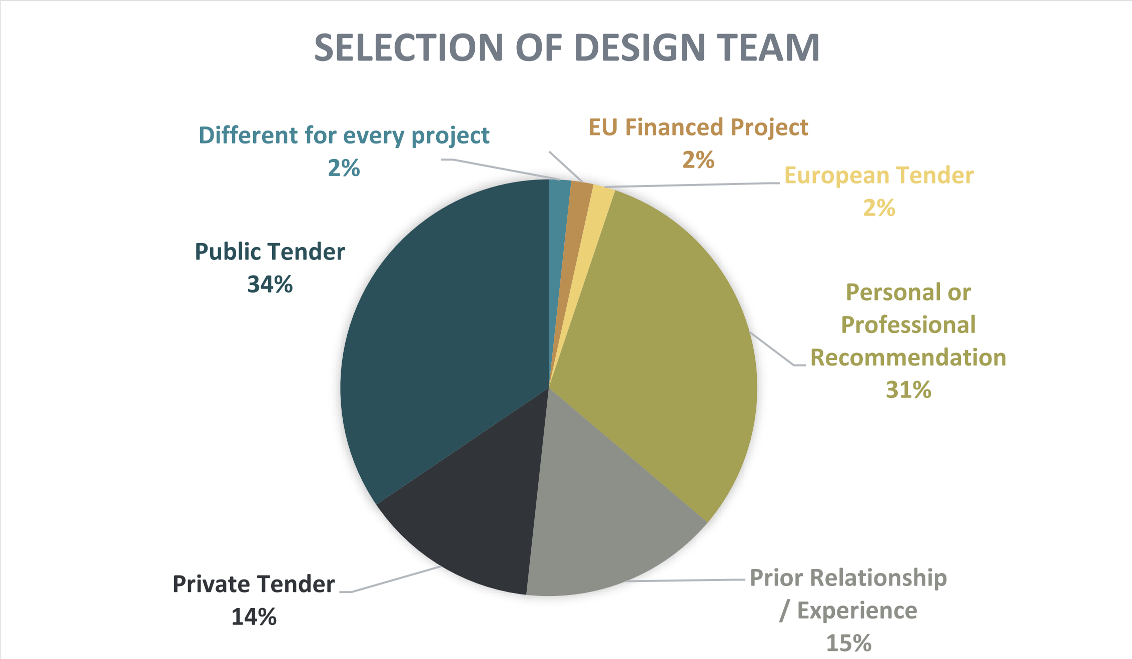


FIGURE 22: SURVEY – SELECTION OF THE DESIGN TEAM

This question is closely related with question 10: in 34% of cases design team selection is by "Public Tender", probably because 35% of the projects included had been funded by Public bodies ("Government or Local Authority), while for other projects professional or personal recommendations (31%) and prior relationship (15%) are the most popular ways to build up a team.

9. **How was the construction team selected?**

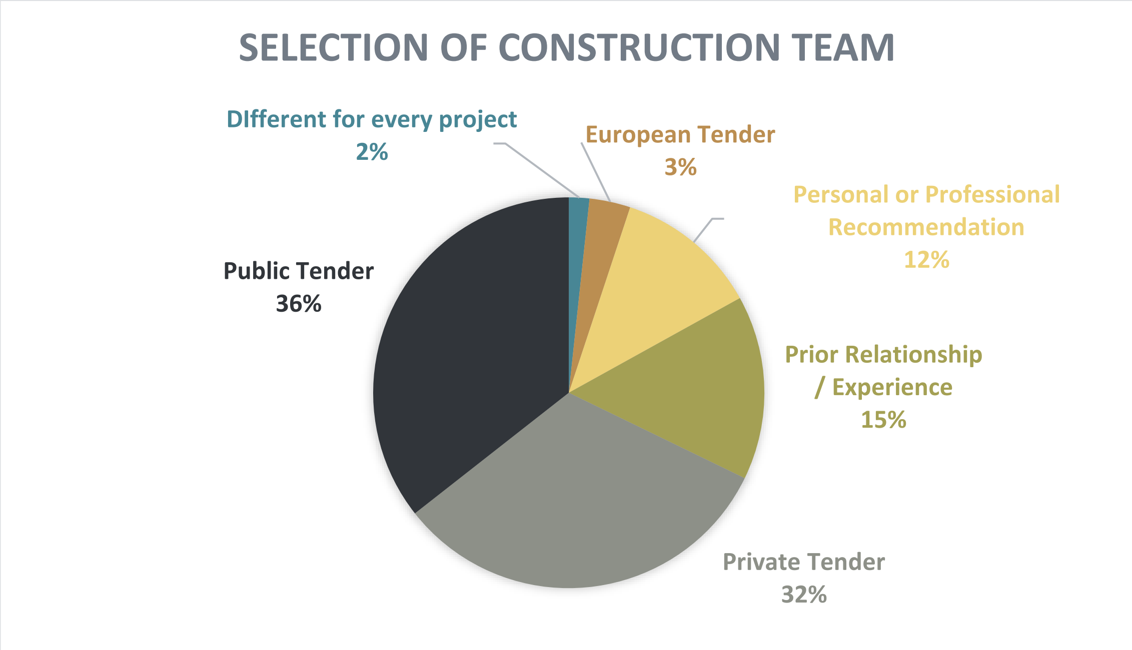


FIGURE 23: SURVEY – SELECTION OF THE CONSTRUCTION TEAM

The majority of the construction team had been selected by Public Tendering (36%); compared to the previous question prior experiences and recommendations played a minor role and there is a large use of Private Tendering (32%).

10. **Who was paying for the project?**

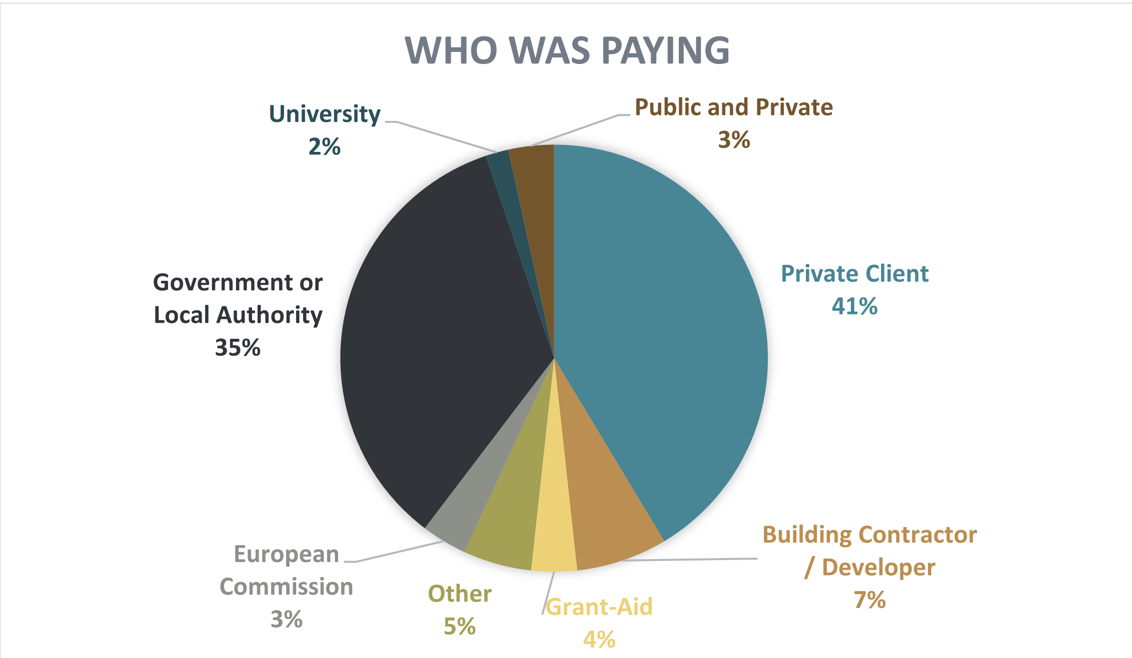


FIGURE 24: SURVEY – WHO WAS PAYING FOR THE PROJECT

Almost all the projects had been paid for by a private client (41%) or the Government/Local authority (35%).

11. Which of the following would you identify as key design principles of the project?

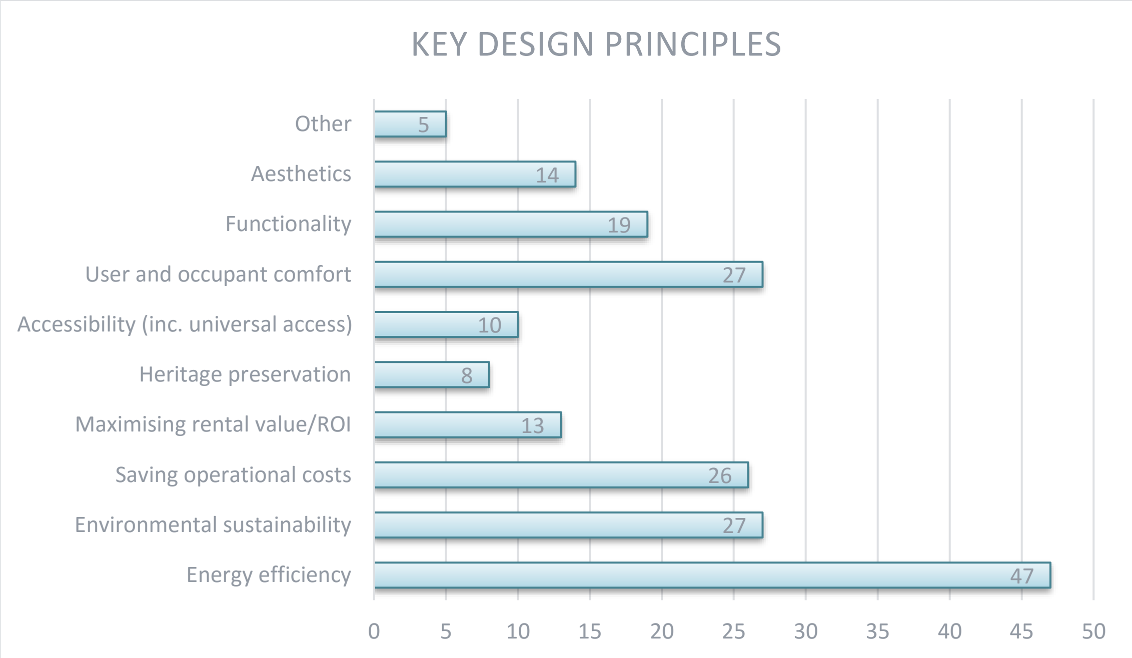


FIGURE 25: SURVEY – KEY DESIGN PRINCIPLES

This chart clearly shows that the projects under investigation fit perfectly with our survey because almost all of them had "energy efficiency" and/or "environmental sustainability" as key design principles. It's also interesting that "user and occupant comfort" and "saving operational costs" had been considered more relevant than "maximising rental value/Return On Investment".

12. **Which of the following would you identify as key barriers or constraints encountered during the design process?**

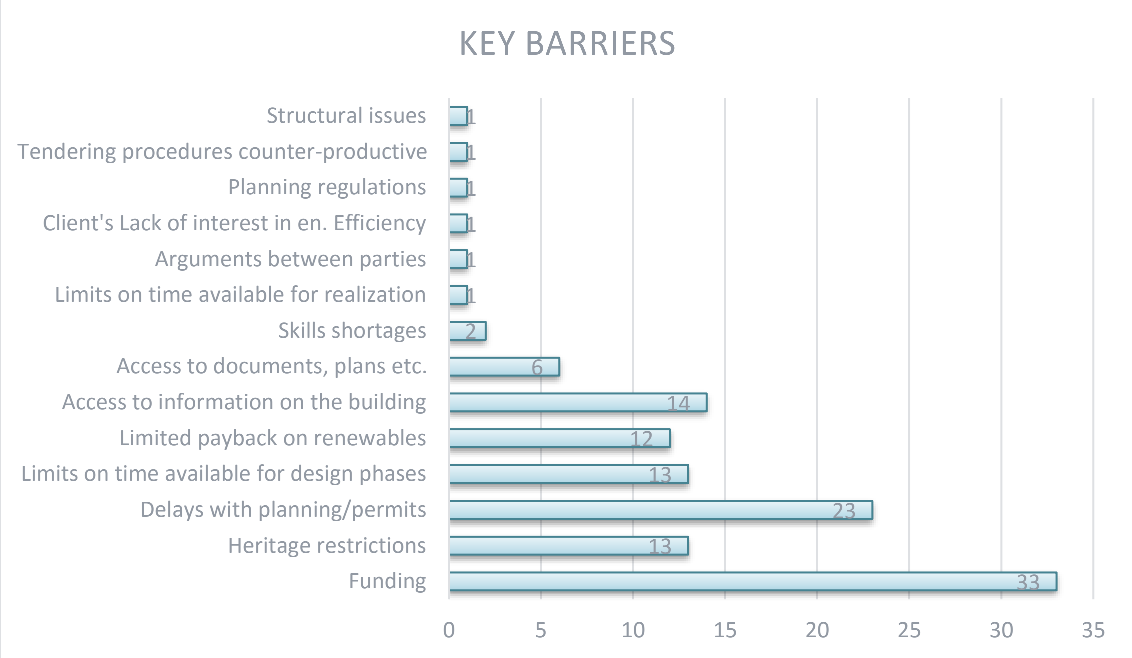


FIGURE 26: SURVEY – KEY BARRIERS

As expected, the key barriers are "funding" and "delays", followed by difficulties in accessing building information.

13. **What types of certificates or grants of permission were required?**

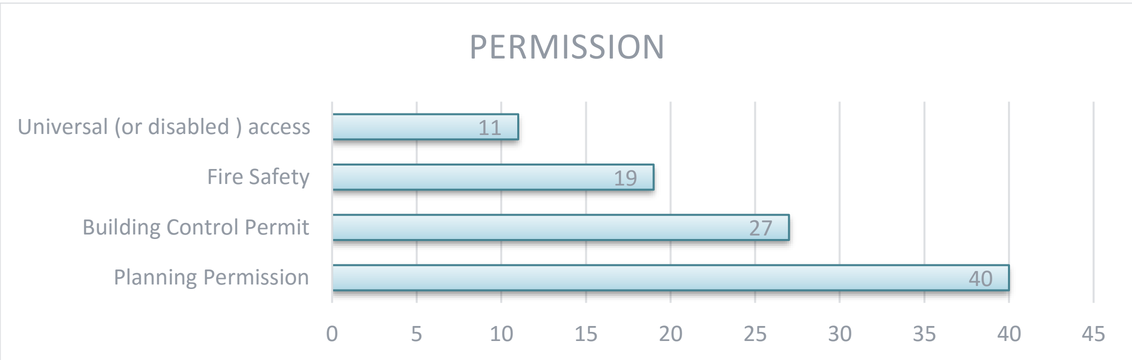
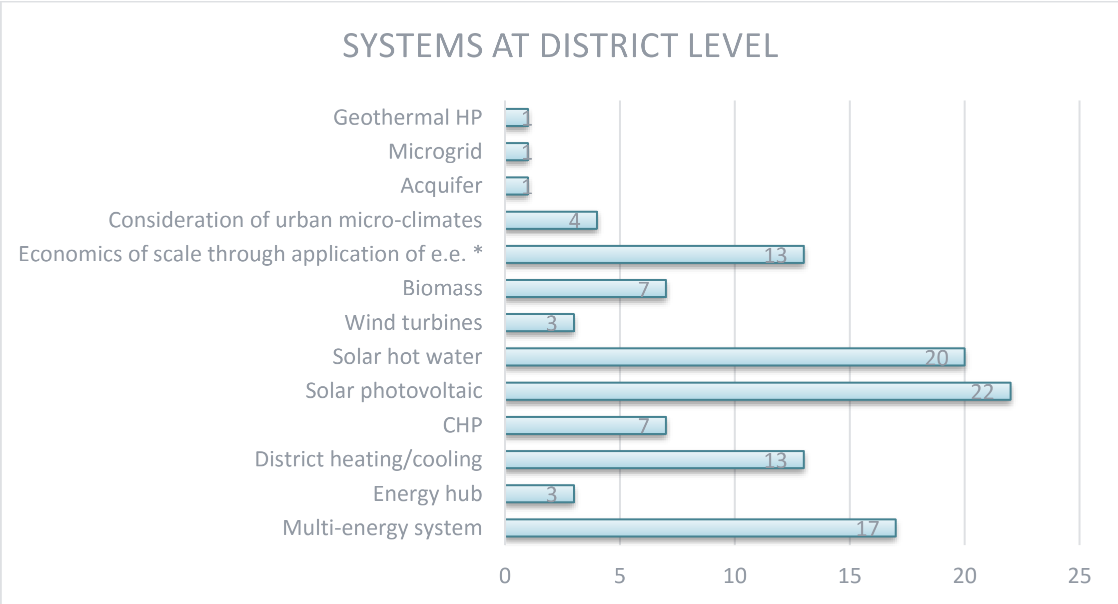


FIGURE 27: SURVEY – REQUIRED PERMISSION

14. Where consideration was given to the integration of the building's energy systems with the surrounding district, which, if any, of the following were involved?



**Economics of scale through application of energy efficiency measures to multiple buildings*

FIGURE 28: SURVEY – SYSTEMS AT DISTRICT LEVEL

The chart shows that the most consolidated system technologies are also the most used at district level, such as: solar PV, solar water heating, multi-energy system, district heating/cooling. Economics of scale through application of energy efficiency measures to multiple buildings are also regularly considered.

15. Did the design change during the construction phase?

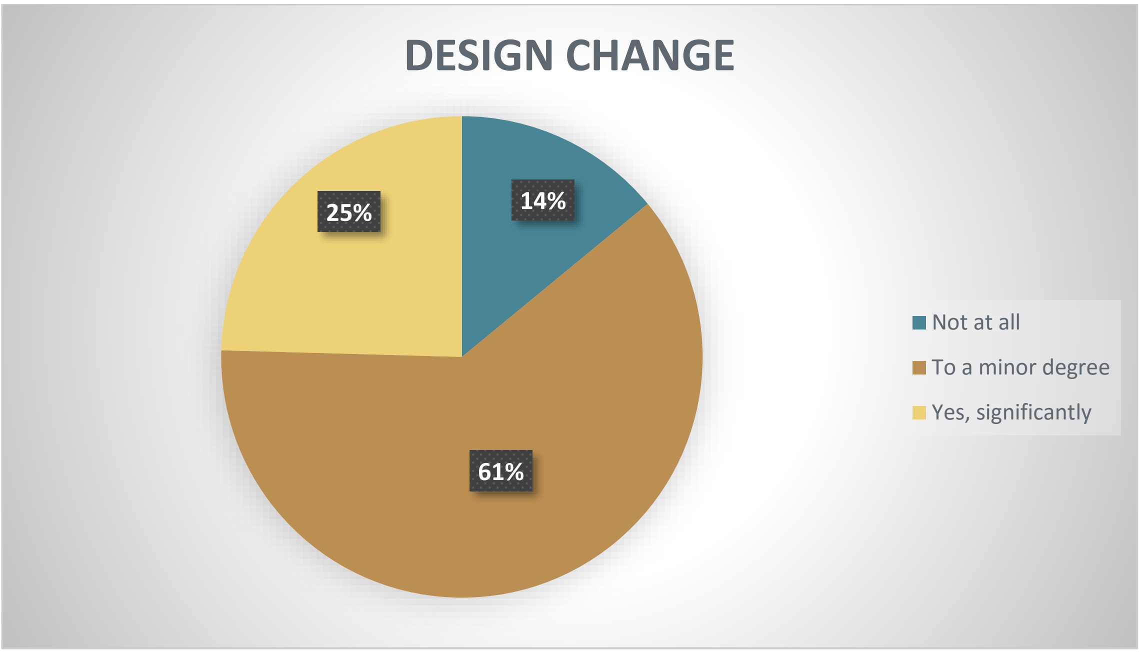


FIGURE 29: SURVEY – DESIGN CHANGE DURING CONTRUCTION

In almost any project, even if it is perfectly designed, there is something that should be modified during construction; the feedback shows that in 61% of cases a minor change had been applied, while 25% required a heavy re-design.

