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Residential Retrofit assessment platform and demonstrations for near zero energy and CO2 emissions with optimum cost, health, comfort and environmental quality		

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#### Abstract:

Buildings energy consumption in Europe represents more than 40% of the final energy consumption. The most challenging aspect of reducing energy use in building is in increasing the rate, quality and effectiveness of building renovation since the current rate of renovation is only 1.2% per year and should increase by a factor of two to three to reach the EU 2030 targets. However, residential building retrofitting is not taking up. Among many different barriers, there is a lack of knowledge on the demand side, as Owners are not in a position to answer the multiple questions they are confronted with when initiating a renovation project. This Guidance document and its associated Toolkit aims to help the end-user in his decision- making process to retrofit residential multi buildings, ultimately, towards a NZEB target.

**Keyword List:** Residential Retrofit, Steps to launch residential Retrofit, Energy Savings, Retrofit Routes / Scenarios, Energy Performance Contracting.

(This is for an internal Overview of the Changes. Delete this Page when presenting a final Version. The Table below describes the main Changes done in the Document in consecutive order.)

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## Abbreviations

ADP – Abiotic resource Depletion Potential

BEMS – Building Energy Management System

BMK – Business Model Kit

Cx – Commissioning

EE – Energy Efficiency

ECM – Energy Conservation Measures

EMIS – Energy Management Information System

EnMS – Energy Management System

EPIA – Energy Performance Improvement Actions (identical to ECM)

EPC – Energy Performance Contract

EPG – Energy Performance Gap

ESCO – Energy Service Company

ESG – Energy Savings Guarantee

ESGi – Initial Energy Savings Guarantee

ESGom – Operation & Maintenance Energy Savings Guarantee

EVO – Efficiency Valuation Organization

IEA – International Energy Agency

IEQ – Indoor Environmental Quality

IPD – Integrated Project Delivery

IPMVP – International Performance Measurement and Verification Protocol

IRR – Internal Rate of Return

KSF – Key Success Factors

LCC – Life Cycle Costing

LCM – Least Cost Method

LPD – Lean Project Delivery

M&V – Measurement and Verification

O&M – Operation and Maintenance

OSS – One-Stop-Shop

PDCA – Plan-Do-Check-Act

RAT – Refurbishment Assessment Tool

ROI – Return On Investment

SEM – Société d'Économie Mixte

TVD – Target Value Design

WACC – Weighted Average Cost of Capital

## Glossary of Terms

- **ADP** : Abiotic resource depletion includes depletion of nonrenewable resources, i.e. fossil fuels, metals and minerals. The total impact of one resource (in our case fossil fuels) is calculated as the ratio of the quantity of a resource used per functional unit to the total estimated world reserves of that resource.
- **Building Energy Management System (BEMS)**: A BEMS supervises and controls Technical Services of a Building. It is used as a Monitoring Optimization, Maintenance, Reporting and Energy Management Tool. It manages Building Automation and Control Systems (BACS).
- **Business Model Kit (BMK)** :
- **Energy Efficiency (EE)**: Using less Energy to perform the same Function at the same Level of Quality – Programs designed to use Energy more efficiently – doing the same (or more) with less.
- **Energy Conservation Measures (ECM)**: Any Actions that maintain or increase Energy Performance.
- **Energy Performance Gap (EPG)**: defines as the difference between Measures and the calculated Energy Consumptions. Previous researches have highlighted the importance of the EPG for the attainability of an energy strategy objective, given that only part of the predictive energy savings in building is typically realized.
- **Energy Performance Improvement Action (EPIA)**: Action or Group of Measures implemented or planned intended to achieve Energy Performance Improvement through technological, managerial or operational, behavioral, economic or other changes. Source: ISO 50046:2019(en). See also ECM.
- **Energy Management Information System (EMIS)**: System of computer-aided tool used to monitor, control and optimize the performance of the Energy generation, transmission or end-use.
- **Energy Management System (EnMS)**: An EnMS integrates Energy active Management into everyday business Systems and Procedures. The goal is to enable an organization to better manage their energy usage to achieve operating costs savings and to continuously improve energy efficiency.
- **Energy Performance Contract (EPC)**: According to the Energy Efficiency Directive ([2012/27/EU](#)), “Energy Performance Contracting” means a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored during the whole term of the contract, where investments (work, supply or service) in that measure are paid for in relation to a contractually agreed level of energy efficiency improvement or other agreed energy performance criterion, such as financial Savings.
- **Energy Supply Contracting (ESC)**: Energy Supply Contracting is the efficient supply of energy. The Contracting Partner provides products such as heat or cold media, compressed air or electricity. The subject of the contract is not the energy value, like for example volume of oil, but the utility value – billed in Euros per volume items of heat, steam or compressed air.