16. **Do you know if the energy use of the building was audited prior to the works taking place?**

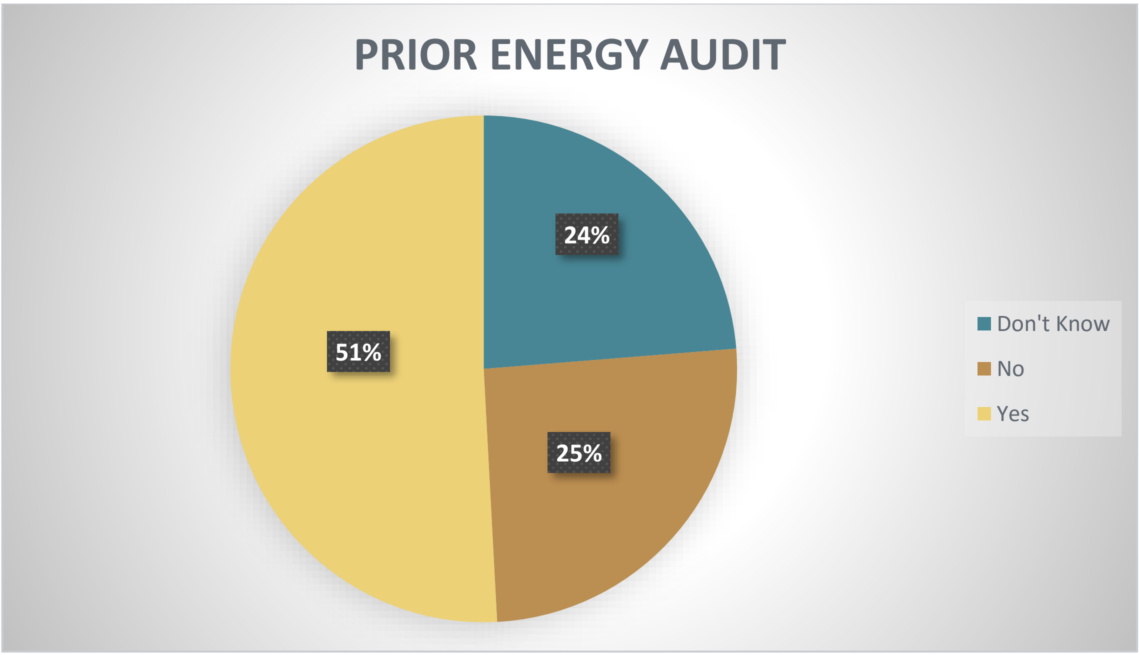


FIGURE 30: SURVEY – PRIOR ENERGY AUDIT

Even if, from literature review, a preliminary energy audit is an essential initial step for a retrofitting, this is not performed for 51% of the projects.

17. **Are you aware of how the building has been performing since the works were completed and it was occupied?**

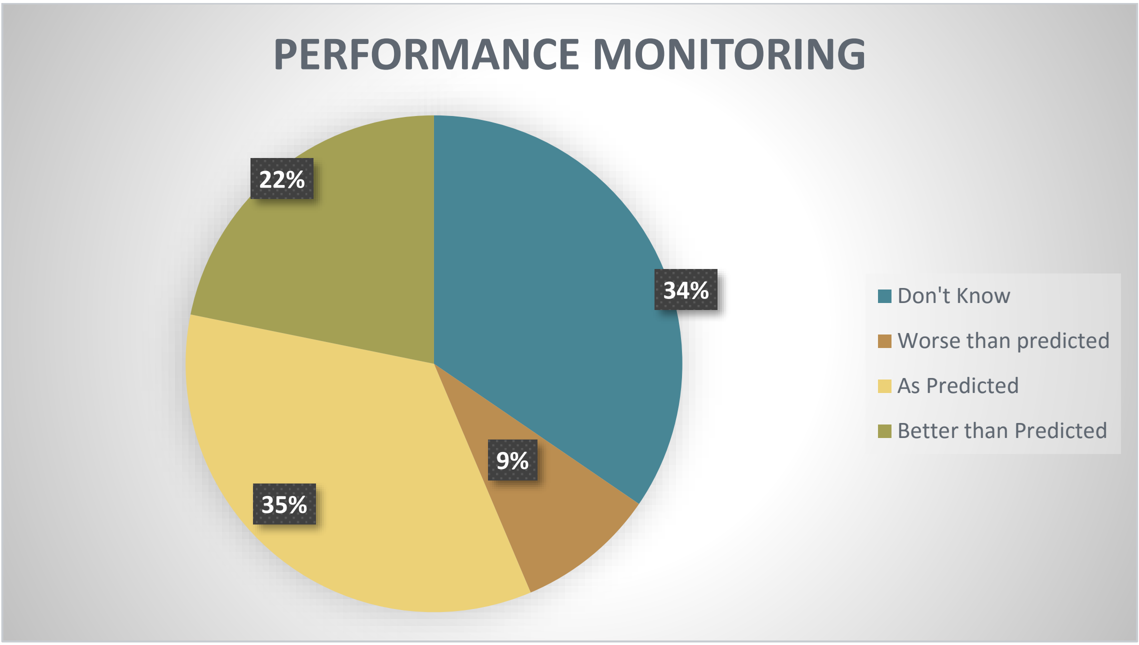


FIGURE 31: SURVEY – BUILDING PERFORMANCE AFTER INTERVENTION

If post-occupancy performance was monitored (34% did not know about post renovation performance measurements), almost all the time the final building performance was as predicted or better than expected.

18. **Are the occupants / users of the building the same as before the works, or is it being occupied or used by an entirely new group of people?**

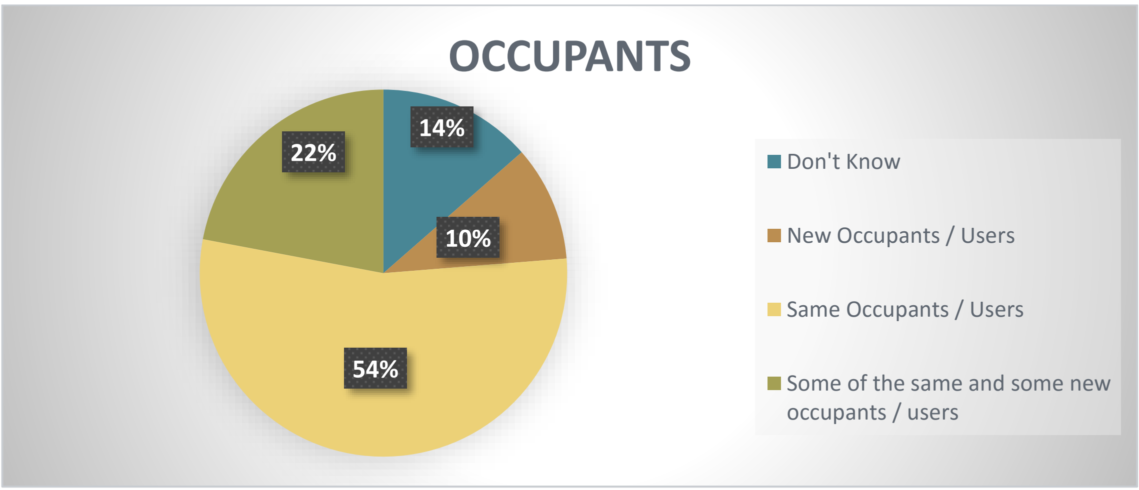


FIGURE 32: SURVEY – OCCUPANTS

The majority of the occupants still continue to live in the same building as before the retrofitting.

3.4.3. Specific questions about design process and protocols

This second round of questions has been based on the previous information collected during the literature review and are designed to investigate the design process and its management.

19. Which level of influence may the following regulation/standards/protocols have in your activities?

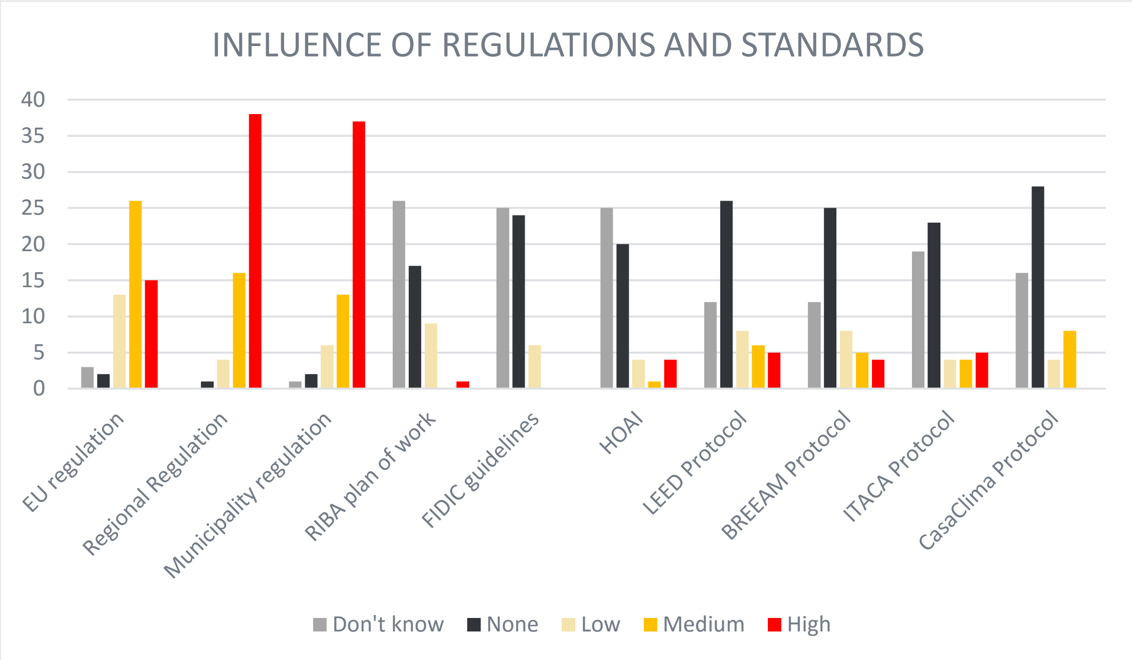


FIGURE 33: SURVEY – INFLUENCE OF STANDARDS AND PROTOCOLS

Regional and local regulations drive decision making and the design process for almost all the professionals involved in this survey. It is interesting that protocols like RIBA that have been created for improving and standardising the design steps do not have much influence over the work in reality.

20. In your country, which is the popularity of the following standards/guidelines/protocols for design process in retrofitting projects?

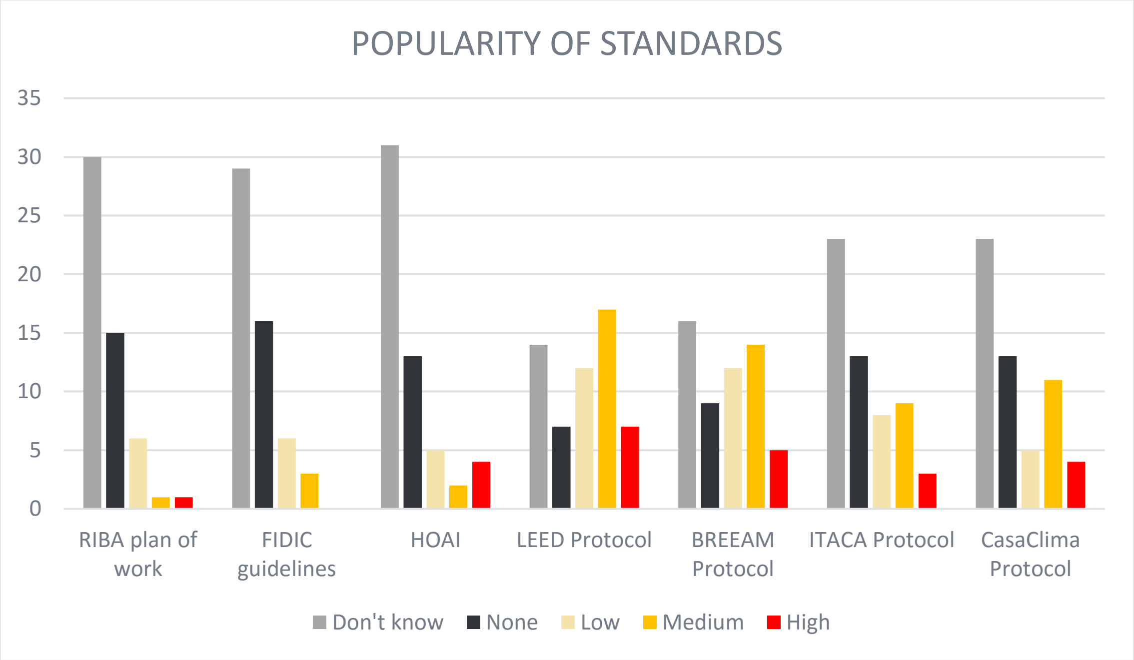


FIGURE 34: SURVEY – POPULARITY OF STANDARDS AND PROTOCOLS

The LEED and BREEAM protocols are well known in almost all countries, while ITACA and CasaClima, as expected, are popular in Italy and bordering countries. LEED is the most popular energy certification standard. It is noteworthy that international guidelines for a standardised design process (FIDIC and the English RIBA) are hardly considered at all.

21. Which is the level of effectiveness of the following standards/guidelines/protocols for retrofitting projects?

FIGURE 35: SURVEY – PERCEPTION OF EFFECTIVENESS OF STANDARDS AND PROTOCOLS

The effectiveness of protocols oriented to energy certification is considered medium-low, while the RIBA and FIDIC guidelines are not even known.

22. **Do you think that applying standards/protocols in the design process has an impact on the following criteria?**

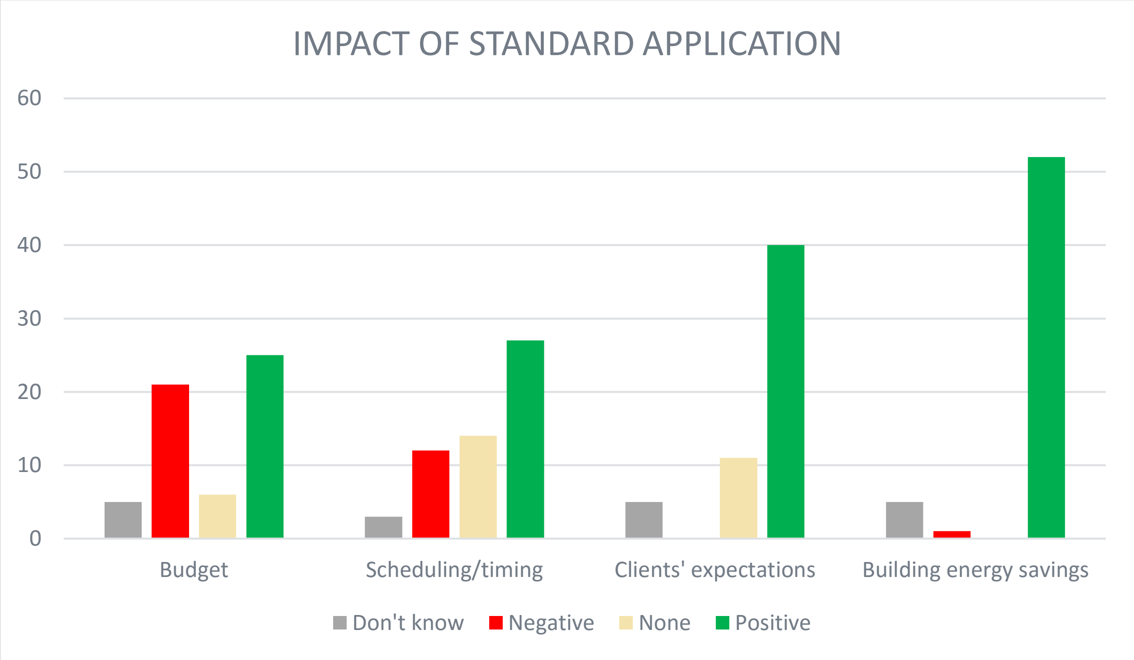


FIGURE 36: SURVEY – IMPACT OF STANDARDS AND PROTOCOLS

This chart shows some discordances regarding the impact of the application of standards and protocols in retrofitting projects: from the literature review, both “budget” and “timing” should have a negative impact, while the majority of the interviewees said that it should have positive impact. On the other hand, everybody is sure that following standards leads to a positive impact on the client’s expectations and building energy savings.

23. In energy retrofitting projects, what are the major causes of failure?

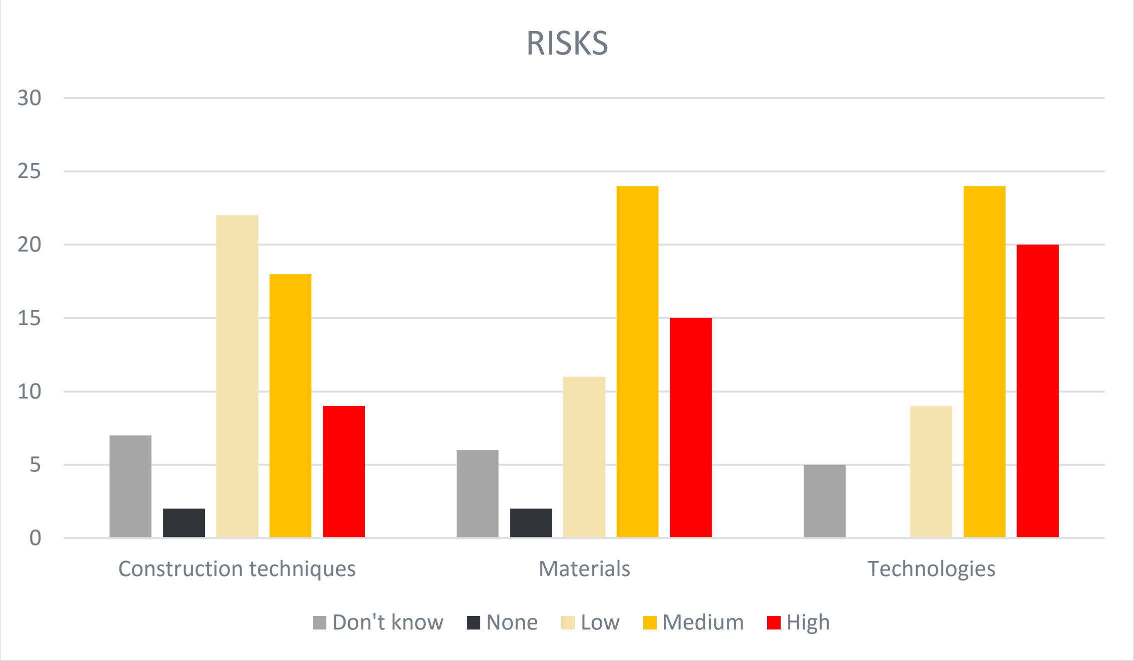
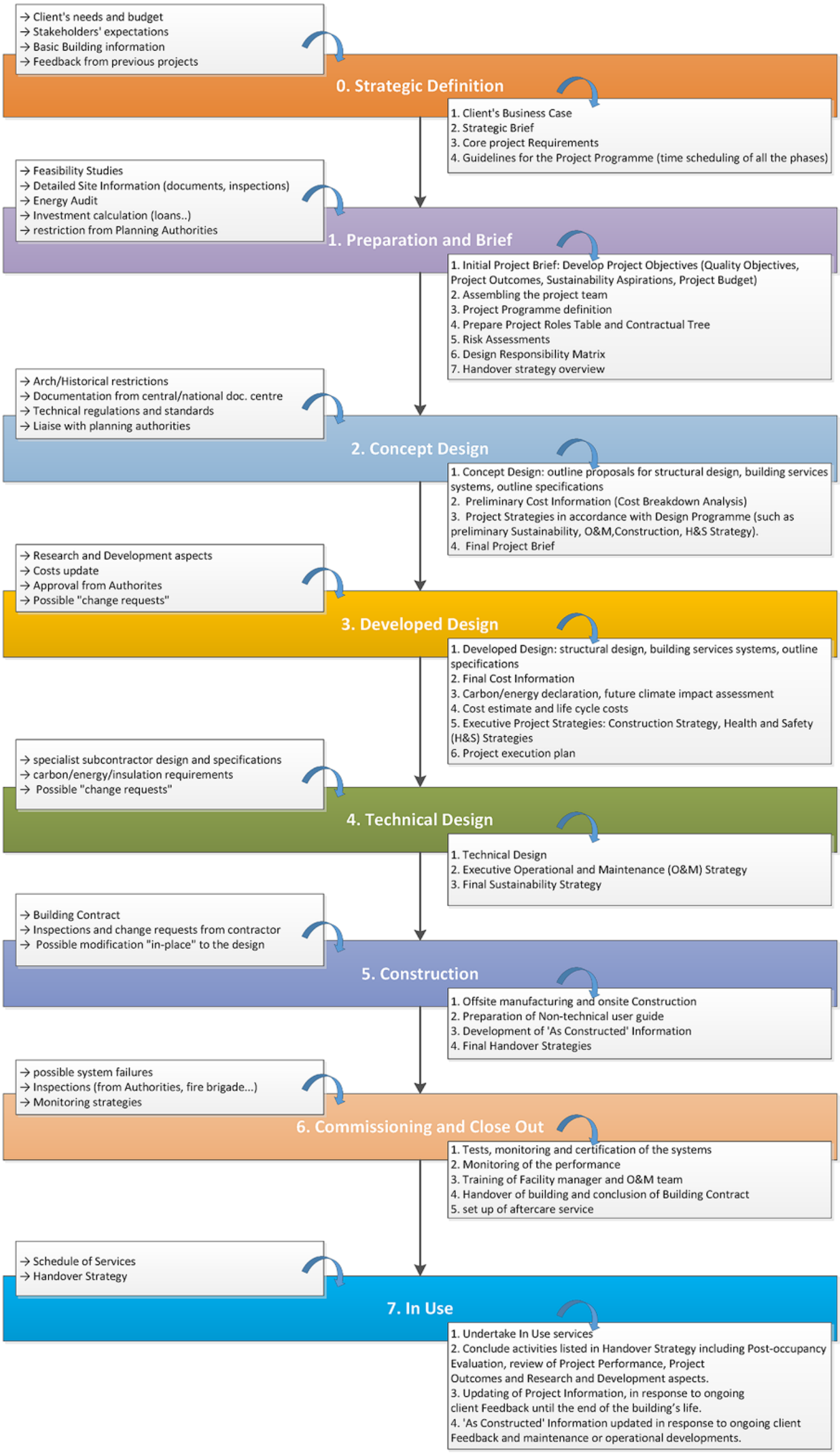


FIGURE 37: SURVEY – MAJOR CAUSES OF FAILURE

This chart confirms that construction techniques and technologies/materials may generate medium to high risks of project failure.

24. Looking at the following model, which is an elaboration of Riba Plan of Work, can you evaluate the level of accuracy or usefulness of each stage?


→ Client's needs and budget
→ Stakeholders' expectations
→ Basic Building information
→ Feedback from previous projects
0. Strategic Definition
1. Client's Business Case
2. Strategic Brief
3. Core project Requirements
4. Guidelines for the Project Programme (time scheduling of all the phases)
→ Feasibility Studies
→ Detailed Site Information (documents, inspections)
→ Energy Audit
→ Investment calculation (loans..)
→ restriction from Planning Authorities
1. Preparation and Brief
1. Initial Project Brief: Develop Project Objectives (Quality Objectives, Project Outcomes, Sustainability Aspirations, Project Budget)
2. Assembling the project team
3. Project Programme definition
4. Prepare Project Roles Table and Contractual Tree
5. Risk Assessments
6. Design Responsibility Matrix
7. Handover strategy overview
→ Arch/Historical restrictions
→ Documentation from central/national doc. centre
→ Technical regulations and standards
→ Liaise with planning authorities
2. Concept Design
1. Concept Design: outline proposals for structural design, building services systems, outline specifications
2. Preliminary Cost Information (Cost Breakdown Analysis)
3. Project Strategies in accordance with Design Programme (such as preliminary Sustainability, O&M,Construction, H&S Strategy).
4. Final Project Brief
→ Research and Development aspects
→ Costs update
→ Approval from Authorites
→ Possible "change requests"
3. Developed Design
1. Developed Design: structural design, building services systems, outline specifications
2. Final Cost Information
3. Carbon/energy declaration, future climate impact assessment
4. Cost estimate and life cycle costs
5. Executive Project Strategies: Construction Strategy, Health and Safety (H&S) Strategies
6. Project execution plan
→ specialist subcontractor design and specifications
→ carbon/energy/insulation requirements
→ Possible "change requests"
4. Technical Design
1. Technical Design
2. Executive Operational and Maintenance (O&M) Strategy
3. Final Sustainability Strategy
→ Building Contract
→ Inspections and change requests from contractor
→ Possible modification "in-place" to the design
5. Construction
1. Offsite manufacturing and onsite Construction
2. Preparation of Non-technical user guide
3. Development of 'As Constructed' Information
4. Final Handover Strategies
→ possible system failures
→ Inspections (from Authorities, fire brigade...)
→ Monitoring strategies
6. Commissioning and Close Out
1. Tests, monitoring and certification of the systems
2. Monitoring of the performance
3. Training of Facility manager and O&M team
4. Handover of building and conclusion of Building Contract
5. set up of aftercare service
→ Schedule of Services
→ Handover Strategy
7. In Use
1. Undertake In Use services
2. Conclude activities listed in Handover Strategy including Post-occupancy Evaluation, review of Project Performance, Project Outcomes and Research and Development aspects.
3. Updating of Project Information, in response to ongoing client Feedback until the end of the building's life.
4. 'As Constructed' Information updated in response to ongoing client Feedback and maintenance or operational developments.

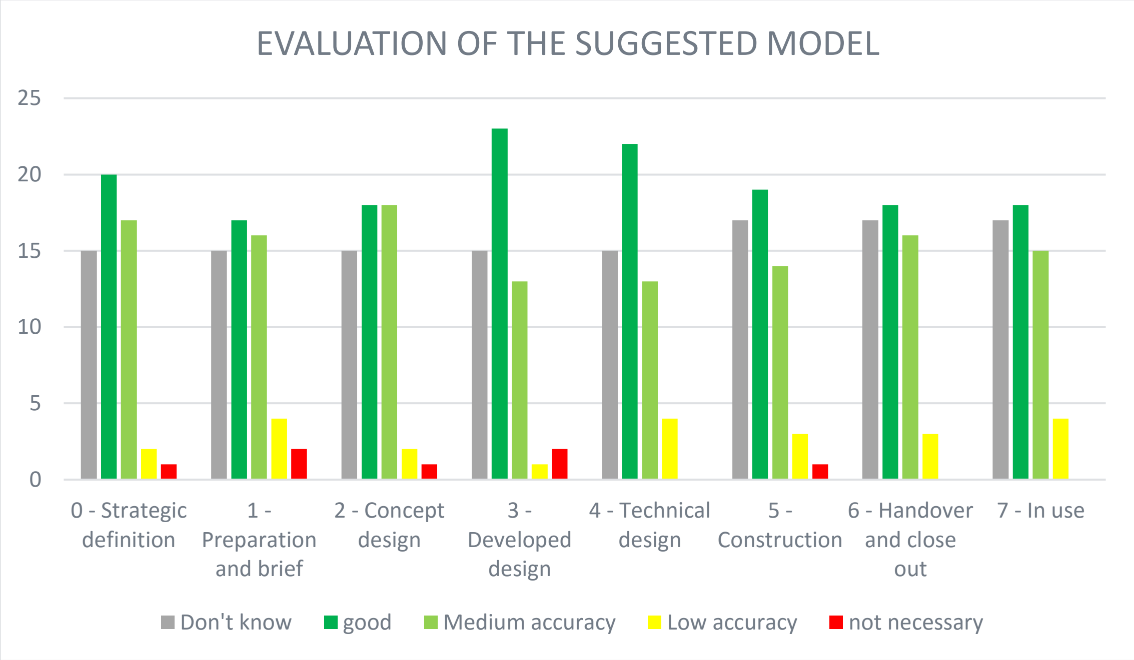


FIGURE 38: SURVEY – FEEDBACK ABOUT THE SUGGESTED MODEL

In general, all the stages are considered as necessary and good-medium accurate and so this workflow could be considered as a good basis for the final model.

25. Can you suggest any modification? (Open question)

Some suggestions have been collected and taken into account for the final synthesis of findings and model definition.

A further major cause of failure which it was suggested should be included in question 23 lay in the selection of collaborators and workers and their skills.

Other interesting suggestions were to include an "indoor environmental quality assessment" as a key step in the concept, developed and technical design stages, and to include more user interaction and participation within the design stages.

Some new approaches have been suggested, such as: Lean Construction, coupled to some kind of "nZEB facilitator" roles (or "low emission buildings" facilitator) where the central hub of the building process is "trust" between contractor, owner, construction company, engineering, users and zero energy requirements.

3.5. Expert panel 'validation'

The Delphi technique is a widely used method for gathering real-world data from respondents within their domain of expertise. The technique is designed as a group communication process that aims to achieve a convergence of opinion on a specific real-world issue (Hsu & Sandford, 2007). It can be used for goal setting, policy investigation, or predicting the occurrence of future events (Turoff & Hiltz, 1996). The Delphi technique operates to build consensus on an issue by using a series of questionnaires to collect data from a panel of selected experts (Young & Jamieson, 2001).

Min contrast to other data gathering and analysis techniques, the Delphi process employs multiple iterations to develop a consensus of opinion concerning a specific topic. More specifically, the feedback process allows and encourages the selected Delphi participants to reassess their initial judgments about the information provided in previous iterations (Hsu & Sandford, 2007). Thus, in a Delphi study, the results of previous iterations can change or be modified by individual panel members in later iterations based on their ability to review and assess the comments and feedback provided by the other Delphi panellists. Basically, the controlled feedback process consists of a well-organized summary of the prior iteration which is distributed to the participants and allows each of them an opportunity to generate additional insights and clarify their perspective on the topic (Hsu & Sandford, 2007).

Typically, a Delphi panel involves three to five rounds of questions. In the first round, the Delphi process traditionally begins with an open-ended questionnaire. This serves as the cornerstone for soliciting specific information about a content area from the Delphi subjects. It should be noted that it is both an acceptable and a common modification of the Delphi process format to use a structured questionnaire in Round 1 that is based upon an extensive review of the literature. Kerlinger (1973) noted that the use of a modified Delphi process is appropriate if basic information concerning the target issue is available and usable. In the second round, each Delphi participant receives a more detailed questionnaire based on the information gathered in the first round. Delphi panellists may be required to rate or rank-order items to establish preliminary priorities among them. In the third round, each Delphi panellist receives a questionnaire that includes the items and ratings summarized by the investigators in the previous round and is asked to revise their judgment or specify the reasons for remaining outside the consensus. This round gives Delphi panellists an opportunity to make further clarifications of both the information and their judgments of the relative importance of the items. In the fourth and often final round, the list of remaining items, their ratings, minority opinions, and items achieving consensus are distributed to the panellists. This round provides a final opportunity for participants to revise their judgments. It should be remembered that the number of Delphi iterations depends largely on the degree of consensus sought by the investigators and can vary from three to five (Hsu & Sandford, 2007).

One of the primary advantages of the Delphi process is subject anonymity. This can reduce the effects of dominant individuals which is often a concern when using group-based processes to collect and synthesize information (Dalkey, 1972). Additionally, the issue of confidentiality is facilitated by geographic dispersion of the subjects as well as the use of electronic communication such as e-mail to solicit and exchange information. As such, certain downsides associated with group dynamics such as manipulation or coercion to conform to a certain viewpoint can be minimized (Adams, 2001).

Regarding the criteria used to guide the selection of panellists, individuals are considered eligible to participate in a Delphi study if they have somewhat related backgrounds and experiences concerning the target issue, are capable of contributing helpful inputs, and are willing to revise their initial or previous judgments for the purpose of reaching or attaining consensus. Delphi subjects should be highly trained and competent within the specialized area of knowledge related to the target issue. Investigators need to closely examine and seriously consider the qualifications of Delphi subjects. Delbecq, Van de Ven, and Gustafson (1975) suggest that ten to fifteen subjects could be sufficient if the background of the Delphi subjects is homogeneous.

Regarding data analysis, decision rules must be established to assemble and organize the judgments and insights provided by Delphi subjects. Basically, consensus on a topic can be decided if a certain percentage of the votes falls within a prescribed range (Miller, 2006). One criterion recommends that consensus is achieved by having 80 per cent of subjects' votes fall within two categories on a seven-point scale (Ulschak, 1983). Other authors however suggest that a more reliable alternative is to measure the stability of subjects' responses in successive iterations.

Subject selection, time frames for conducting and completing a study, the possibility of low response rates, and unintentionally guiding feedback from the respondent group are areas which should be considered when designing and implementing a Delphi study (Hsu & Sandford, 2007).

For NewTREND, a modified Delphi-panel approach was adopted. Rather than providing the primary source of data, the Delphi process was utilised to validate and check the conclusions drawn from the interviews and questionnaire. Consequently, it was felt that two rounds of questions would be sufficient. A panel of 10 experts were recruited from the professional networks of NewTREND partners. This included individuals with both industry experience and academic knowledge of the building energy retrofit sector. Two rounds of questions, based on the findings of the interview analysis and online survey, were submitted to the panel, with the results of the first round of questions being collated to inform the second. The final model of the design process developed in this report was also submitted to the modified Delphi panel for validation and comment. The results of the modified Delphi process are incorporated in the Results section of this report.

4. Findings and Recommendations

4.1. Synthesis of Findings

In this section of the report we present a synthesis of our findings, based on the results of the interviews with stakeholders supplemented by the questionnaire survey and the responses of the modified Delphi process. For ease of comparison, the findings are organised according to the same general headings used in the literature review.

4.1.1. Design Process and its Management

Design Phases

As outlined in the literature review, there are a number of guidelines available (including the RIBA plan of work, FIDIC definition of services, and HOAI) that attempt to standardise the design process for building projects. Each of these defines a fixed series of work stages which any project should go through. During the interviews, stakeholders were asked to comment a sequence of design phases based on an elaborated version of the RIBA plan of work. This comprised:

- Strategic definition
- Preparation & brief
- Concept design
- Developed design
- Technical design
- Construction design
- Construction
- Commissioning and close out
- In use

The general consensus was that these stages were a fairly accurate representation of the design process. However, they were also felt to be somewhat abstract and schematic. In the words of one interviewee, the RIBA phases are 'an ideal process' (NT16016). Another interviewee (NT16026) agreed that the RIBA phases describe the process of energy retrofit, but suggested the energetic survey of the building be included as a separate phase. However, despite the general agreement that the RIBA plan of work reflected the principal stages of the design process, only one interviewee (NT16019) claimed to follow it when designing a building. Others (including NT16018, NT16022, NT16024, NT16025, and NT16026) explicitly stated they did not follow standardized plans of work such as RIBA.

A similar picture emerges from the results of the questionnaire. Just 8% of respondents ascribed either RIBA, FIDIC or HOAI a high level of influence in their activities. Just 6% described these standards as highly effective. The overwhelming majority of respondents were either unaware of these protocols or did not perceive them as popular or influential in their country. On the other hand, when presented with the sequence of design phases outlined above, an overwhelming majority judged each phase accurate and useful and only a handful of respondents judged any phase unnecessary.

When interviewees gave detailed descriptions of the design process in specific projects, the picture that emerged was more complicated. Responses varied widely not only in terms of the design phases listed, but the duration and complexity of the design process, the importance given to different phases, and the degree to which occupant and user participation was formally incorporated. Frequently, design phases specified in RIBA and other standardised plans of work were run together or even skipped entirely. Below, we summarise the design stages of a number of projects outlined by interviewees.

Interviewee: NT16002
Project: Renovation of a historic building for office space as part of a wider district redevelopment

- Masterplan developed for overall district: 'So they set the principles, the heights, the scale, the volume, and position. So we're given a set of parameters that we then developed' (NT16002)
- Outline planning permission secured for office building on basis of Masterplan
- Developer retains architect to develop building design (shell and core)
- Design is prepared alongside consultation with other architects designing buildings in the area
- Building is pre-let before construction to a long-term tenant, who bring in their own architect and interior designer
- Once design is at a fairly advanced stage, the contractor takes over on a design-build contract. 'We took it to Stage D Planning, plus employer's requirements, which gives them a fairly rigid specification for them to work up to, and then (the contractor) took over, on a design build, with their own architect's team, and their own engineers. Now we were retained, by (the developer) as the client's representative, as was the QS and the project manager' (NT16002)
- Some changes made to design during construction
- Completed building will be sub-let to a final tenant who will do their own design for the interior fit-out

Comment: In this instance we can identify three overlapping design processes, each of which incorporates several different phases: the original masterplan for the district, the shell and core of the building, and the final fit-out. Moreover the developer, the principal tenant, and the contractor all successively retained architects to contribute to the design of the shell and core of the building.

Interviewee: NT16017
Project: Redevelopment of a city centre site for residential and educational use

- Multiple plans commissioned over a 12 year period before the current plan was agreed
- Client brief established an initial vision for site
- Initial ideas and sketches prepared by architect on this basis
- These were further developed through a series of design charrettes involving representatives of the client, who were also the future occupants and users of the building
- Further consultation took place between architect and client once they had produced a developed design

- Full design team including QS and structural engineer retained to prepare a detailed, costed design (specialists such as a landscape architect were also involved at this stage)
- Planning application was submitted
- The planning appeals board reviewed the design and recommended some changes following a planning objection
- Planning permission was granted

Comment: This case study maps fairly readily onto the standardised RIBA design phases, with the addition of the planning stage at the end resulting in some changes to the original plan. Also noteworthy is the iterative character of the design process with a constant back-and-forth movement between the architect and the clients, who would also be the end-users and who in this case had a deep emotional investment in the site.

Interviewee: NT16017
Project: Renovation of an apartment building as part of a wider urban redevelopment

- Clarify goals of client (whether these include lower operating costs, reduced energy use, minimal investment, obedience to grant authority rules, etc.)
- Calculate energy use and thermal efficiency of existing buildings
- Formulate proposals (audit based or certification based)
- Discussion with client
- Agree a renovation concept

Comment: This case study is in some ways similar to NT16011 in that, compared to the RIBA plan of work, several design phases appear to be telescoped or skipped. Once again the renovation is presented as a technical exercise, a matter of selecting the best retrofit solution given the client's requirements and the characteristics of the building, so the scope for creativity on the part of the design team is limited.

Interviewee: NT16011
Project: Commercial office renovation

- Look over building with design team (M&E consultant and architect) to see if the space is suitable for raised access floors, etc.
- Initial feasibility study by design team
- Preparation of first-run layouts, cross-sections, and budget
- M&E consultant prepares layout options for different air conditioning systems

Comment: In this case several phases in the RIBA plan of work appear to be missing or telescoped. The scope for creativity on the part of the design team is severely limited. The renovation proceeds according to a standardised and mechanical approach. Certain criteria are demanded of potential office space, such as raised access floors to permit modern air-conditioning systems; it is largely a technical question for the design team how to insert these facilities in the space available.

Interviewee: NT16020
Project: Demolition and reconstruction of an old building on a university campus

- Preliminary feasibility study (including high level CAD drawings)
- Preliminary or concept design (subcontracted to engineering company)
- Preliminary design validated and approved
- Project funding received from national call
- Detailed design
- Construction design (work on the latter two phases put out to tender)
- Permission to build
- Municipal approval process
- Construction
- Commissioning

Comment: The design process in this case maps readily onto the RIBA plan of work. The only difference is the rather complicated process of securing planning permissions, which took nearly a year.

Interviewee: NT16013
Project: Refurbishment of local authority housing

- Government Department of Environment funding for refurbishment secured
- Preparation of design brief (possibly involving outside consultants)
- Discussions with municipal departments, such as housing, roads and planning, to develop technical details of plan
- Public consultation
- Preparation of planning application (engineers become involved at this point)
- Further consultation with residents and neighbours
- Planning application (Part 8)
- Preparation for tender
- Update residents on any changes to design
- Tender process
- Construction

Comment: When we compare this case study with the RIBA design phases, concept design and developed design do not appear as separate stages, whereas planning application and tender preparation are mentioned as separate phases. Also noteworthy is the inclusion of consultation with building occupants at every major stage of the design process – something which is not included in any of the standard plans of work included in the literature review of this report

Interviewee: NT16024
Project: Large-scale renovation of local authority housing development

- Initial report prepared by consultants offering a range of options (demolition and rebuild, refurbishment, a mixture of the two)
- Public consultation with residents on the different options
- Preparation of masterplan for site
- Preparation of detailed design for first blocks to be renovated
- Public consultation on design
- Planning application
- Preparation of tender drawings
- Public consultation
- Tender process
- Construction

Comment: In comparison to the RIBA plan of work, several phases appear to be telescoped (concept design, technical design) while the tender process and planning application appear as separate phases. As in the UK example, there are distinct but overlapping design process involved – the masterplan for the area and the detailed design of particular blocks. The emphasis on public consultation at each major phase of the design process is also noteworthy.