- **Energy Service Company (ESCO):** Business that provides a broad range of energy solutions including designs and implementation of energy savings projects, retrofitting, energy conservation, energy infrastructure outsourcing, power generation and energy supply, and risk management. A newer breed of ESCO includes innovative financing methods, such as off-balance sheet mechanism.
- **Energy Savings Guarantee (ESG):** Energy Guaranteed Savings is a form of risk transfer in which a Client transfers the Responsibilities and Risks associated with Energy Performance Improvements (the guaranteed savings) to a Supplier which accepts to provide this Service against a specific fee.
- **Guaranteed Savings Principle:** Guaranteed Savings is a form of Risk Transfer in which a client transfers fully or partially the responsibilities and risks associated with Energy Performance Improvements (the Guaranteed Savings) to a Supplier which accepts to provide this Service against a specific Fee.
- **Initial Energy Savings Guarantee (ESGi):** Energy Savings proof within 2-3 years from ECM implementation. Combines Savings generated by Design and O&M. Not applicable to ESCO financing.
- **International Performance Measurement and Verification Protocol (IPMVP):** Protocol that documents common Terms and Methods to evaluate Performance of efficiency Projects for Buyers, Sellers and Financiers.
- **Internal Rate of Return (IRR):** is the annual Rate of growth an Investment is expected to generate.
- **Life-Cycle Costing (LCC):** A Process to determine the total Cost of a Building over its Lifetime in net present Value Terms. LCC considers among others: design, contract, purchase, own, operate, maintain, improve and, finally, either residual value and/or the costs to dispose of an Object or Process.
- **Operation and Maintenance (O&M):** All Services in order to properly operate the Building (mainly technical Services) and maintain it during its Lifetime or for any predefined contractual Period. High quality O&M Practices comprising on going Commissioning and Process Optimization may lead to additional Energy Savings.
- **Operation & Maintenance Energy Savings Guarantee (ESGom):** Energy Savings or Energy Performance Conservation Proof piggybacked over conventional O&M commitment. Usually 5-10 years. May include additional savings generated ad-hoc by Contractor.
- **Persona :** In Marketing Terms, a Persona is a fictional Character representing a User Type with similar Characteristics and Behavior.
- **Refurbishment Assessment Tool (RAT):** Refurbishment Assessment Tool is a platform created to segregate information for a project and empower the building owner or designer in taking decisions.
- **Weighted Average Cost of Capital (WACC):** Calculation of a firm's Cost of Capital which each category of capital is proportionately weighted. All sources of capital, including common



stock, preferred stock, bonds, risk and any other long-term debt, are included in a WACC Calculation.

# 1 Executive Summary

## 1.1 Introduction

Buildings Energy Consumption in Europe represents more than 40% of the final energy consumption. The most challenging aspect of reducing energy use in building is in increasing the rate, quality and effectiveness of building renovation since the current rate of renovation is only 1.2% (2018 figures) per year and should increase by a factor of two to three times to reach the EU 2030 targets (a 27% improvement in energy efficiency, a 27% share of renewable energy). Although this emergency, residential building retrofitting is not taking up. Barriers to launch energy efficiency projects in residential buildings can be seen as complex and are numerous.

The aim of this Guide is to help the owner to launch energy conservation measures (ECM) and to select the best model of energy saving contractual routes to process its retrofit program: what are the different steps to launch an energy efficiency project? How to mitigate the risks? What type of support tools? What are the different energy saving models contractual routes? How to select them? These questions are discussed and answered in this guide.

## 1.2 Guaranteed Energy Savings or Shared Risks Energy Savings

Renovating a building in order to reduce its carbon footprint is a multi-dimensional challenge. It requires knowledge, resources and capacities that may not be found within every Building Owner's organization. Usually, construction risks are substantially identified and well-known by Building owners, in addition, there is enough professional documentation and guidance to mitigate these risks. On the other hand, for Energy performance renovation there is an additional "conception" risk attached to each Energy Conservation Measure (ECM), as well as for their combination: What will be the outcome in terms of saved kWh of this particular investment?

*How can I evaluate the probability that the portfolio of ECMs I will implement will generate the expected energy savings and therefore pay back my investment over the time period I planned to amortize it?*

Guaranteed energy savings is a form of risk transfer in which the owner of a building transfers, fully or partially, the responsibilities and risks associated with energy performance improvements (the guaranteed savings) to a Supplier which accepts to provide this service against a specific fee. This guide will highlight the mechanisms and the possible contractual schemes allowing for such a risk transfer.