How are we to interpret this data? In the first place it should be acknowledged that in the nature of the interviewee process, some interviewees gave more detailed answers to this question than others. Interviewees may also have highlighted design stages they felt to be more interesting or important while skipping over others as taken for granted. Nonetheless, it is significant that none of the standardised plans of work cited in the literature review would fit all the case studies above. In some instances this is because steps such as application for planning permission or preparation for tender (both incorporated in FIDIC and HOAI but not in RIBA) were treated by the interviewees as separate design phases. In others, especially where building renovation is largely a technical matter of upgrading air conditioning or insulation, several of the standard design phases are telescoped. When we interpret the interview results in tandem with the survey responses, it is clear that while standardised sequences of design stages are seen as offering a valid description of the design process in the abstract, in actual projects some phases come to be seen as more important, while others may be telescoped due to time pressure or project requirements.

The case studies show that building renovations, and their design processes, come in more than one size. Some can involve multiple, overlapping design processes involving different stakeholders – for example, where an individual building is part of a wider district renovation scheme, or where tenants are responsible for the interior fit-out. On the other hand, an energy retrofit which does not involve changes to the building structure may require a less elaborated design process compared to a more substantial renovation. Standardised plans of work such as RIBA and FIDIC may therefore provide an ‘ideal type’ of the design process, but individual projects can be expected to vary widely from the templates they set out. For such plans to be useful, they need to incorporate a high degree of flexibility and adaptability to different circumstances.

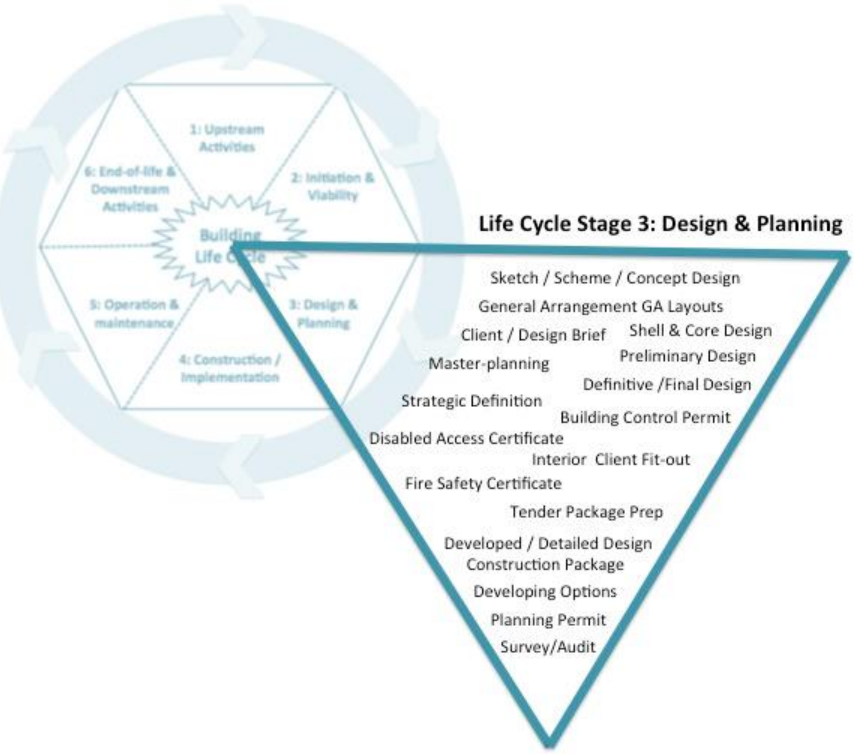


FIGURE 39: DESIGN STAGES DISCUSSED IN THE INTERVIEW PROCESS

The interviews also underline how deeply the design process is influenced by the matrix of stakeholder relationships within which it unfolds. For example, in the UK project outlined in NT16002, the developer, principal tenant and contractor all retained architects who had an input in the building design. In a situation like this, strong working relationships, good lines of communication and a willingness to compromise are critical to the success of a renovation project, and these cannot be ensured by adherence to a standardised plan. The role of planning authorities in influencing the building design was also evident in a number of the interviews, and is exercised not only through the formal planning process, but in pre-planning discussions. Several interviewees described the pre-planning process as involving detailed consultations with planning authorities (NT16002, NT16003, NT16007, NT16014, NT16023). In the UK, the pre-planning process has in the last decade become much more formalized (NT16002), while in Ireland it still appears more informal. The influence such informal discussions can have on the design is suggested by NT16023: 'The same with the planners themselves, we would have brought them out to site, we would have walked the site with them, just to understand their thoughts, their concerns'.

Finally, it is clear from the interviews that where the participation of building occupants and users was an important goal of the design team, it was usual for several rounds of engagement to be included as specific phases of the design process. However, engagement with building occupants and users does not feature strongly in any of the standardised plans, and certainly not as a specific phase or phases of design. A lesson of the case studies is that for user and occupant involvement to be meaningful, it should be structurally incorporated in the design process. Any new standard model of the process should take this into account.

How Does Energy Renovation Change the Design Process?

Most interviewees felt that energy retrofit projects do not substantially deviate from the standard design process. NT16023 stated: 'The only place I suppose it really has an impact on is if you need to put another level on a building, almost like a plant room, a screened area up at the roof…but typically it doesn't really have a major impact on the design, or the process of coming through that'. NT16006 said that while in building retrofits the designer must work closely with the energy engineer, this does not necessarily require extra time. On the other hand, NT16020 claims that for energy retrofitting the feasibility study and preliminary design take more time because the designers need to examine the condition of the building and its energy systems. This can involve an energy audit, structural audit, list of material specifications, assessment of thermal bridges, systems audit, etc.

Several interviewees also indicated that in the case of energy retrofit a building survey forms an important part of the design process. The depth of inspection of the buildings however can vary widely. In the case of existing buildings, surveys may be limited to measurements, photographs and recording the existing condition of visible elements of the building. Where more money and access is allowed, a certain amount of opening up works may be carried out to ascertain the building's condition: are timbers suffering from dry rot, roofs leaking, walls crumbling, or structures unsound? Interviewee NT16013 carried out a survey of local authority housing to assess problems of condensation and mould before carrying out any works.

It appears from the interviews that energy audits are often not extensive, and calculations are based on theoretical figures, i.e. an estimation of the energy a building of this size made with these materials should be using, rather than a measurement of the energy actually used (NT16013). Of the survey respondents, 51% said the energy use of the building was audited prior to the works taking place, 25% said it was not, and 24% did not know. This was an issue where there was a clear consensus among Delphi panel respondents, with all of them viewing an energy audit as a vital part of any retrofit. This could take place either as a separate phase in the design process, or in parallel/intertwined with other stages – in either case, time needed to be definitively allocated to it from early on. As one respondent put it:

> An energy retrofit of a building should always be preceded by an energy audit of the existing building and its existing energy use patterns. Without this the works would often stop at replacing light fittings and upgrading heating plant and controls. By exploring the specific energy use patterns within the building it is possible to identify which energy spikes are caused by an underperforming plant installation and which are caused by unusual occupant behaviour. Detailed energy audits can also help to identify parasitic power loads that would often otherwise be dismissed as part of the nighttime IT server load in a rushed energy refurbishment.
>
> -Delphi panel respondent, Dublin

Levels of inspection, monitoring, and feedback once the construction works are complete, and the building has been occupied or re-occupied also seem to be patchy. Few interviewees routinely carried out post-occupancy surveys, while among survey respondents 34% had no knowledge of the post-renovation performance of the building. On the other hand the fact that 66% of survey respondents had carried out some monitoring of the performance of the building post-occupancy, and 22% of respondents reported the building as performing better than expected, is a positive finding of the study. In general, Delphi panel respondents felt post-occupancy evaluation was insufficient, with a number of exceptions including (1) where a building management system is put in place which requires it, or (2) where the retrofit is supported by a funding body which requires it. It was also noted that post occupancy evaluations are becoming more common in larger building projects in recent years.

Another way in which the design process for energy retrofit is distinctive is the influence of systems of energy certification. Since the introduction of the EU Directive on the Energy Performance of Buildings, it has become mandatory for member states to have a rating certification system in place for building energy performance. In addition there are a variety of voluntary systems of certification, such as BREEAM, LEED and ITACA, both for new and renovated or in-use construction. It is clear from both the interview and survey responses that these have a significant influence. Presented with a list of four certification systems (BREEAM, LEED, Casa Clima or ITACA) a majority of survey respondents said at least one of them had either a 'high' or 'medium' influence on their activities. Most respondents rated one of them as popular within the industry in their country, although they rated somewhat lower on effectiveness.

No single certification system emerges as clearly dominant. BRE's Energy Assessment Method (BREEAM) was said by the architect in NT16002 to be widely accepted as standard in the UK. The BREEAM process was also described by this interviewee as a little irritating due to the almost 'infantile' questions asked in the application process. One of the buildings in the French project discussed in NT16025 was also accredited by BREEAM, while all the buildings in that project were required to meet the standards of the French environmental certification called HQT. The American system of rating, LEED (Leadership in Energy Efficient Design), developed by the United States Green Building Council, is increasingly being used in Ireland according to interviewee NT16023. This is driven by the increase in demand for LEED certification on buildings by American and multinational commercial clients. On the other hand, LEED does not appear to be common in the UK, most likely due to the pre-existing prevalence of BREEAM. Few of the interviewees from continental Europe mentioned either LEED or BREEAM. The German Passivehaus (Passive House) standard was however mentioned by one interviewee (NT16028) as having been attained by the building they were involved with. Passive House is becoming increasingly popular in Ireland and the UK as indicated in the monthly magazine Passive House Plus, the establishment National of Passive House Organizations and proposed plans by at least one Irish Local Authority to demand Passive House Standard for all new housing in their area. Overall, according to the survey results, both BREEAM and LEED have a degree of recognition across Europe, but each of the multiple national systems of certification has its own sphere of influence and none is clearly dominant. It should be noted, however, that BREEAM, LEED and Passivhaus are all voluntary systems of building certification. Mandatory national energy performance certification (EPC) systems arising from the EU Directive on the Energy Performance of Buildings (EPBD & EPBD Recast) will in each member state be far more prominent, e.g., BER in Ireland, Edifícios in Portugal, LECHNER in Hungary, and so on.

Potential Improvements in the Design Process

Interviewees were also asked to make suggestions for potential improvements to the design process for the energy retrofit of buildings. According to NT16012, the design process could be improved by more flexible plans that allow for contingencies encountered during construction, and by involving the contractor in the design phase. In the project described by interviewee NT16023, the contractor had been involved in the design phase and this was seen as strongly beneficial to the overall design process. NT16025 also outlined a project where the construction company and facility management company were involved in the design phase from the beginning. The interviewee highlighted this as an innovative feature of the project, which they considered highly valuable.

It is clear from the interviews that the energy usage figures for buildings are frequently theoretical, with consumption estimated based on the physical characteristics of the building. 'There was a preliminary assessment of the building. We received paper-based plans. Based on these we prepared the study' (NT16025). Actual consumption figures are difficult to get unless metering systems have been put in place and long-term follow up investigations are carried out – which is generally not the case. Once a building is handed over and occupied there is little chance, contractual obligation, or incentive for the design team to return and compare actual energy performance against the design calculations. One interviewee, NT16017 did discuss energy auditing and said their organisation does usually follow up and monitor their buildings in order to learn lessons for future projects, but most others do not. As another interviewee phrased it, 'We deal in theoretical calculations of how bad they are now, and theoretical calculations of how good they are going to be' (NT16013).

Key Findings

1) The sequence of design stages based on an elaborated version of the RIBA Plan of Work provides a fairly accurate 'ideal type' representation of the design process

2) However, in actual building renovation projects, the design phases can vary widely from the model, depending on the scale of the project and its objectives (structural renovation of a building or upgrading of building systems), the configuration of stakeholders, the influence of the planning process, and the participation of occupants and users

3) Many building industry professionals do not follow a standardised plan of work or see such plans as a particularly effective tool

4) Inclusion of an energy audit and post-occupancy review should be considered in any standardised plan of work for the energy renovation sector

5) Participation of building occupants and users should be included in a structured way in standardised models of the design process

6) Early involvement of contractors in the design process can have a significant positive impact

7) Voluntary energy certification systems such as BREEAM, LEED and ITACA are well known and influential in the industry, but there is some disagreement about their effectiveness and no one system is dominant

4.1.2. Stakeholders in Energy Retrofit Projects

This section of the report offers an initial listing and characterisation of the key stakeholder groups that might be involved in a building or district level retrofit project. It also examines how these stakeholders relate to the design process – in terms both of their interests (what they want out of the final design) and influence (their capacity to shape that design).

A building or district scale energy retrofit is a significant project which draws on the skills and resources of many different organisations and professionals, impacts on a range of people from building occupants and users to neighbouring residents, and may have implications for municipalities, planning authorities, heritage bodies and utilities. In order to develop a useful analysis of stakeholder interactions, it was necessary to reduce the wide variety of possible stakeholders to a limited number of generic categories and order them hierarchically in terms of their relation to the project. Drawing on the results of the interviews, a literature review, and work previously done on UMBRELLA[7], dozens of possible stakeholders were identified and included in an initial list. These were then assigned to one or another of a limited number of categories of stakeholder, such as design team, client, statutory body or end user. These naturally divided into two groups: those who are centrally involved in the design and delivery of a project, and those other stakeholders who impact on or are impacted by the project in a variety of ways. To reflect this, a distinction was made between project roles and stakeholder categories.

Project roles: This refers to a limited number of generic roles, which are inseparable from the delivery of any building or district refurbishment project. Each of these roles will be present in any project, but can be filled by different types of stakeholder. For example, the client in a project might be the owner of a building, a development company, or a local authority acting on behalf on multiple owners of different buildings. Ownership in turn can be complex, involving different types of stakeholders such as owner-occupiers, institutional investors, trustees, landlords, etc.

Stakeholder categories: These are groups of stakeholders who do not have responsibility for the delivery of a project, but who impact or are impacted by it in various ways. For example, the category 'public and statutory bodies' includes all those who exercise a regulatory function over the design and implementation of the project, such as local authorities, planning bodies, environmental protection agencies, and health and safety authorities. Several such bodies may be engaged in different ways with the same project at different times over its lifecycle; they will not all fulfil an identical role, but there is sufficient similarity to allow them be placed in the same category.

Project Roles

Client

Role: The client initiates a construction project and contracts with the designer and contractor to design and build it. They have either legal ownership or control of the building for the duration of the project.

[7] The UMBRELLA FP7 project aimed to support the development of the market for building energy retrofit through the creation of innovative business models tailored to different stakeholders (e.g., building owner, building occupant, management company, public authority etc.), building types, climate and policy. A web-based decision support application, which provides independent evaluation tools built around adaptable business models, was developed as part of the project. For more information see http://www.umbrella-project.eu/

Examples: Owner occupiers, landlords, developers, municipalities, state agencies, housing associations, boards of universities, trustees, special purpose vehicles, cooperatives.

Interests: There are different ways in which an energy-efficient refurbishment can serve a client's interests - ensuring compliance with regulations, promoting a positive corporate image, reducing energy costs, or increasing the rental value of their property. NT16011 felt that large commercial occupiers were less concerned with building energy certification than with aesthetic features, finishes, and potential market-rental values. However commercial clients are more likely to be supportive of energy retrofit if it increases their return on their investment in the property. Public building owners and tenants on the other hand were more concerned with achieving good energy ratings, due to the requirement to display the energy use of public buildings. Interviewee NT16018 noted how in their project improvements in energy efficiency were driven by regulations in spite of a reluctant client. On the other hand, some companies want their buildings to be energy efficient because it is good for their image, public relations (PR) and corporate social responsibility policies (CSR). Such clients can push for more extensive and innovative sustainable features in buildings (NT16023). Incorporation of renewable energy generation tended to be more common in privately owned (or at least long-term leased) and owner occupied buildings. Moreover where public bodies have a policy of letting only offices with high energy ratings, this can have an influence on the commercial property market with clients anxious to have the option of letting their buildings to government agencies (16011).

Influence on the design process: The client's influence over the course of the design process and the kinds of energy retrofit measures to be included is potentially very strong, although it may be restricted both by the limitations of their technical knowledge and by factors like money, time and building regulations.

Design Team

Role: The design team includes all those involved in translating the requirements of the client into a finished design for the project, which takes into account the budget and the constrictions of the site as well as the needs of occupants, users, public authorities and the wider neighbourhood. The design team will usually include one partner who is the lead designer, producing an overall architectural vision for the development, and a range of specialists who contribute their own specialist expertise to the design of different aspects of the project. It may or may not include a client representative depending on how involved the client is in the design.

Examples: Architect, architectural technician, engineer (civil, structural, mechanical, electrical, services), quantity surveyor, energy consultants/assessors, ESCOs, energy certification consultant, architectural specialists (landscape, conservation), design specialists (interior fit-out, multimedia, etc.), client representative.

Interests: The design team can bring a range of interests to bear on a project, often reflecting their own personal expertise. When asked how they measure the success of a project, the majority of interviewees answered delivering client satisfaction. However, in general interviewees involved in design were favourably disposed to energy efficient solutions, even in cases where client, tenant or regulatory issues prevented them from implementing them on the scale they would ideally have wished.

Influence on design process: Some members of the design team (such as a consultant archaeologist) may have only a peripheral involvement in specialist areas of a project. Architects and engineers, on the other hand, have a major role in the conception, development and execution of the building design. Their influence will be particularly strong where they are involved from the beginning of a project and help the client to draw up the design brief (NT16007). However, it is not uncommon for several different architects or engineering firms to be involved in a project, sometimes retained by different stakeholders (NT16002, NT16023). Architects may also be strongly constrained by an overarching district masterplan (NT16002, NT16024). Different stakeholder and project configurations, and the relationships within them, may therefore either enhance or dilute the influence of any one member of the design team.

Project Manager

Role: The project manager is responsible for the implementation of the building project according to the design. They will liaise between the client, the design team and the various contractors to ensure the work of construction is carried out efficiently and smoothly and in accordance with the wishes of the client.

Examples: A variety of different stakeholders can assume the role of project manager. It could be an architect, engineer, main contractor, or a representative of the client.

Interests: The primary interest of the project manager is in the timely and efficient completion of the project.

Influence on the design process: Depending on their professional background and the stage at which they become involved in the project, the project manager may have more or less influence over the design phase.

Contractor

Role: The contractor is a construction company which contracts to carry out all or a portion of the construction work on site. The main contractor undertakes to carry out all the construction work; specialised tasks within this may then be subcontracted to companies or professionals with specific skills.

Examples: Main contractor, sub-contractor, specialists, etc.

Interests: The contractor will be primarily concerned to deliver the project on time and within the agreed cost.

Influence on the design process: In general, the contractor becomes involved in an energy retrofit project after the design has been completed. However changes may still be made to the design as a result of issues that arise during the construction process (NT16012, NT16014, NT16023). Among respondents to the survey, in 25% of cases these changes were significant; in 61% of cases they were minor; and in only 14% of cases were there no changes at all. Usually changes are consensual, however a Hungarian interviewee described how the contractor attempted to introduce changes in the plans in relation to materials and budgets, but been prevented by the architect. A number of projects discussed in the interviews involved the contractor from early on in the design stage, giving them a significant voice in the building design, and this was seen as an improvement on the standard design process (NT16023, NT16025).

Stakeholder Categories

Financiers

Role: External parties involved in providing finance for a project, whether in the form of investment funds, loans, grants or tax rebates; also in providing services which facilitate the provision of finance, such as assessing cost.

Examples: Shareholders, investors, banks, national and local governments, public grant programmes, energy supplier schemes, solution-provider backed schemes, ESCOs, donors, charities; insurers, accountants, quantity surveyors.

Interests: Securing a return on their investment, or in the case of public finance providers, ensuring the building meets the agreed conditions of the funding, such as minimum standards of energy efficiency. Given the huge importance of public funding to the energy renovation sector (just under half of the projects in the survey were financed either by governments and local authorities, the EU, or a public body such as a university), public funding bodies are clearly in a strong position to ensure building renovation projects meet policy goals in the area of energy and climate change. Private financiers may have much less interest in the energy aspects of a building.

Influence on design process: Financiers can have a strong influence over the design of a building refurbishment, but this is exercised indirectly, through the conditions that may accompany funding. Public funding bodies in particular can play a significant role in promoting energy retrofit by imposing stringent conditions on funding.

Public and Statutory Bodies

Role: Public and statutory bodies include all those who exercise a regulatory function over the design and implementation of the project. As well as bodies charged with implementing legislation and regulation, this category all includes those public bodies which establish legislation and regulations.

Examples: Local authority (including planning department, architect's office, traffic, roads and housing departments, heritage officers, mayor, chief executive and councillors), planning bodies (including planning appeals boards), environmental protection agencies, health & safety agencies, fire services, EU, national and local legislators, standards bodies (ISO, CEN), green building certification schemes (BREEAM, LEED, Passivehaus, etc.)

Interests: Public bodies can have multiple, overlapping and sometimes conflicting interests such as promoting sustainability, economic development, heritage protection, health and safety, environmental protection, traffic regulation, etc.

Influence on the design process: The direct input of public bodies in the design process is likely to be limited, unless they are themselves the client. However, their indirect influence is very significant, as they set the parameters within which the design process takes place. It is clear from the interviews that public bodies have a massive influence on the market for energy retrofit, through building regulations, planning requirements, public policy, certification schemes and funding mechanisms. They also influence the market as both clients in building retrofit projects and as potential tenants of office space. European and national regulations regarding energy efficiency were explicitly mentioned as key driver of energy retrofit projects in many of the interviews (NT16006, NT16011, NT16022, NT16020, NT16017, NT16018, NT16023, NT16024). This impression is backed up by the survey, where municipal and regional regulations are cited as having a high influence on the design process by nearly all respondents, with EU regulations ranked as influential by a large minority. Significantly, there is evidence of a widespread perception that the standards of energy efficiency required will continue to increase, which stimulates some projects to exceed existing minimum standards. Interviewee NT16011 stated 'You know energy requirements are only going to go one way'. Another interviewee commented, 'standards will change, the next level of Part L will be very close to passive, so in the future phases we may have to be more ambitious…' (NT16024). NT16011 also said companies renovating buildings for office space in the Dublin market were incentivised to achieve the highest level of energy rating by a desire to attract government departments and agencies as tenants.

In addition to national and European regulations, the attitudes of planning officials and local authorities were mentioned by some interviewees as drivers of increased energy efficiency. This influence is exercised not just through the formal planning process but through pre-planning discussions (NT16002, NT16003, NT16007, NT16014, NT16023). A London-based architect states: 'There is almost a sense sometimes that if you put a green roof on a building, then it will get planning' (NT16002). Another interviewee cites energy retrofit as 'the first aim of the previous local government, that started the project' (NT16017). However, planning may not always be needed for refurbishments. An Irish interviewee states 'in a lot of cases, you don't need planning if you are only refurbishing a building…but if you are changing the external appearance of the building significantly, you may need planning' (NT16011). 40% of respondents in the survey cited the local authority or urban planner as a stakeholder in the design process.

Public bodies, at EU, national and local level, also play an important role through directly funding energy retrofit projects. Local authorities or government bodies were mentioned as either clients or financiers in multiple interviews (NT16001, NT16006, NT16012, NT16013, NT16022). In the case of NT16006, although the project involved the refurbishment of residential apartments with mixed ownership, the local authority was a key driver through leading the application for grant funding which enabled it to proceed. Another interviewee (NT16022) explicitly mentioned the importance of EU funding. At the same time, it was suggested that as clients, public bodies are not always innovative when it comes to energy issues (NT16023). Aside from financial constraints, institutions like hospitals wanted to be 100% sure technologies would work before they installed them. As already noted, just under half the projects in the survey were publicly funded.

End-Users

Role: End-users are all those who will use the building. A single project can incorporate many different categories of user, each of whom will have different needs that will have to be taken into account in the design process. The different categories of staff who may be employed in a building are also users of the facilities, who will be particularly important from the point of view of energy efficiency.

Examples: Staff, tourists, students, service users, customers, occupants

Interests: Users demands from a building will depend on their individual relation to it, but in general they have an interest in the comfort, functionality, and appearance of the building. Users may have an interest in energy retrofit where it improves their comfort levels; on the other hand, if they are not paying for energy in the building, or if retrofit works and new technologies will cause disruption, they may not be in their interest. A significant theme in the interviews was the disruption caused by retrofit works to users in buildings which were already occupied (NT16011, NT16006, NT16026).

Influence on design process: Users may have widely differing levels of influence over the design depending on their relationship to the building. In cases where the end-user is also the client, their influence can be very powerful, especially when they have a deep commitment to the building (NT16007). In other cases interviewees spoke of consulting with building users in order to minimise disruption during the construction phase, but this rarely extended to giving the users a significant input into design. Where building users would only be identified after completion of the refurbishment, there was not even this level of engagement (NT16023). Among respondents to the survey, 72% cited building users as stakeholders and 50% cited employees. However only 44% considered the impact of building users and occupants on the design as significant.

Occupants

Role: Occupants are a specific class of users who include all those resident in the building, whether on a short-term or long term basis, before, during or after the retrofit. Occupants are therefore not a single category of users and as part of the design process specific consideration will need to be given to the different kinds of occupants who may inhabit a building over its lifetime and how their needs can be incorporated. In the case of a retrofit project a building will often already be occupied at the initiation of the project. Occupants will then need to be taken into account through every stage of the design and construction process, including through minimising disruption.

Examples: Owner-occupiers, tenants (commercial and residential), subtenants, student residents, hotel guests, etc.

Interests: Occupants will have a range of interests which can influence the design process; comfort, functionality, aesthetics, etc. Energy is often low down the list. In one example from Ireland, access to facilities and improving neighbourhood safety were cited as being top of the occupants' agenda although the design process was initiated by the requirement for an energy retro-fit due to a building survey which had noted cold, damp and mould problems (NT16013). Where building occupants are responsible for the energy bills they will feel a direct benefit from energy retrofit. Autonomy and control over energy use was also seen as important to occupants. NT16011 underlined this in the case of commercial tenants, particularly where a building is let out on a floor-by-floor basis. A centralised heating system was considered undesirable, and rejected so that 'there is no risk of me paying for the guy downstairs who has his heating on all the time'. Centralised heating systems were also identified as problematic in the case of public housing tenants (NT16013).

Influence on design process: The influence of occupants over the design process can vary widely. Where the occupant is also the client, it can be very substantial. On the other hand, where the occupants of a building are going to be completely different after a retrofit, it is likely to be minimal. But where a building or district retrofit has to deal with owner occupiers or sitting tenants, their views will need to be taken into account to some degree, ranging from information and consultation to a full participatory design process. Among projects in the survey, in 76% of cases the occupants and users were the same or partially the same before and after the building works. Interviewees described a range of activities designed to engage occupants, from one-on-one consultation with commercial office tenants (NT16011) to active participation of public housing tenants in every stage of the design (NT16024). In general, the influence of occupants will be greater when they are owner-occupiers or long-term tenants, when they have numbers and some form of representative organisation on their side, and when they are dealing with public bodies rather than private developers.

Neighbourhood Stakeholders

Role: These are parties who are not involved in the project, but are impacted by it due to physical contiguity. It is worth noting that in many cases (such as developments including retail or service functions) neighbourhood stakeholders will also be potential users of the facility.

Examples: Residents in surrounding areas, businesses, neighbourhood and community associations, sporting and voluntary groups, local business groups, road users.

Interests: The primary interests of neighbourhood stakeholders will be to avoid disruption, and potential negative impacts of a development on the appearance, services and social fabric of an area.

Influence on design process: Neighbourhood stakeholders are unlikely to be afforded an active voice in the design process. However they wield an indirect power through their ability to object to a development through the planning process or representations to public bodies. Significant efforts may be made by the design team to avoid this by taking potential neighbourhood concerns into account. A number of the interviewees described formal consultation processes with neighbourhood stakeholders designed to ensure their support for a development (NT16007, NT16013, NT16014, NT16023, NT16024). Among survey respondents, 32% mentioned neighbours as stakeholders in a project.

Consultants and Third Parties

Role: These are parties whose involvement in the project is limited to a consultative role involving a particular area of expertise, which is not directly related to design or construction.

Examples: Planning consultant, auctioneer, media & marketing, property valuation, insurers, utilities, etc.

Interests: The interest of these stakeholders in the project will be limited, beyond the performance of their specific role.

Influence on design process: Where these stakeholders have an influence on project design, it is likely to be highly specific and limited to their area of technical expertise.

Stakeholder Configurations

One point that emerges clearly from the interviews is that the same stakeholder can occupy multiple project roles/stakeholder categories. Likewise, the same project role can be divided between multiple stakeholders. Building energy retrofit projects therefore tend to be delivered by complex stakeholder configurations. Some examples from the interviews include:

- The client is an organisation whose members were also occupants/users of the building (NT16007, NT16023)
- In addition to the client, a commercial/institutional tenant had a substantial say in the building design (NT16001, NT16007, NT16023)
- The client in the project is also responsible for both project management and design (NT16004, NT16013, NT16024)
- The design team includes architects retained by both the developer, a property company with a long term lease on the building, and building contractor (NT16001)

Different stakeholder configurations can have a significant impact on the interests and levels of influence over a project of the stakeholders who participate in them. As a result, the influence of architect, client, occupant, etc. over the design process in individual projects can vary widely, depending on the particular stakeholder configuration in the project and their position within it.

Key Findings

1) Stakeholders can be assigned to a limited number of project roles (client, design team, contractor, project manager) and stakeholder categories (financier, public and statutory bodies, end-users, occupants, neighbourhood stakeholders, consultants and third parties)

2) Building renovation projects are often delivered by complex stakeholder configurations, which vary from project to project

3) The shape of these configurations impacts on the interests of stakeholders and the influence they can exert over the design process

4.1.3. Decision-Making in Energy Retrofit Design

Design Principles

Unsurprisingly given the focus of the research, energy efficiency and sustainability more generally were identified as key design principles in many of the interviews (NT16002, NT16003, NT16005, NT16012, NT16013, NT16015, NT16017, NT16020, NT16022, NT16025, NT16027). However, few were as specific about their objectives as NT16022: 'to reduce energy consumption of the residential building by 30% and to increase by 80% the values of thermal insulation of existing facades'. There were also some interviewees for whom energy efficiency was not a priority – for example, because heritage considerations meant they were not subject to the regulatory standards (NT16003). It is clear that many stakeholders merely want to meet the minimum mandatory requirements for energy efficiency (NT16023, NT16025). Since these often apply only to new-builds, energy improvements to existing buildings tend to be voluntary, and take place only where an opportunity arises and they coincide with other objectives, such as increasing the rental value of a property. Among survey respondents 78% identified energy efficiency as a key design principle, and 45% cited environmental sustainability. Some 43% cited achieving savings on operational costs as a design principle.

Increasing the insulating capacity of the thermal envelope was the most popular method of improving the energy performance of buildings amongst the interviewees. In the case of NT16017, the retrofit was more ambitious: 'The project was aiming for a whole transformation of the living environment…the possibility of implementing solar collectors and configuring green roofs was also examined' (NT16017). This illustrates how sustainability as a design principle is open to varying interpretations, in terms of the depth of retrofit and the expansiveness of environmental aims. Other projects incorporated micro-generation (NT16013) or took account of sustainable water use and transport (NT16023). However, interviewees suggested the kinds of measures adopted can sometimes be driven by the availability of grants, rather than the potentials of the building and surrounding area (NT16012).

Comfort as a design principle was mentioned in several interviews (NT16024, NT16002, NT16011, NT16013). This could impact on the design of energy saving measures, as for example where provision is made for opening windows. 'We were quite keen…that there was an opportunity that people can open windows if they wish. We felt that was important that it was wasn't a sealed box' (NT16002). 45% of survey respondents identified user and occupant comfort as a key design principle of the projects they were involved in.

The maximisation of rental value or return on investment was mentioned as influencing design by a number of interviewees (NT16011, NT16014, NT16023). This was particularly important in the case of those involved in refurbishing buildings to provide commercial office space, where the number of workers who can be accommodated in a given space is a critical factor. 'You get densities now of one person per 8 square metres, down to one person per 6 square metres, they are driving. In London now, the big deal is one person, the buildings are designed to take one person per 5 square metres. They are packing people into buildings' (NT16011). This results in high levels of standardisation in design: 'You don't get into great variation from project to project, because you are trying to provide space that appeals to the market at large' (NT16011). The exception is where companies are constructing headquarters for themselves, in which case – depending on the company ethos – more innovative energy-saving features may be incorporated (NT16011, NT16023). 22% of survey respondents cited increasing rental value or return on investment as a key design principle.

Preserving or exploiting the heritage value of a building was mentioned as a design principle in multiple interviews: NT16003, NT16007, NT16012, NT16014, NT16016, NT16027. Frequently this acted as a constraint on the implementation of energy efficiency measures. However only 13% of survey respondents cited preserving heritage as a design principle. Aesthetics was cited as a design principle by interviewees NT16005, NT16006, and NT16011 and by 23% of survey respondents.

Accessibility was cited as a design principle by interviewees NT16007, NT16007, and NT16014 (in the last two cases with specific reference to universal access). It was a key design principle for 17% of survey respondents. Flexibility – so that spaces would be adaptable for multiple uses – cited as a key principle by NT16014. Functionality was a key design principle for 32% of survey respondents.

Aside from the members of the design team, the stakeholders most commonly cited as influencing design principles were local authorities and public bodies (NT16003, NT16004, NT16005, NT16006, NT16012, NT16017). The local City Development Plan and zoning objectives were cited as an influence by NT16003, while urban regeneration and revitalization were mentioned by NT16003, NT16014, NT16017, and NT16027. User and occupant considerations were mentioned as significantly shaping the design principles by multiple interviewees, including NT16002, NT16003, NT16014, NT16016, NT16017, NT16019 and NT16025. Clients are explicitly mentioned as having helped shape the design principles by interviewees NT16023 and NT16007: their role is probably taken as a given elsewhere even when not explicitly mentioned.

The interviews, even though based almost exclusively on a sample of projects where energy was the main or an important component of the building renovation, confirm the findings in the literature that energy improvements are seldom the main deciding factor in whether to go ahead with a building renovation project (see figure below). This is reflected in the design process, where energy is often one of several coinciding needs, such as comfort levels, heritage value, aesthetics, building modernisation, return on investment, etc. which need to be taken account of. The design principles are in turn largely determined by the configuration of stakeholders; those who have most influence will get to decide the design principles of the project. Based on stakeholder theory (see literature review), the design process will be optimised when the interests and particular knowledge of all stakeholders are taken into account.

FIGURE 40: DRIVERS FOR ENERGY RETROFITS MENTIONED IN THE INTERVIEWS

Key Findings

1) Energy efficiency is seldom the only factor determining building design

2) Comfort, maximising rental value or return on investment, preserving heritage value, aesthetics, accessibility, flexibility, functionality, and saving operational costs were other design principles commonly cited

3) An effective design process will achieve the optimal blend of different objectives in the same building

4) This in turn will need to be aligned with stakeholder objectives. Maximum inclusion of all stakeholders, their interests and specific bodies of knowledge in the design process can help achieve the optimal blending of design objectives.

4.1.4. Design Constraints

This subsection outlines the main constraints or 'bottlenecks' encountered in the design process according to the interviewees, once again supplementing the analysis with the results of the questionnaire survey.

Heritage Restrictions

Design teams working on energy retrofit in European cities are frequently faced with the challenge of buildings which have heritage or architectural value which needs to be preserved and which are protected by regulations. Numerous interviewees described how this limited their freedom in designing and implementing energy conservation measures (NT16001, NT 16002, NT16003, NT16012, NT16019, NT16022, NT16026). 22% of respondents to the survey identified heritage factors as a key barrier encountered during the design process. Heritage preservation was reported as a constraining factor in Ireland, the UK, Italy, France and Hungary. Several of the interviewees pointed out the difficulties with getting the authorities to agree to works on heritage buildings. Comments included: 'they (the planners) are being too precious' 'our client is spending whatever millions to prolong the life of a heritage building in a very positive way and we are getting a bit too into the details' (NT16002).

Often heritage buildings cannot be covered over with insulation or cut for ducting (NT16002 & NT16006). Replacing windows may not be an option depending on local planning and conservation laws, and their interpretation. Insulating the roof of a protected structure or listed building may also be difficult without removing and potentially damaging roof tiles, or disturbing delicate materials. 'We have to accept certain buildings as they are' (NT16007). It was commented that 'marble and decorations on facade are beautiful and in Italy are widely used and protected, but terrible for insulation' (NT16020).

In energy retrofit works where the outside of the building is protected due to architectural features, heritage listing, or streetscape aesthetics, (e.g., NT16012) a common but problematic solution has been to dry-line buildings, as opposed to fitting external insulation – i.e. 'create an inner skin of insulation' (NT16002). However, this not only results in a loss of floor area, and massive disruption during retrofit works where the building is in use, it also creates cold-bridging at wall and floor junctions, which can lead to condensation and mould growth.

Impact on the design process: Where a building is protected due to heritage status, the number of design options available for energy retrofit can be severely constrained

Delays in Certification and Approval

Delays in projects caused by dealings with local government and other authorities and by securing a variety of forms of certification and approval were mentioned by nearly all interviewees. These can result in the time available for the actual design work being restricted. NT16012 feels that when dealing with local government there can be too much bureaucracy, too many delays, and that the details tend to get worked out by lawyers. A further problem is that the personnel or departments involved can change during the process of application (NT16017), so that documents need to be resubmitted, designs changed, and permissions and approvals can be delayed. Grant aid is often used to fund energy retrofit projects, but several interviewees described the process of applying for such aid as excessively onerous (e.g., NT16006).

Not all building refurbishments require planning permission, however a significant majority (66%) of survey respondents required planning permission for the project they were involved in. The procedures for seeking planning permission vary between jurisdictions. In London the pre-planning process has been formalised in recent years, leading to an increase in the amount of work involved, meaning the entire process takes longer. However NT16002 points out that this is reassuring for larger clients, as it affords them greater certainty that a project will receive planning permission before they make the decision on proceeding with an investment. An Italian interviewee described a municipal approval process that lasted a year: 'the project had to be submitted to a detailed review of utility supply capacity and Municipality approval process' (NT16020).

Fire certificates were mentioned as an issue in both Ireland, where new regulations requiring certificates to be issued before work commences can delay projects by 6-9 months (NT16011) and Hungary, where regulations have also changed in the last 2-3 years (NT16012). 32% of the survey respondents required fire certificates for the projects they were currently involved in. Constraints due to regulations governing access for people with disabilities were mentioned as an issue by one interviewee (NT16001). 18% of survey respondents were required to have their buildings certified as accessible to people with disabilities.

Of the survey respondents, 38% said that delays with planning and permits were a key bottleneck in the design process. This made it the second biggest constraint, after funding. For the local authority interviewed in NT16013, a typical retrofit project can take five years from initiation to breaking ground. Most of this time is spent seeking approvals, rather than on actual design. Having to seek approval from a particular government department at every stage was cited as a big delaying factor. The project discussed by interviewee NT1609 took two and a half years from the request to the client, a public body, to start work to its completion: however, construction took only three months of this. NT16020 had to wait a year from the point where they were ready to commence construction work to breaking ground, due to the need for municipal approval.

It is clear from these and other cases that waiting for approvals of various kinds can take up the bulk of design process. This can result in the time available for design being squeezed, with pressure on design teams to prepare a project for the next stage quickly once a particular approval is granted. 22% of survey respondents cited lack of time for the design phase as a key constraint. One interviewee stated that lack of time to apply for funding meant insufficient time to prepare a project (NT16012). Another spoke of a grant programme being announced suddenly, with a short submission deadline, so that there was less time for design preparation than was desirable (NT16006). The limited amount of time available for design was also a theme of NT16017, NT16026, NT16027. According to NT16018, lack of time for the design phase meant that 'careful consideration and details are compromised… it could cause opportunities to be left out'. According to NT16023, private contracts have more flexibility with timelines than public ones, since while waiting for planning permissions, you can go through the tender process, apply for a fire cert, etc. This allows you reduce the time required but can involve increased risk. 'Commercial companies will do that sometimes, because time is more profitable to them in the end price. If the end price goes up by 5%, but if they get the project finished 3 months, 4 months earlier, they will have workers in the building working for four months, which will probably make them twice as much' (NT16023).