## 1.3 Steps to launch an Energy Efficiency Project in Residential Buildings

In order to launch ECM's, the building owner has to go through several different stages (identification and stipulation of the requirements, contractor selection and implementation), each of them composed of different steps. Most relevant project task items and milestones are described in this guide, with their inputs, outputs and variants. Two major Phases are identified: The Initial Phase and the Operation & Maintenance Phase.

- **Phase of Energy Savings Guarantee (ESGi):** this phase mainly deals with the retrofit Design and works implementation. It includes part of the commissioning activities (Implementation Cx). The purpose of this Cx task is to ascertain that the design criteria have been met and to determine that all installed equipment is operating correctly according to specifications. Therefore, commissioning starts at the beginning of the project and completes when the initial guaranteed results are met. This Phase ends when the committed savings have been achieved for a period of at least one full year.
- **Phase of Operation & Maintenance Energy Savings Guarantee (ESGom).** It consists in operating, managing and maintaining the equipment/NZEB as well as continuously optimizing the equipment settings to ensure the energy performance of the building. This activity might be carried out by the contractor, a specialist in equipment maintenance, or by the building owner in case of internal maintenance. Several “flavors” of commitment are considered in this guide:
  - Allow for natural aging, with loss of performance, followed by a recommissioning phase, in order to correct the performance level.
  - Maintain the committed performance achieved during ESGi
  - Continuously improve the performance achieved during ESGi

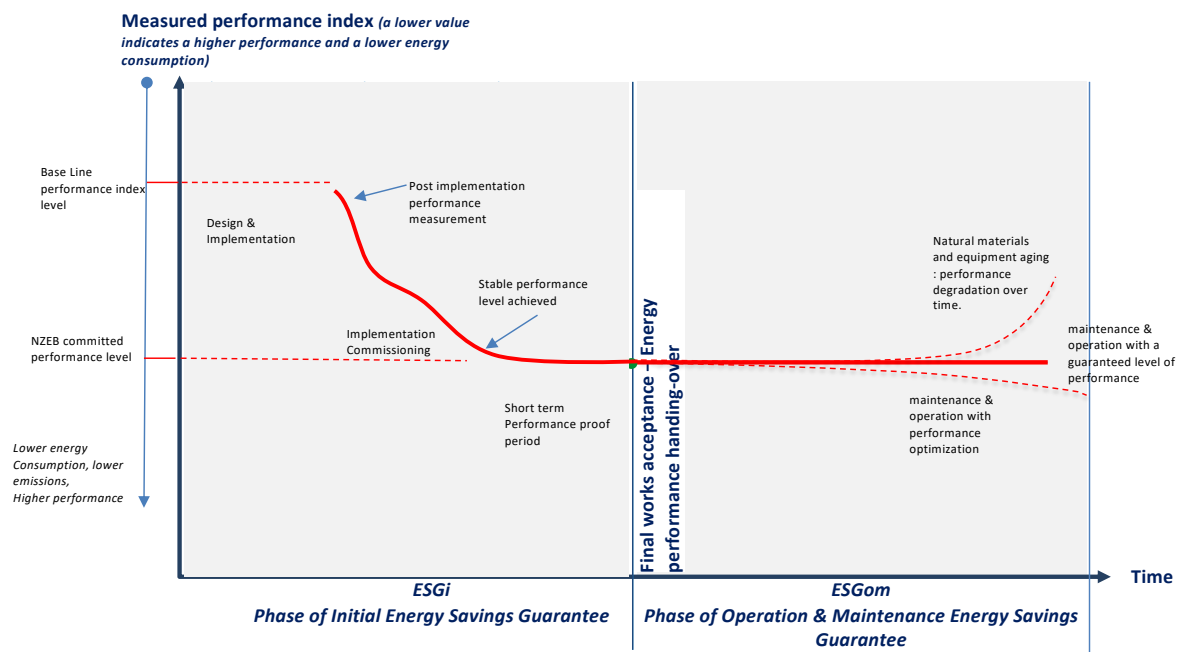


Figure 1: Typical ESG Project timeline

## 1.4 The four Energy Savings Contractual Models / Routes

In this guide, four different contractual models / routes are proposed to cope with the variety of risks transfer strategies. All four schemes allow – with different extent of risk for the Owner- to launch energy retrofit works in residential buildings (or even in other type of buildings): the conventional contractual route, the engineering office contractual route, the partial ESCO contractual route and the Full ESCO contractual route.