Impact on the design process: Delays caused by waiting for various kinds of grant aid, planning permission and certification can reduce the time available for actual design, restricting innovation and resulting in lost opportunities

Infrastructure Issues

Inadequate infrastructure to facilitate construction works, or ensure accessibility to the site for potential users once the work has finished, is a further possible constraint. Energy retrofit, or indeed any construction and maintenance works, can be hampered by poor access to the site, or to particular parts of a building (NT16001). Limitations on access can also determine the types of materials or renewable energy technologies specified for the project. One interviewee complained about the absence of adequate access roads to the construction site (NT16001). Others, discussing an urban regeneration project, commented on how much work was being done on-site in order to redevelop the buildings, provide public amenities, create universal access and so on, while the local authority was doing nothing to improve surrounding roadways, signage, and footpaths (NT16003, NT16010, NT16014). So although the municipal planning department had given the building works permission to go ahead, and had presumably charged significant fees for local authority services and amenities development, the other departments in the local authority had not even begun to provide those services despite construction works being almost complete. On the other hand, the decision by planners to allow no provision for private vehicular access in the case of the project in NT16002 bolstered its credentials as a sustainable building development.

NT16004 pointed to delays caused by the connection of the gas supply, while NT16008 also cited constraints due to problems connecting buildings to the local municipal water and sewerage systems. It is not only delays in connection to public or municipality services that has caused problems however – connection to privately owned services such as district heating and co-generation was also mentioned (NT16009).

Impact on the design process: Failure of local authorities and utilities to support a project by providing the appropriate infrastructure to ensure accessibility of the site and prompt integration with services can limit design choices and delay construction. On the other hand, a deliberate decision by local authorities not to facilitate access by private vehicles can enhance sustainability in district scale projects by ensuring they focus on sustainable transport options in the design

Structural Issues

A variety of structural issues can delay building renovations and limit design options. This is compounded by information gaps, especially in older buildings where plans and drawings are either missing or inadequate. 23% of survey respondents said lack of information on the building was a key constraint in the design process, while 10% cited problems accessing documents, plans, etc.

Achieving a balance between energy saving, structural integrity and fire safety was discussed in several of the interviews, particularly in relation to the insulation thickness and material selection for high-rise buildings (NT16017). Finding a material that can meet structural and fire safety standards, while achieving high levels of energy efficiency, can raise the cost of a project. For example if you increase the thickness of insulation in a cavity wall, you have to increase the thickness of the cavity, associated fire stopping, wall ties and so on – and to maintain structural integrity, there will be a maximum cavity width for different materials.

Small floor plates and low floor to ceilings heights in old buildings can pose a challenge for energy improvements (NT16002, NT16005 & NT16011). Air conditioning and cable trays can be particularly difficult to incorporate in commercial buildings where the required ceiling heights are generally higher than in residential use – for example, in Ireland the standard minimum ceiling height in a private house is 2.4m, but the minimum for an office is 2.7m. This is the height from the top of the floor finish to the underside of the ceiling, and at least another 300mm may be required above for services such as ducting and cables. However there are some clients who like exposed services and visible cable trays, and in these cases it is less of a problem (NT16002).

Working with heritage buildings can be particularly difficult, and unfortunately works and interventions carried out in the past are not always good quality, well documented or appropriate. In some cases previous refurbishments have left buildings in a worse condition, and have made their structural stability more 'precarious' (NT16001). Structurally unsound buildings are more difficult (and expensive) to refurbish.

When working with older buildings, it is not always known at design stage what will be found behind a wall, or under a floor when construction and opening-up works begin (NT16012 & NT16025), especially since plans and drawing can be either missing or very basic. As one interviewee comments: 'there are always hidden surprises which have to be managed' (NT16006). Examples of the kind of issues uncovered include dry-rot (NT16007) and support columns, which did not align with those above or below (NT16023).

The discovery of such issues during construction frequently necessitates changes to the design, which is a particular problem with building refurbishment. 61% of survey respondents said minor design changes were required during construction, while in 25% of cases significant changes were required. Interviewee NT16012 asserted that the difference between their project as designed and as constructed was less than 10%, which is minimal for a project of that (large) size. NT16014 stated that some changes to the design arose in spite of a thorough on-site investigation prior to the commencement of construction, but this was inevitable given the nature of the building, some parts of which dated back over 200 years. NT16023 found that once they took the brick facing off the 1960s building they were retrofitting, the block work behind was unstable and the whole inner leaf needed to be replaced. 'Where you are renovating an existing building we would recommend always to get a surveying company to go in and literally survey the whole building' (NT16023). Such issues can arise on a daily basis during the construction stage – which means that the designers need to be present more often than on a new build. This is not always possible, since the designer's contract and the project budget usually only allows for them (or a representative) to be on site at intervals, and not every day. However one project in Ireland did employ a site architect, who was hired by the main architect, but worked on site and was therefore on hand to deal with any issues as they arose. This ensured an effective liaison between the client, contractor, and design team (NT16007).

> *Impact on the design process*: Structural issues such as floor-to-ceiling height, floor plates and wall thickness can limit the range of choices available to the designer of a building energy renovation, sometimes severely. Gaps in information and drawings can also cause issues during the design stage, generating uncertainty, delays and additional costs. They increase the likelihood of significant changes to the design being required during construction. Some of these issues can be overcome through the use of a building survey

Skills Shortages

Views among designers are mixed as to whether industry and construction site personnel in particular are sufficiently equipped with the specific skills and competence required by energy retrofit projects. Only 3% of survey respondents cited skills shortages as a constraint during the design process, but several cited workers and their skills as a potential cause of project failure in additional comments.

Return on Investment

Opinions on the incorporation of renewable energy generation into buildings were mixed, but frequently unfavourable, due to perceptions that they offer little return on investment and create split incentives. Interviewee NT16006 as a reason for not installing renewables cited low payback. A further problem in this case was that the building tenants, rather than the client, would benefit from the electricity being generated. Another residential project installed solar PV panels for electricity generation, but there was no method of storage and no feedback tariff in place. Consequently, while the building occupants were out at work and school during the day, the electricity generated was simply fed back into the grid (NT16013). 20% of survey respondents cited low payback for renewables as a key constraint in the design process.

Similar problems with payback were cited for district heating. The air tightness and insulation standards in building regulations are now reaching levels where heating requirements are very low for new buildings. As existing buildings are retrofitted, the heating requirement overall in districts is reduced, as is the incentive for investing in expensive district heating systems where none currently exist – especially where population densities are low (NT16013).

Impact on the design process: Where renewable energy sources or district energy systems are perceived not to offer an adequate return on investment, the range of design choices for energy renovations is constrained

Occupants and Neighbours

Despite the generally favourable attitude of planners towards energy efficient buildings, obtaining planning permission in residential areas can still be tough (NT16002). Neighbours can act as constraints on a project. This was echoed by NT16023 who said that the neighbouring residents were quite 'active'. However, in the case of one project that had been delayed for six months by a planning appeal, the design team felt that in the end it had been 'enriched' (NT16007). The delay gave everyone time to stop and think about what they really wanted, to fine tune and improve the design so that they had a better offering at the end of the appeal process (NT16014).

The other area where there is potential for conflict with neighbours is during the construction phase, where works can cause scope for significant disruption. The planning of construction works is crucial, especially where the site is occupied and in use. This can be a significant constraint on a project (NT16012). Safety, noise, access and possible relocation of building users must all be considered.

Impact on the design process: The design team must take account of the sensitivities of occupants and neighbours if they wish to avoid planning objections and delays. While occupant involvement in the design process can generate positive benefits, a failure to constructively involve occupants can result in significant obstacles being placed in the way of a project. The desire to avoid objections can also limit the choices of designers. On the other hand, delays caused by planning objections can sometimes give additional time to think through a project, resulting in an improved design.

Tender Process

Interviewee NT16001 described the tender process as very restrictive for public projects in France. NT16020 and NT16023 also spoke about the complexities involved in public tendering processes. The latter pointed out that under the open tendering system mandated for public bodies by EU regulations, it is less likely that a contractor they have worked with before, and have a good working relationship, will win the bid. The cheapest contractor might not necessarily be the best to work with. According to NT16011 and NT16013 the tender process can be very intense, and generally (for small to medium commercial projects) it takes up to three months to prepare the tender package, another two months for the contractors to respond with their tender bids, and at least another month for the client to award the contract to the winning tender – approximately six months in total. For larger projects the whole process can take longer, perhaps even twice as long. Public projects may differ depending on the government bodies that are required to approve the various stages of the process, and the intricacies of public procurement guidelines.

Impact on the design process: Public tender regulations can cause delays to a project, and impede efforts to include contractors early in the design process

FUNDING

Funding was most commonly cited constraint on the design process cited by survey respondents – 55% stated it was an issue. Funding was also mentioned in almost every interview, frequently in the context of its impact on decision-making in design. Who pays for a project is an important factor in the outcome, as there can be important differences in design principles and the design process depending on who is doing the funding. Private clients may be more open to new ideas, public clients may create more levels of bureaucracy, grant-aided projects may require more paperwork.

Increasing profitability and maximising the possible financial gain from every square metre was a priority for interviewee NT16007 and their partners. Most interviewees discussed the costs associated with the construction works, and the payback time of materials and technologies used for energy retrofitting. From this perspective, the benefits of renewables are an issue for disagreement amongst the stakeholders in many countries (NT16006). NT16010, by contrast, was more concerned with how the operation, general running and maintenance of the building would be funded in the long term once it was commissioned. In this instance, constructing a second building on the site, and leasing it on a long-term basis to a pre-agreed client was derived as one solution. Thinking of creative ways to attract visitors, investors, tourists etc. was another. Both had a decisive influence on the final design of the project.

Achieving the maximum financial gain per square meter of the building or site was the main objective of any works according to NT16011 – even if that meant demolition and replacement of an existing building. Whether the existing building floor plates, and floor-to-ceiling heights could accommodate air conditioning determined whether a building was going to be refurbished or demolished. NT16012 pointed to the futility of making projects 'cheaper and cheaper' as 'you only create problems for yourself, because you have to go back for warranty repairs all the time'. In other scenarios the costing of projects was assessed based on a 30 year building lifecycle (NT16017). A 30-year lifespan for private building projects was also mentioned by NT16023. Maintenance and running costs are also very important, but in many cases, are either not considered at design stage at all, or discounted because the client paying for the building works is not the one who will pay for the upkeep. This potentially acts as a disincentive for clients to invest in energy efficiency measures.

Impact on the design process: Funding can pose a range of constraints on design options for a building renovation, depending on the priorities of the client. However an excessive focus on minimising costs in the short term can be counter-productive. Maintenance and running costs should be fully taken into account during the design phase.

4.1.5. Occupant and End-user Participation

The Design Phase - Consultation or Participation?

Nearly all interviewees had something to say about the relationship between energy efficient building projects and the actual or potential occupants and users of the buildings. However, the extent, format, timing, and character of occupant involvement with design differed markedly between projects. Many projects had no engagement with occupants and users, either because they were dealing with an empty building or because it was not a priority for the client and design team. Others engaged in various levels of consultation, while for some significant occupant and end-user participation in the design process was a priority. Of survey respondents, only 33% stated there was occupant involvement in the design process. 44% claimed the impact of building occupants on the design was significant, 34% said it was minor and 22% said there was little or no impact of occupants. This suggests that even where occupant and user considerations figure in the design process, all too often it is without the participation of actual occupants and users. Instead, designers take account of what they perceive are the occupants' needs.

Certainly, in many of the projects discussed in the interviews, occupants and users were given no voice in the design process. One interviewee stated 'there were residential forums, where the plans were presented to them, but no actual communication happened. The residents were not involved in the design process' and again 'it was just a plan/design presentation, not a consultation. And this was definitely bad' (NT16017). Another interviewee stated: 'We didn't involve occupants in the concept and detail design' (NT16020). For other design team stakeholders, users and occupants are viewed primarily as sources of data who can tell designers what indoor temperatures are like, how much electricity they consume, how often they use their appliances, turn on their heating etc. When asked to name the stakeholders in an energy retrofit project, some respondents failed to mention building occupants at all (NT16005).

Others viewed relationships between the stakeholders, including occupants, as purely commercial and financial (NT16011). In many commercial projects there is no feedback from the occupants or users in the early design stage, as the norm (NT16002) is for the developer to arrange for a shell and core fit-out, as per assumed market demands. The tenant who is to occupy the building is left to fit out the interior later – 'we provide a blank canvass to people' (NT16011).

In such case the future occupants and building users are often unknown, and unknowable, making it more difficult to judge their needs. However designers still need to take account of these, so a wholly generic 'user' is constructed. One interviewee outlined the various rule-of-thumb methods used to take account of future users in the design of office space: 'Typically we base it on what we call a 60-60 split. So if there is 100 people, instead of going 50 men and 50 women, we design to 60 men and 60 women. So that if its 60-40 in either way we have over compensated on both, so for toilet numbers, wheelchair numbers, changing areas, you just have a slight bit more than the minimum so that you can take discrepancies' (NT16023). In larger buildings, creating multi-purpose spaces is a way of both future-proofing buildings, and dealing with design scenarios where the end-user is not known at design stage, or the end-user is not clear on what their requirements are. Basic information on the activities that will be taking place in a room are also an essential consideration in terms of energy use: 'Let's say you have a scientist that is doing something that provides a lot of heat, or you have teaching rooms, you know, you are really looking at a very different way of using energy' (NT16005). Another interviewee stated they used social survey data on the number of single parent families in an area, how many people are social housing, etc., to determine what sort of services might be needed in the refurbished buildings (NT16010).

The next level of engagement is consultation, where users, occupants and neighbours are provided with information on the building plans and given the opportunity to voice their opinions. Usually this takes place when the plans are at or close to finalisation, so the scope to influence the design is limited to the possibility of having some particularly objectionable feature amended or removed. Several of the interviewees discussed how local communities, occupants, neighbours and the general public were engaged prior to the commencement of the work. In some cases, it was noted, that people were just glad to see the buildings being refurbished and reused rather than being allowed to remain unused and falling into disrepair. Simply being allowed into the process, and made aware of the proposals was seen as a positive (e.g., NT16007, & NT160014). Other interviewees tended to view the occupants as rather passive 'they have just taken our plans, and accepted them' (NT16010). On the other hand, interviewee NT16023 discussed how neighbours of the building project, in an affluent urban area, were extremely pro-active and attentive to any building works in their neighbourhood. Getting them involved in the process was seen as vital to the success of the project, and having a 'better friendship' with them led to a 'better end product'. In Ireland, one project held several open days on site for neighbouring residents to view the proposed plans (in drawing and three dimensional model format) and meet with the client and design team to discuss the proposals. Attendance was in the hundreds at these events (16007 & 160014). Another interviewee (NT16028) mentioned sending out questionnaires, surveying building users, neighbours and occupants, and engaging with stakeholders such as the local sports clubs, elderly care groups and the local bowling club in advance of a project.

As multiple authors have argued, actual participation rather than consultation means that residents and other end-users are given a real voice in the design process (Arnstein, 1969; Cross, 1993; Robertson & Simonsen, 2012). At minimum, this requires that they be involved at an early stage in the preparation of the design. A variety of tools and techniques may also be required to ensure stakeholders who are not design professionals are empowered to make their voices heard. In one project public meetings, design charrettes and open days were held (NT16007), while in another occupants and local residents participated in brainstorming sessions with the design team (NT16013, NT16024). Interviewee NT16013 discussed how the residents of an urban redevelopment project availed of the services of their own architect in order to liaise with the local authorities (who were the developers in this case). The architect, who was paid by the local authority, acted as a translator of sorts, a go-between who would help ensure the residents' voices were heard in the design process (NT16013). Interviewee NT16007 described 'just listening' as being very important to the design process, and discussed the use of physical scale-models and three dimensional drawings that can be easily understood by people outside of the construction industry (tools also mentioned by NT16024). Such tools can make design proposals accessible and legible to occupants and users: 'people who were coming in looking at the planning application could actually see what it looked like in 3D, and that is very helpful' (NT16003). NT16009 described a project where engagement with the locals included a neighbourhood dinner at the local parish hall attended by officials such as the local mayor.

One interviewee noted that the process of participation was very useful for the municipality which was the driver of the project, as it allowed them 'discover the reality of the neighbourhood, the rivalries, the world of young people who lived there, and of the elderly residents. Thanks to this investigation, we have understood how the society is organized.' (NT16009). Other respondents cited addressing the safety concerns of locals living and working in the general area, such as fire safety, control of access, and protection from anti-social behaviour, as having prompted works on two different projects. In this case user and occupant concerns were not centred around energy, but energy issues were then tackled as part of an overall confluence of issues (NT16006 & NT16013). Aesthetics, and the general appearance of buildings were paramount to some users and occupants and dictated the choice of energy retrofit interventions, technology and materials (e.g., as discussed by NT16007 and others).

Some technologies will not work because the occupants or users have a strong dislike for them, for example metering. One interviewee said it had been tried in the past with residents in their buildings but had met with strong hostility (NT16013). Consequently, their organisation had ruled out using metering again. Where energy is metered and paid for by the occupants there is, theoretically, a possibility to reduce energy use. However, for those in fuel poverty, this may be detrimental to their health – as they may have to make trade-offs between purchasing basic essentials such as food and paying for heating. Their energy consumption may seem low, but this may be because they are living with indoor air temperatures of 12 degrees for example. It is clear from the interviews that the requirement for energy efficiency in some cases led to designers taking steps to limit the control occupants and users had over the building systems. In the case of NT16013 this involved fully enclosing the building and putting in ventilation systems rather than grids. NT16015, an Italian interviewee, was explicit about this managerial approach and the reasons for it: 'Mechanical ventilation systems were foreseen in the project and camera bodies were placed in the habitable roof-space, in order to avoid that users could access to it to change the air circulation, because they are not educated about the operation of the systems technology'.

The kinds of occupant and user engagement described by most interviewees would be placed towards the bottom or middle of Arnstein's (1969) famous ladder (below). Usually it involved informing or consultation, where there was any engagement at all. In only a small minority of projects did it ascend towards the top of the ladder, involving partnership or even some level of delegated power.

Where occupants and users were involved it was usually towards the end of the design process, through consultation on a more-or-less finished design. However in those cases where occupants were involved near the beginning (eg. NT16007, NT16013, NT16024) the level of participation achieved was much greater. In general, the results show an awareness among building industry stakeholders of the need to take occupant and user considerations into account, combined with a frequently technocratic and managerial attitude towards them ('the design team know best') and an absence of effective mechanisms for occupant and end-user participation early on in design. Delphi panel respondents likewise combined an acknowledgement of the need for occupant and user involvement with various caveats, stressing that it depended on the function of the building, the nature of the organisation which owned or occupied the building, and the tenure of occupants:

> There are two sides to the argument here and it strongly depends on what type of lease is involved. On one hand we must consider that the building should be tailored to meet the needs of the occupant and enhance their ability to effectively manage the facility and minimise energy costs. Identifying the patterns and behaviours of the long-term occupants can inform the decision-making process when deciding on what energy efficiency measures to include in the design and squeeze some additional savings on the running costs.

On the other hand if the building is not owned or on a long-term lease by the occupants, then it is better to create a generic energy-efficient building that will continue to operate at a low energy cost even if the occupant and occupant type changes significantly.

The Construction Phase

Occupants and users also need to be taken account of when planning the construction phase of a project. Noise and inconvenience during the building works were cited as the main occupant and user consideration during the construction phase in several interviews (e.g., NT16011, NT16006, NT16026). 'A lot of employees did not understand it, to be honest. They did not understand that the wind blows through the window, but their problem was that now there is someone hammering on the wall' (NT16012). In the case of commercial office buildings, interviewee NT16011 described how it can be necessary to carry out the works on a piecemeal basis in order to retain sitting tenants. Tenants may be moved from floor to floor, or building to building, while refurbishment works are carried out in stages. This type of project requires very careful coordination, stakeholder management and occupant consideration. Working outside of normal office hours may also be required in order to facilitate commercial or public tenants of buildings (NT16011, NT16012, NT16024).