From the Owner/Landlord perspective, the proposed four business (or Contractual) Routes go from a minimized Performance Risk, with – consequently- a minimal degree of freedom in terms of technical / architectural solutions up to a maximal degree of freedom in the technical / architectural Solution with a maximum Performance Risk.

## 2 Introduction: Context of large Residential Building Refurbishment and Role of the BMK (Business Model Kit)

Buildings Energy Consumption in Europe represents more than 40% of the final Energy Consumption. The most challenging aspect of reducing energy use in building is in increasing the rate, quality and effectiveness of building renovation since the current rate of renovation is only 1.2% per year and should increase by a factor of two to three to reach the EU 2030 targets (a 27% improvement in energy efficiency, a 27% share of renewable energy). It is estimated that in investment of at least 78 bn €<sup>1</sup> investment per year in technical renovation of existing residential buildings in Europe would be required to achieve to the EU objectives of 2050. Projects related to energy transition are thus becoming a priority while energy renovation projects are considered to be safer than energy creation and more prone to jobs creation than public works. Although this emergency, residential building retrofitting is not taking up. The following barriers may be cited as the most common reasons not to launch energy efficiency projects in residential Buildings:

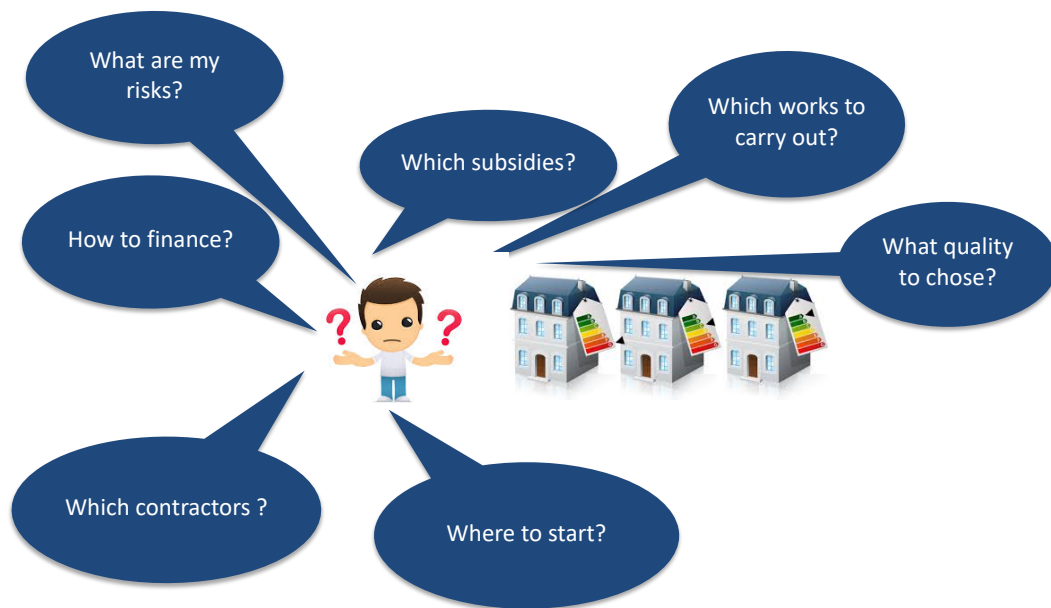
- The Owner is not a professional in energy efficiency retrofitting; he is not able to assess the best ECMs (Energy Conservation Measures: all Actions that maintain or increase Energy Performance).
- The Information is not accessible in one single Place and does not always refer to the same stage in the history of the building.
- The Owner of the building is not always the same Entity as the Occupant of the building – there is a split incentive between Landlords and Tenants.
- There are multiple Owners in case of a Condominium, each of the Owners with different Priorities.
- Lack of capital to finance Energy Efficiency Retrofitting (Owner side).
- Lack of awareness and expertise among the financiers for Energy Savings Works financing Opportunities.
- Austerity Policies that limit public investments and incentives.
- Lack of certainty that forecasted Savings will be achieved.
- No compensation scheme available in case forecasted Savings are not achieved.
- Lack of knowledge about Measurement & Verification Procedures in order to assess true Savings Achievement.
- Investor Risk Assessment Methods and possible contractual Routes not well known.
- Lack of will to achieve EER, doing nothing is easier.

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<sup>1</sup> Source: DG Energy (Estimation to mobilize 177 billion per year to meet the 2050 goals–taking into consideration that 2/3 needs to be mobilized in Buildings and out of the Buildings, 2/3 in residential and 1/3 in commercial Buildings): 78 billion need to be invested in residential Buildings.