In the project described by interviewee NT16025, refurbishment works on a cluster of university buildings took place while they were in use by staff and students. An online survey was conducted on the university website while the work was in progress to measure any disruption, and weekly meetings were held between representatives of the building users and the construction and design team. Interviewee NT16013 notes that on one project in a residential area roads and driveways had to be dug up, causing disruption to road users and residents, while in another residents refused to allow their garden walls, which abutted on the site, be demolished and rebuilt. Meeting and talking with residents one-on-one was the favoured way of defusing such potential conflicts. A lot of this work was devolved to the contractor, as the partner on site, with provisions in the contract to this effect. The extraordinary lengths this local authority went to in accommodating residents is shown by the following anecdote: 'One of them who was tenant had a lot of sheds, had a lot of pigeon houses, so we had to negotiate in a lot of detail with him what we were going to put back and exactly when we were going to do it, because it couldn't be done during racing season or during the breeding season, so we had quite a small window [laughter] of when we could put in the new one' (NT16013). Significantly, however, all these cases involved simply managing the impact of construction on building occupants and users: the extensive consultations involved did not have a significant impact on the design, which was completed beforehand.

Post-Occupancy

A notable feature of the interviews is that few of those contacted routinely measured building energy use post-occupancy to gauge the effectiveness of energy efficiency measures. On the other hand, 66% of survey respondents were aware of how the building had performed since works were completed and it had been occupied. Getting feedback from the users or occupants of a building once it has been occupied can be very difficult. In some cases this may be due to issues of security and privacy – such as the protection of intellectual property in an office building for example (NT16002). But in most cases, this is because once the building works are complete, and handed over to the client, all ties with the design team are severed. There are no further contractual obligations.

There are suggestions however that energy retrofits may not perform as promised, in part due to the behaviour of users and occupants. One interviewee mentioned an office building that was designed to Passivhaus standard, but was not meeting its targets. The designed energy use was based on a 21-degree indoor air temperature, but the occupants preferred to maintain the building at 23 degrees Celsius (NT16013). Another interviewee pointed out how the staff of commercial buildings change throughout the life of a building (NT16023), so educating one group of occupants in the 'correct' use of the building may not solve these issues if the process has to be repeated regularly, or if there is a complete change of occupancy. The survey provides a more optimistic perspective: only 9% of respondents stated the energy performance of the building was worse than predicted, compared to 35% who claimed it was as predicted, 22% better than predicted, and 34% who didn't know.

One respondent to the Delphi process underlined the importance of the post occupancy phase in the following words, and tied it in with the issue of occupant and user engagement:

> …there is no prolonged Stage of Work following handover of completed building to client, and hence no opportunity to engage with occupants following occupation.
>
> This is a real issue in 'performance' led buildings, as this hinders the provision of guidance to occupants, and the tweaking of systems when settled in (both can lead to much poorer performance of the building) and post occupancy monitoring or user evaluation is always an 'add-on'. Often simple performance issues are not addressed, and occupants do not understand the building design and technologies well enough to address without assistance. It is estimated that such monitoring and evaluation should be undertaken in year two of occupation, but even the standard defects period is completed by then.

Key Findings

1) There is broad recognition of occupants and users as stakeholders in the design process; however this is not matched with effective techniques to enable their participation from an early stage

2) Engagement with occupants and users is usually limited to consultation when the design is already complete, although there were some projects which adopted a more participatory approach

3) In some cases, a strongly techno-centric and top-down attitude was detected, with designers deliberately restricting occupants' control over building systems such as ventilation in the interests of energy efficiency

4) Occupant and user participation is most effective when they are offered a structured input into the design process, when this occurs from early on, and when they are provided with appropriate tools and supports to facilitate participation

5) Post-occupancy evaluation and measurement is vital and, despite the challenges involved, should be recognised as an integral stage of the design process

4.1.6. Energy Retrofit in a District context

A striking feature of the interviews was the almost universal failure of the projects discussed to integrate the energy measures they applied with the wider district energy system. There was little attempt to develop district heating and cooling systems or energy hubs, district scale renewable energy generation, or to achieve economies of scale through bundling multiple buildings in district scale retrofits. A number of reasons for this may be suggested: energy retrofit was often only one of a number of goals in the refurbishment; perceived problems with the payback times of renewables; split incentives between building owners and tenants, residents and public bodies, which are amplified at district level; logistical problems caused by fragmentation of property ownership in districts; lack of incentives from municipal or national authorities; funding mechanism which concentrate on single-building refurbishment; a market characterised by a desire to achieve the maximum and shortest payback for the least money; and the fact building refurbishment is often initiated on an 'opportunistic' basis, for example when there is a change of tenant in an office building, which makes it difficult to plan a district scale renovation in advance. Most interviewees had never even thought of taking the wider energetic context into account. The two exceptions are instructive: a project on a university campus which was already served by a CHP plant fuelled by biomass, and a large-scale urban regeneration project where developments were governed by the initial master plan requiring buildings to connect to the district heating system. The consensus of the Delphi panel respondents, likewise, was that energy retrofit usually takes place in isolation from the wider district context.

A slightly different picture is presented by the survey, which showed 33% of respondents incorporating solar hot water in the project design and 37% incorporating solar panels. It should be noted, however that the strong representation of southern Europe in the survey may have had an impact here. Other design features, which took account of the district context, were less prominent. 22% reported incorporation of district heating or cooling, with 12% utilising CHP. 22% sought economies of scale through including multiple buildings in an energy retrofit. Only 5% of respondents incorporated energy generation from wind, while 12% used biomass. Only 7% took account of urban microclimates in the design.

Regional, urban and municipal local authorities generally have area development plans that will to some extent dictate the district context of any building construction or refurbishment in their area. Where the local authority is the owner of large amounts of property, for example a housing estate or apartment complex, they will have a crucial role in ensuring the district context is appropriately considered in the project. There is little evidence however that they have used this influence to incorporate a district-scale perspective in neighbourhood energy systems. Large private developments, meanwhile, tend to be carried out autonomously. There is contact with local authorities in terms of gaining the various planning and building control permits, but the design and construction teams do not formally communicate with one another in any way. However, one UK respondent (NT16002) did note that, despite their being no mandatory requirement, the design teams of several projects within an urban regeneration area, who shared common public spaces, did meet several times to keep each other appraised of that what happening on each of their projects.

Building assessment methodologies often score developments higher for taking into account the district context, although this is limited to aspects such as public transport and district heating. The points system in LEED for example allots points for proximity to bus stops – however, the actual routes and destinations served by the stop are not given any weighting, so its usefulness to occupants and users may be minimal in reality (NT16023). Another issue is that retrofit work is often carried out piecemeal, and there is nervousness about new technologies when it comes to district heating and CHP for example (NT16025).

While common in EU countries such as Denmark, district heating is very rare in other countries such as Ireland. One respondent working in a local authority felt that district heating was unworkable in many situations in Ireland because residents would resent both metering and having to pay for someone else's heating if un-metered. A Hungarian respondent also pointed out that district heating could be difficult to implement in buildings with complex ownership (NT160006). Where buildings are mostly privately owned, individual solutions such as thermal envelope improvements, and installation of solar panels, or PV panels are more common. Lack of incentive in the way of a feed-in tariff to recoup the return on investment in PV panels was mentioned as a deterrent (NT16013). The district context was also cited as being a restricting factor in terms of what retrofit works could be carried out in order to fit in with existing building facades (NT16022). In general, many interviewees felt that the district context did not really have a 'prominent role' (NT16027) in the projects that they were discussing.

Key Findings

1) Incorporation of the district context into building retrofit design was often absent or limited

2) Where it took place, it usually involved established technologies such as CHP, solar water heating or photovoltaic panels

5. Conclusion

This report has examined the current design process for building energy refurbishment through a combination of an extensive literature review, interviews with stakeholders, a survey of industry professionals, and a modified Delphi process taking into account the views of both academic and industry experts. The research has concentrated on six thematic areas which are most relevant to the goals of NewTREND and which together provide a substantive overview of the design process:

- The design process and its management
- Stakeholders in energy retrofit projects
- Decision-making in energy retrofit design
- Design bottlenecks
- Participatory design
- Energy retrofit in a district context

Every building project is different, and this is particularly the case with building refurbishment. The opportunities and constraints afforded by the existing building and its surrounding district, the objectives of the refurbishment project, the configuration of stakeholders and their dynamics – all these will differ from project to project, often widely, and these differences need to be taken account of in the design process. Nonetheless, certain key steps which feature in the design process of most projects can be identified and abstracted. Consequently, a variety of normative or standardised models have been developed (RIBA, FIDIC, HOAI). While our research has shown that these tend to have limited impact on actual building projects, they do afford a generalised overview of the design process.

The table below collates a number of sources to provide such an overview. The left hand column outlines the six phases in a building's life-cycle which were identified in the UMBRELLA FP7 project, based on a collation of dozens of different models. The second column illustrates the phases of the design process identified by three standardised industry models, RIBA, FIDIC and HOAI. These cover a shorter timescale than the building's lifecycle, excluding for example upstream activities, downstream activities, and all or most of the operational phase. The third column draws on the results of the research carried out for this report. Under the heading 'key phrases', those design steps most commonly referred to in the interviews are matched with the comparable stages in the standardised plans of work. This gives an indication of which steps, according to our informants, are most important or challenging for building energy retrofit. Finally, under the heading 'occupant involvement', we highlight those phases of the design process where building occupants and users are *currently* most likely to be involved (when they are involved at all).

It is important to note that not every project discussed in the interviews went through all of the phases outlined. The table is not intended to present a normative model of what the design process ought to be. Rather, it offers a generalised, 'birds-eye view' of the design process, marking the *possible* phases which a particular project may go through, and indicating those which were most prominent in the interviews or where occupants and users are currently engaged.

Building Life Cycle Stages	**Selection of three Normative Models**			**Fieldwork (from interviews)**	
Umbrella	*RIBA*	*FIDIC*	*HOAI*	*Key Phrases*	*Occupant Involvement*
Upstream Activities					
Initiation & Viability Check	Strategic Definition	Scoping of Services	Definition & Scope of Work	Developing Options	Occupants & Users not generally involved
				Building Survey / Audit	
	Preparation & Brief	Pre-Design		Client Brief / Design Brief	
Design & Planning	Concept Design	Schematic Design	Concept Design	Sketch / Scheme / Concept / Preliminary Design	Public meetings, brain-storming, flyers, open-days, surveys etc Stakeholder engagement varies – sometimes does not exist at all
	Developed Design	Developed Design	Preliminary Design	General Arrangement Layouts	Not generally involved
	Technical Design	Construction Documentation		Shell & Core Design	
		Building Permission Application	Building Warrant Drawing	Building Control Permit Planning Application Disabled/ Universal Access Cert Fire Safety Permit	Individuals or groups of concerned stakeholders Can submit objections, take proposals to court etc
			Detailed Design	Definitive / Developed/	Not generally involved

				Detail/ Final / Design	
		Procurement	Preparation of Tenders	Tender Package	
			Tender Analysis		
Construction / Installation	Construction	Construction	Site Inspection & Work Supervision	Construction	May be on site while works are on-going or may need to be moved
	Handover & Closeout		Administration & Documentation – Work Completion	Handover/ Snagging	As builts, instructions, manuals and so on to be handed over
Operation / Maintenance	In-Use	Post Construction		Occupied / In-use	Main Stakeholders at this stage
Downstream Activities				Demolition	Not generally involved

TABLE 3:FINAL COMPARISION

LEGEND:
Umbrella = Dunphy et al., 2013, Six Life Cycle stages based on an amalgamation of model terms found in literature review (see Appendix A)
RIBA = Riba Plan of Work
FIDIC = Federation Internationale des Ingenieurs-Conseil
HOAI = Honorarordnung für Architekten und Ingenieure
Key Phrases = Key words and phrases mentioned in the interviews
Occupant Involvement = User participation and consideration in the interviews

This model provides a template on the basis of which some of the key conclusions of this report can be addressed in future deliverables of NewTREND:

Energy audit and post-occupancy evaluation: For building energy retrofits, an energy audit and post-occupancy evaluation need to be included as standard, and clearly incorporated in the NewTREND integrated design methodology (T2.6). They could be indicated either as specific phases, or as critical steps within one of the existing phases of the design process.

Occupant and user participation: Despite a general acknowledgement of occupants and users as stakeholders in building refurbishment, their actual participation in the design process is limited and usually occurs towards the later stages, when they are presented with a more or less finished design. A technocratic and managerial attitude towards occupants is also prevalent, with a tendency to seek to limit their control over building energy systems in the interests of energy efficiency. Occupant and user participation needs to take place from early on in the design process, to be supported with effective techniques, and to be facilitated by providing occupants and users with adequate information. For each of the possible design stages above, appropriate techniques to facilitate participation need to be developed. This will form the work of T2.5 of NewTREND.

Stakeholder management: Maximal stakeholder engagement at every stage of the design process can help overcome bottlenecks and constraints (for example in sharing documents and information) and achieve an optimal blend of design objective. In particular, it is clear from the research that the involvement of specific stakeholders such as the contractor, facility management, and BREEAM and LEED consultants from early in the design process can have a positive effect both on the quality of the final design, and the efficiency of construction and the operation of the building. Stakeholder engagement and communications will be explored in more depth in T1.1 and T2.6.

District context: It is clear the district context of energy retrofits is not being sufficient addressed. The integrated design methodology in T2.6 should include consideration of district synergies at every one of the possible design stages that have been outlined.

6. References

ABET, Definition of Design. http://www.abet.org/

Adams, S. J. (2001). Projecting the next decade in safety management: A Delphi technique study. Professional Safety, 46 (10), 26-29.

Allegrini, Jonas, Orehounig, K., Mavromatidis, G., Ruesch, F., Dorer, V., & Evins, R. (2015), 'A review of modelling approaches and tools for the simulation of district-scale energy systems'. Renewable and Sustainable Energy Reviews 52, 1391-1404

Antonelli, L. (2016), Energiesprong, in Passive House Plus (online version), Passive House Plus, Temple Media, Dublin accessed at: https://passivehouseplus.ie/magazine/insight/energiesprong

Arnstein, S. R. (1969). A ladder of citizen participation. Journal of the American Institute of Planners, 35(4), 216–224.

Auvinen, H., Ruutu, S., Touminen, A., Ahlqvist, T., Oksanen, J., (2015), Process supporting strategic decision-making in systemic transitions, in Technological Forecasting and Social Change, Vol 94, pp97-114

Baber, C, & Damecour, R. (2008), 'Going for the gold: sewage heat recovery system to serve Olympic Village'. Dist. Energy, 20-24

Bauer, D., Marx R., Nubicker-Lux, J, Oches, F., Heidemann, W., & Muller-Steinhagen, H. (2010), 'German central solar heating plants with seasonal heat storage'. Solar Energy, 84 (4): 612-23

Berardi, U., (2013), Stakeholders' influence on the adoption of energy-saving technologies in Italian homes, in Energy Policy, Vol 60, pp 520-530

BSRIA, (2014), *The Soft Landings Core Principles, BSRIA BG 38/2014*, published by the Building Services Research and Information Association, Bracknell, England.

Brocas, I., & Carrillo, J.D., (2014) Dual-process theories of decision-making: A selective survey, in the Journal of Economic Phycology, Vol 41. Pp45-54

Brown, M.M., (2003), Technology Diffusion and the "Knowledge Barrier": The Dilemma of Stakeholder Participation, in Public Performance and Management Review, Vol 26, No 4, pp 345-359

Bryson, J. M., Quick, K. S., Slotterback, C. S., & Crosby, B. C. (2013). Designing Public Participation Processes. Public Administration Review, 73(1), 23–34. http://doi.org/10.111/j.1540-6210.2012.02678.x.Designing

BSRIA, BREEAM or LEED - strengths and weaknesses of the two main environmental assessment methods, 2009.

Busby Perkins +Will, S. C. (2007). Roadmap for the Integrated Design Process. Toronto: BC Green Building Roundtable.

Chicco, G., Mancarella, P. (2009), 'Distributed multi-generation: a comprehensive view'. Renewable and Sustainable Energy Review, 13 (3): 535:-51

Chittum, A. & Ostergaard, P.A. (2014), 'How Danish communal heat planning empowers municipalities and benefits individual consumers'. Energy Policy, 74: 465-474.

Chorus, C.G., (2015), Models of moral decision making: Literature review and research agenda for discrete choice analysis in The Journal of Choice Modelling, Vol 16, pp69-85

Chow, y. (2009), 'Utilizing district energy systems as a cost-effective measure in meeting UK domestic 'zero carbon' targets'. International Journal of Low-Carbon Technology, 4: 169-174

Clastres, C., 2011. Smart grids: Another step towards competition, energy security and climate change objectives. Energy Policy, 39(9), pp.5399-5408.

Cole, S., (2014), Keep calm and learn Dutch: Energiesprong the future of sustainable homes?, in, United Kingdom Green Building Council Online Blog, London, accessed at: http://www.ukgbc.org/resources/blog/keep-calm-and-learn-dutch-energiesprong-future-sustainable-homes

Compagnon, R. (2004). Solar and daylight availability in the urban fabric. *Energy and Buildings*, *36*(4), 321–328. http://doi.org/10.1016/j.enbuild.2004.01.009

Coyne, Rosemary n.d., 'The Community Green Deal: A model for area-wide delivery of housing retrofit to benefit whole communities'

Crane, A., & Ruebottom, T., (2011), Stakeholder Theory and Social Identity: Rethinking Stakeholder Identification, in the Journal of Business Ethics, Vol 102, Supplement 1: Ethics, Corpoations, and Governance, pp 77-87

Crosbie, T., & Baker, K. (2010). Energy-efficiency interventions in housing: learning from the inhabitants. Building Research & Information, 38(1), 70–79.

Cross, N. (1993). A history of design methodology. In M. de Vries, N. Cross, & D. Grant (Eds.), Design Methodology and Relationships with Science (pp. 15–27). Berlin: Kluwer Academic Publishers.

D'Anjou, P., (2011), An alternative model for ethical decision-making in design: A Sartrean approach, in Design Studies, Vol 32, No 1, pp45-59

Dalkey, N. C. (1972). The Delphi method: An experimental study of group opinion. In N. C. Dalkey, D. L. Rourke, R. Lewis, & D. Snyder (Eds.). Studies in the quality of life: Delphi and decision-making (pp. 13-54). Lexington, MA: Lexington Books.

De Carli, M., Galgaro, A., Pasqualetto, M., & Zarrella, A. (2014), 'Energetic and economic aspects of a heating and cooling district in a mild climate based on closed loop ground source heat pump'. Applied Thermal Energy, 71 (2): 895–904.

Delbecq, A. L., Van de Ven, A. H., & Gustafson, D. H. (1975). Group techniques for program planning. Glenview, IL: Scott, Foresman, and Co.

Doyle, R., & Davies, A. R. (2013). Towards sustainable household consumption: Exploring a practice oriented, participatory backcasting approach for sustainable home heating practices in Ireland. Journal of Cleaner Production, 48, 260–271. http://doi.org/10.1016/j.jclepro.2012.12.015

Dumitriu, C., Timofti, I, C., Nechita, E., Dumitriu, G., (2014), The Influence of the Locus of Control and Decision-making Capacity upon the Leadership Style, in Procedia – Social and Behvaioural Sciences, WCTLA 2013, Vol 141, pp494-499

Dunphy, N.P. & Morrissey, J.E., (2015), Optimization of Construction Supply Chains for Greenhouse Gas Reduction, in E. Sabri (Ed), Optimization of Supply Chain Management in Contemporary Organizations, (pp280-310). Hershey, P.A.:IGI Global.

Dunphy, N. P., Morrissey, J. E., & MacSweeney, R. D. (2013). Analysis of stakeholder interaction within building energy efficiency market: FP7 project deliverable for umbrella: Business model innovation for high performance buildings supported by whole life optimisation. Cork, Ireland: University College Cork.

Dunphy, N.P., Little, J., & van der Krogt, R., (2012), Model for Retrofit Configurations Selection Using Multiple Decision Diagrams, in proceedings of the First Building Simulation and Optimization Conference, 10-11 September 2012, Loughborough, UK.

Elsawah, S., Guillaume, J.H.A., Filatova, T., Rook, J., Jakeman, A.J., (2015), A methodology for eliciting, representing, and analysing stakeholder knowledge for decision making on complex socio-ecological systems: From cognitive maps to agent-based models, in the Journal of Environmental Management, Vol 151, pp 500-516

Fassin, Y., (2012), Stakeholder Management, Reciprocity and Stakeholder Responsibility in the Journal of Business Ethics, Vol 109, No 1, pp 93-96

Fonseca, J. A., Nguyen, T. A., Schlueter, A., & Marechal, F. (2016). City Energy Analyst (CEA): Integrated framework for analysis and optimization of building energy systems in neighborhoods and city districts. Energy and Buildings, 113, 202–226. doi:10.1016/j.enbuild.2015.11.055

Freeman, R.E., (2010), Managing for Stakeholders: Trade-offs or Value Creation, in the Journal of Business Ethics, Vol 96, Supplement 1, pp7-9

Freeman, R.E., Wicks, A.C. & Parmar, B., (2004), Stakeholder Theory and "The Corporate Objective Revisited" , in Organization Science, Vol 15, No 3, pp364-369

Garcia-Fuentes, M. A., Vasallo, A, Garcia-Pajares, R., Pujols, W. C. & Meiss, A (2014), 'Residential areas retrofitting towards nearly Zero Energy Districts (nZED). A case study: Valladolid-Cuatro de Marzo

García-Peñalvo, F.J., & Conde, M.A., (2014) Using informal learning for business decision making and knowledge management , in the Journal of Business Research, Vol 64, pp 686-691

Garrido, M., Mendes, R., Jr., Scheer, S., and Campestrini, T. (2015) Using BIM for Last Planner System: Case Studies in Brazil. Computing in Civil Engineering 2015: pp. 604-611.

Genovese, A., Koh, S.C.L., & Acquaye, A., (2013), Energy efficiency retrofitting services supply chains: Evidence about stakeholders and configurations from the Yorskhire and Humber region case, in the Int. J. Production Economics, Vol 144, pp20-43

German Fee Schedule for Architects and Engineers HOAI §1

Girodon, J., Monticolo, D., Bonjour, E., Perrier, M., (2015), An organizational approach to designing an intelligent knowledge-based system: Application to the decision-making process in design projects in Advanced Engineering Informatics, Vol 29, pp696-713

Gironès, V.C., Moret, S., Maréchal, F., Favrat, D., (2015), Strategic energy planning for large-scale energy systems: A modelling framework to aid decision-making, in Energy, Volume 90, pp 173-186

Gocer O, Hua Y., Gocer K., (2015). Completing the missing link in building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance.

Gordon W, Hunter S, Evans B, Devine-Wright P, Fay H, (2007) Harnessing community energies: explaining community based localism in renewable energy policy in the UK. Global Environmental Politics, 7 (2). pp. 64-82. ISSN 1526-3800

Gray, S., Chan, A., Clark, D., Jordan, R., (2012), Modeling the integration of stakeholder knowledge in social–ecological decision-making: Benefits and limitations to knowledge diversity, in Ecological Modelling, Vol 229, pp88-96

Harrison, J.S., & Freeman, R.E., (1999), Stakeholders, Social Responsibility, and Performance: Empirical Evidence and Theoretical Perspectives, in The Academy of Management Journal, Vol 42, No 5, pp 479-485

Harvey, D. (2012), A Handbook on Low Energy Buildings and District-Energy Systems: fundamentals, techniques and examples. Routledge.

Hawkey, David, Webb, J., & Winskel, M. (2013), 'Organisation and governance of urban energy systems: district heating and cooling in the UK'. Journal of Cleaner Production 50, 22-31

Heier, J., Bales, C., & Martin, V. (2015), 'Combining thermal energy storage with buildings – a review'. Renewable and Sustainable Energy Review, 42: 1305-25

Heravi, A., Coffey, V., & Trigunarsyah, B., (2015), Evaluating the level of stakeholder involvement during the project planning processes of building projects, in the International Journal of Project Management, Vol 33, pp985-997

Hou, J., Liu, Y., Wu, Y., Zhou, N., & Feng, W. (2016). Comparative study of commercial building energy-efficiency retrofit policies in four pilot cities in China. Energy Policy, 88, 204–215. http://doi.org/10.1016/j.enpol.2015.10.016.

Hsu, Chia-Chien & Sandford, Brian A. (2007). The Delphi Technique: Making Sense of Consensus. Practical Assessment Research & Evaluation, 12(10). Available online: http://pareonline.net/getvn.asp?v=12&n=10

Improvement Skills Consulting Ltd. (2009). Data Collection Questionnaires – A Quick Guide. Available online: https://ianjseath.files.wordpress.com/2009/07/questionnaires-quick-guide.pdf

Jones, T.M., & Wicks, A.C., (1999), Convergent Stakeholder Theory, in The Academy of Management Review, Vol 24, No 2, pp 206-221

Jonsson, P., Landelius, T., & Lindberg, F. (2012), 'Review of solar energy modeling in the urban environment' [Internet]. Available from: ⟨http://www.wspgroup.com/upload/upload/sebe_state_of_the%20art_120323.pdf⟩.

Kaler, J. (2006), Evaluating Stakeholder Theory, in the Journal of Business Ethics, Vol 69, No 3, pp249-268

Kaler, J., (2003), Differentiating Stakeholder Theories, in the Journal of Business Ethics, Vol 46, No 1, pp 71-83

Kanters, J., & Wall, M. (2016). A planning process map for solar buildings in urban environments. Renewable and Sustainable Energy Reviews, 57, 173–185. http://doi.org/10.1016/j.rser.2015.12.073

Kerlinger, F. N. (1973). Foundations of behavioral research. New York: Holt, Rinehart, and Winston, Inc.

Kollmuss, A., & Agyeman, J., (2002), Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behaviour? In Environmental Education Research, Vol 8 No 3, pp 239-260

Koch, A., Girard, S., & Mckoen, K. (2012). Towards a neighbourhood scale for low- or zero-carbon building projects. *Building Research & Information*, *40*(June 2014), 527–537. http://doi.org/10.1080/09613218.2012.683241

Laine, M., (2010), The Nature of Nature as a Stakeholder, in the Journal of Business Ethics, Vol 96, Supplement 1: TRIBUTE TO JUHA NÄSI, pp 73-78

Liao, P-C., Tsenguun, G., Liang, L.W., (2016), Development of Social Responsibility Evaluation Framework of Construction Projects: A multi-stakeholders perspective, in Procedia Engineering 145, International Conference on Sustainable Design, Engineering and Construction, pp 234-241

Lund, H., Moller, B., Mathiesen B. V., & Dyrelund, A. (2010), 'The role of district heating in renewable energy systems'. Energy, 35: 1381-1390

Mancarella, P. (2013), 'Distributed multi-generation & district energy systems', in James Keirstead & Nilay Shah Urban Energy Systems: An Integrated Approach. Routledge: London & New York, 76-96.

Mancarella, P. (2014), 'MES (mutli-energy systems): an overview of concepts and evaluation models. Energy 65: 1-17

Mangold, M., Österbring, M., Wallbaum, H., Thuvander, L., & Femenias, P. (2016). Socio-economic impact of renovation and energy retrofitting of the Gothenburg building stock. *Energy and Buildings*, *123*, 41–49. http://doi.org/10.1016/j.enbuild.2016.04.033

Martin, L., (2015), Incorporating values into sustainability decision-making, in the Journal of Cleaner Production, Vol 105, pp146-156

McVea, J.F., & Freeman, R.E., (2005), A Names-and-Faces Approach to Stakeholder Management, How Focusing on Stakeholders as Individuals Can Bring Ethics and Entrepreneurial Strategy Together, in the Journal of Management Inquiry, Vol 14, No 1, pp57-69

Menassa, C.C., & Baer, B., (2014), A framework to assess the role of stakeholders in sustainable building retrofit decisions , in Sustainable Cities and Society, Vol 10, pp 207-221

Menzel, S., (2013), Are emotions to blame? — The impact of non-analytical information processing on decision-making and implications for fostering sustainability, in Ecological Economics, Vol 96, pp 71-78

Michelsen, Claus, Rosenschon, S. & Schulz, C. (2015), 'Small might be beautiful, but bigger performs better: Scale economies in 'green' refrubishments of apartment housing'. Energy Economics 50, 240-250

Miller, L. E. (2006, October). Determining what could/should be: The Delphi technique and its application. Paper presented at the meeting of the 2006 annual meeting of the Mid-Western Educational Research Association, Columbus, Ohio.

Molyneaux, A., Leyland, G., & Favrat, D. (2010), 'Environmental multi-objective optimization of a district heating network considering centralized and decentralized heat pumps'. Energy, 35 (2): 751-8

Neville, B.A., Bell, S.J., & Whitwell, G.J., (2011), Stakeholder Salience Revisited: Refining, Redefining, and Refueling an Underdeveloped Conceptual Tool, in the Journal of Business Ethics, Vol 102, No 3, pp 357-378

Orehounig, K., Evins, R. and Dorer, V., (2015). Integration of decentralized energy systems in neighbourhoods using the energy hub approach. *Applied Energy*, 154, pp.277-289.

Orsi A., Guillén Guillamón I., (2016). Optimization of Green-Building Design Processes – Case Study.

Orts, E.W., & Strudler, A., (2002), The Ethical and Environmental Limits of Stakeholder Theory in Business Ethics Quarterly, Vol. 12, No. 2, pp215-233

Orts, E.W., & Strudler, A., (2009), Putting a Stake in Stakeholder Theory, in the Journal of Business Ethics, Vol 88, Supplement 4: A Tribute to Thomas W. Dunfee a Leader in the Field of Business Ethics, pp605-615

Østergaard, P. A., & Lund, H. (2011), 'A renewable energy system in Frederikshavn using low-temperature geothermal energy for district heating'. Applied Energy, 88: 479-487

Østergaard, P., Mathiesen, B. V., Mooler, B., & Lund, H. (2010), 'A renewable energy scenario for Aalborg Municipality based on low-temperature geothermal heat, wind power and biomass'. Energy, 34: 1236-1245

Østergård, T., Jensen, R.L., Maagaard, S.E., (2016), Building simulations supporting decision making in early design – A review, in Renewable and Sustainable Energy Reviews, Vol 61, pp187-201

Ozgur Gocer, Ying Hua, Kenan Gocer, 2015, Completing the missing link in building design process: Enhancing post-occupancy evaluation method for effective feedback for building performance.

Paiho, Satu, Abdurafikov, R., Hoang, H., & Kuusisto, J. (2015), 'An analysis of different business models for energy efficient renovation of residential districts in Russian cold regions'. Sustainable Cities and Society 14, 31-42

Pajunen, K., (2010), A "Black Box" of Stakeholder Thinking, in the Journal of Business Ethics, Vol 96, Supplement 1: TRIBUTE TO JUHA NÄSI, pp27-32

Parisio, A., Del Vecchio, C., & Vaccaro, A. (2012), 'A robust optimization approach to energy hub management'. International Journal of Electrical Power Supply Systems, 42 (1): 98-104

Pavlov, GK., & Olesen, BW (2012), 'Thermal energy storage – a review of concepts and systems for heating and cooling applications in buildings: Part 1 – seasonal storage in the ground'. HVAC&R Res, 18 (3): 515-38

Perea, E., Oyarzabal, J.M. and Rodríguez, R., 2008. Definition, evolution, applications and barriers for deployment of microgrids in the energy sector. e & i Elektrotechnik und Informationstechnik, 125(12), pp.432-437.

Phillips R.A., & Reichart, J., (2000), The Environment as a Stakeholder? A Fairness-Based Approach in the Journal of Business Ethics, Vol 23, No 2, pp 185-197

Phillips, E., Freeman, R.E., & Wicks, A.C. (2003), What Stakeholder Theory Is Not, in Business Ethics Quarterly, Vol 13, No 4, pp 479-502

QSR (2015), QSR International Official Website: http://www.qsrinternational.com/what-is-nvivo accessed on 12/11/2015

Quick, K. S., & Feldman, M. S. (2011). Distinguishing Participation and Inclusion. Journal of Planning Education and Research, 31(3), 272–290. http://doi.org/10.1177/0739456X11410979

Raymond J. Cole & Maria Jose Valdebenito, 2013. The importation of building environmental certification systems: international usages of BREEAM and LEED.

Reid R. Senescu, John R. Haymaker, 2013, Evaluating and improving the effectiveness and efficiency of design process communication.

Rezaie, B., Rosen MA. (2012), 'District heating and cooling: Review of technology and potential enhancements'. Applied Energy, 93: 2-10

Robertson, T., & Simonsen, J. (2012). Challenges and Opportunities in Contemporary Participatory Design. Design Issues, 28(3), 3–9. http://doi.org/10.1162/DESI_a_00157

Robertson, T., & Simonsen, J. (2013). Participatory Design: an Introduction. In J. Simonsen & T. Robertson (Eds.), Routledge International Handbook of Participatory Design (pp. 1–18). New York and London: Routledge.

Roloff, J., (2008), Learning from Multi-Stakeholder Networks: Issue-Focussed Stakeholder Management, in the Journal of Business Ethics, Vol 83, No 1, pp 233-250

Ruesch, F., Kolb, M., Gautschi, T., & Rommel, M. (2013), Heat and cold supply for neighborhoods by means of seasonal borehole storage and low temperature energetic cross linking. Lausanne, Switzerland.

Saldana, J. 2013. The Coding Manual for Qualitative Researchers. London: Sage Publications.

Santamouris, M. (2001), Energy and climate in the urban built environment. London: Earthscan

Santana, A., (2012), Three Elements of Stakeholder Legitimacy, in the Journal of Business Ethics, Vol 105, No 2, pp257-265

Schulze, M., Freidrich, L., Gautschi, M. (2008), 'Modeling and optimization of renewables: applying the energy hub approach'

Sebastian, V., (2014), New directions in understanding the decision-making process: neuroeconomics and neuromarketing, in Procedia – Social and Behavioural Sciences, PSIWORLD 2013, Vol 127, pp 758-762

Senescu R., Haymaker J., Fischer M., (2012). Design Process Communication Methodology: Improving the Efficiency and Effectiveness of Collaboration, Sharing, and Understanding, CIFE Technical Report #TR197.

Siontoru, CH.G, & Batzia, F.A., (2012), Managing uncertainty in environmental decision-making within ecological constraints - a model based reasoning approach , in Procedia Engineering, 20th International Congress of Chemical and Process Engineering CHISA 2012, 25-29 August, 2012, Prague, Czech Republic, Vol 42, pp 1137-1149

Smith, N. D. (2012). Design Charrette: A Vehicle For Consultation Or Collaboration ? In Participatory Innovation Conference 2012, Melbourne, Australia.

Stenmark, C.K., Mumford, M.D. (2011), Situational impacts on leader ethical decision-making, in The Leadership Quarterly, Vol 22, pp 942-955

Steskens, P., Vanhellemont, S.R., Van Den Bossche, N., (2015), A decision making tool for the energy efficient refurbishment of residential buildings, in Energy Procedia, 6th International Building Physics Conference, IBPC 2015, Vol 78, pp 997-1002

Strantzali, E., Aravossis, K., (2016), Decision making in renewable energy investments: A Review, in Renewable and Sustainable Energy Reviews, Vol 55, pp885-898

Sunikka-Blank , M. & Galvin, R. (2016), Irrational homeowners? How aesthetics and heritage values influence thermal retrofit decisions in the United Kingdom, published in Energy Research & Social Science, Vol 11, pp97-108

Svenfelt, Å., Engström, E., & Svane, Ö., (2011), Decreasing energy use in buildings by 50% by 2050 — A backcasting study using stakeholder groups, in Technological Forecasting & Social Change, Vol 78, pp785-796

Turoff, M., & Hiltz, S. R. (1996). Computer based Delphi process. In M. Adler, & E. Ziglio (Eds.). Gazing into the oracle: The Delphi method and its application to social policy and public health (pp. 56-88). London, UK: Jessica Kingsley Publishers.

Ulschak, F. L. (1983). Human resource development: The theory and practice of need assessment. Reston, VA: Reston Publishing Company, Inc.

Voss, P. & Thorsen, J.E. (2012), 'opportunities for policy-makers and industry: district energy – a solution whose time has come'. Euroheat Power, 9: 32-35

Walker, S.L. (2011), 'Building mounted wind turbines and their suitability for the urban scale – a review of methods of estimating urban wind resource'. Energy & Buildings, 43 (8): 1852-62

Walker, S.L., Lowrey, D., Theobald, K., (2014), Low-carbon retrofits in social housing: Interaction with occupant behaviour published in Energy Research & Social Science, Vol 2, pp 102-114

Winschiers-Theophilus, H., Bidwell, N. J., & Blake, E. (2012). Community Consensus: Design Beyond Participation. Design Issues, 28(3), 89–100. http://doi.org/10.1162/DESI_a_00164

Wolfe, R.A., & Putler, D.S., (2002), How Tight Are the Ties That Bind Stakeholder Groups? in Organization Science, Vol 13, No 1, pp 64-80

Woolley, T.A. (1985), Community Architecture: An Evaluation of the Case for User Participation in Architectural Design, Oxford Polytechnic, PhD thesis

Woolner, P. (2009). Building Schools for the Future through a participatory design process : exploring the issues and investigating ways forward Participation in design. In BERA 2009 (pp. 2–5). Manchester.

Wu, Z., & Pagell, M., (2011), Balancing priorities: Decision-making in sustainable supply chain management, in the Journal of Operations Management, Vol 29, pp577-590

Yang, J., Shen, G.Q., Ho, M., Drew, D.S., & Xue, X., (2011), Stakeholder management in construction: An empirical study to address research gaps in previous studies, in the International Journal of Project Management, Vol 29, pp 900-910

Yang, M., (2010), Consensus and single leader decision-making in teams using structured design methods, in Design Studies, Vol 31, pp 345-362

Young, S. J., & Jamieson, L. M. (2001). Delivery methodology of the Delphi: A comparison of two approaches. Journal of Park and Recreation Administration, 19 (1), 42-58.

Zapata- Lancaster G., Tweed C., (2016). Tools for low-energy building design: an exploratory study of the design process in action. ISSN: 1745-2007 (Print) 1752-7589 (Online) Journal homepage: http://www.tandfonline.com/loi/taem20

ACKNOWLEDGEMENTS

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680474.

ANNEX 1: PROFESSIONAL BACKGROUND OF INTERVIEWEES

	Academic Consultant	Architecture	Building Owner	Chair of Development Board	Engineer	Building Services Engineer (6)	Industrial Technician	Local Authority City Architect	Local Authority City Planner	Project Director	Project Leader and Co-op Founder	Project Manager	Property Development Manager
NT16001					1								
NT16002		1										1	
NT16003									1				
NT16004		1											
NT16005										1			
NT16006								1					
NT16007		1											
NT16008		1											
NT16009					1								
NT16010				1									

NT16011													1
NT16012						1							
NT16013								1					
NT16014												1	
NT16015		1											
NT16016	1												
NT16017		1											
NT16018		1											
NT16019											1		
NT16020	1												
NT16022		1											
NT16023		1											
NT16024								1					
NT16025												1	
NT16026					1								

NT160 27		1											
NT160 28			1			1							
NT160 29							1						

ANNEX 2: BREAKDOWN OF PROJECTS DISCUSSED IN INTERVIEWS

	Budapest Urban Redevelopemnt Hungary	Commerical Complex of Buildings Dublin Ireland	County Government Offices Hungary	Historical Buildings Refurb Italy	Housing Cooperative Buildings Italy	Housing Estates Project Hungary	Hungarian Government Offices	Large Urban Redevelopment London UK	Multiple Townhouse into Office Retrofit Ireland	Office Building Italy	Residential and Educational Buildings Cork Ireland	Residential and Educational buildings Hungary	Residential Building Italy	University Campus Buildings France	University Campus of Savona Italy	Urban Redevelopment Dublin Ireland	Urban Redevelopment Italy
NT 16001				1													
NT 16002								1									
NT 16003											1						
NT 16004				1													
NT 16005														1			
NT 16006						1											

NT 16007											1						
NT 16008				1													
NT 16009																	1
NT 16010											1						
NT 16011		1															
NT 16012			1														
NT 16013																1	
NT 16014											1						
NT 16015																	1
NT 16016											1						
NT 16017	1																
NT 16018												1					

NT 16019										1							
NT 16020															1		
NT 16022													1				
NT 16023									1								
NT 16024																1	
NT 16025														1			
NT 16026							1										
NT 16027				1													
NT 16028					1												
NT 16029																	1