- Reduction of Energy Consumption is not a priority to the Landlord. The Owner and/or the Tenant is more preoccupied by his Comfort and primary Needs.

Owners are not in a position to answer the multiple questions they are confronted with when initiating a renovation project.



*Figure 2: Owner's Questioning*

This Guidance Document and its associated Toolkit aims to help the End-User in his Decision-making Process to retrofit residential multi Apartment Buildings, ultimately, towards a NZEB Target.

## **3 Reader's Guide: Building Business Cases, Use of the BMK**

### **3.1 Audience**

This Guide is primarily dedicated to those aiming at renovating large residential Buildings with a view of drastically reducing their carbon footprint. Such refurbishment projects are - by essence - quite complex as they encompass many disconnected disciplines, requesting a very high level of proficiency in many of them. Few important aspects to meet such challenge are legal, finance, building physics, building construction, controls & AI, project management, risk analysis. Therefore, the audience of such a guidance may be quite large and may cover many different specialized expertise fields and numerous readers familiar to only few of them.

Quite far from being an exhaustive compendium of all these knowledge fields, this guide attempts to bridge the gap - as a sort of bootstrap tool- between common basic property management know-how and the stage at which an efficient NZEB refurbishment risk transfer may be initiated. Indeed, mastering these multiple aspects requires experienced professionals and improvisation is likely to result in failure. This paper tries to give some practical guidance to owners and/or decision makers, to answer questions like: How to select these professionals? What is the least cost approach to reach the NZEB targets? What should be subcontracted? How to mitigate the investor's risk into a manageable one? Which contractual route best suits my approach? It also may be useful to professionals in order to understand the motivations of their clients, prior to any serious attempt to contract with them on NZEB Projects. These Owners, decision makers or even professionals are all analyzed on the "Variety of Stakeholders/ Building and Ownership Definition Type of Ownership" chapter as different personas based on ReCO2ST customer segments.

### **3.2 Goal of this document**

Ultimately, the goal of this document is to help a decision maker in the initial renovation stages to reach its NZEB targets, finding the best possible combination of professional partners, the most efficient contractual route(s) given the present owner's situation, properly delegating the risks and assuring that the NZEB commitments will be achievable and durable.

### **3.3 How to read this document?**

This document is split into six Volumes. The present Volume I is the entry level which is aimed at guiding the reader through all other Volumes, detailing the different concepts.

Several reading experiences are foreseen.

#### **3.3.1 Linear Reading**

The basic linear reading is recommended as a "best suited" apprehension of this document.

#### **3.3.2 Quick Path**

A quick path consists in reading the Important Concepts (Section 4), followed by the Typical Refurbishment Project Phases (Section 7) and jump to the Contractual Routes Selection Tool (Section 9).

Hence questions arising while answering the questions of the BMK Tool will direct the reader to other sections or subsections of this guide.

### **3.3.3 Experience Deepening Path**

This Approach may be recommended at the outset of a real-life project, especially when entering into contractual considerations. Each word has its importance, it is therefore recommended to revisit the relevant sub-sections of the Methodologies and Technical companions (Volume II, Section 1), explore the corresponding annexes and the bibliography. The link between Technical assessment and the guarantees associated to the target's achievement need a deep understanding of both RAT and M&V Practices.



## **4 BMK at a GLANCE**

This section introduces the various sections of the BMK Guide and allow for a hierarchical reading using dynamic links into the various detailed Sections and complementary documentation.

### **4.1 Important concepts & Issues (Volume 2)**

#### **4.1.1 Introduction**

This Volume 2 will focus on some important concepts such as guaranteed energy savings and NZEB renovation main issues. This Volume should be read once in order to understand the approaches that were taken in the rest of the BMK. In particular, the concept of guaranteed energy savings leads to an important change in the way conceptual risks linked to the energy savings results are split between the different stakeholders.

#### **4.1.2 Important Concepts**

A first important section will detail the basic principles of guaranteed savings which are of a paramount importance in the success of a complex renovation project. Indeed, these guaranteed savings are the key income that any decider has to consider in his decision process to invest in such a project.

#### **4.1.3 Main Issues**

Consequently, of these basic principles, the next section will focus on the main issues that a large residential NZEB refurbishment project facings. Aspects like variety of stakeholders and professional culture, financing schemes & guarantees, operation & maintenance practices, ... will be highlighted.

### **4.2 TERRITORIAL PARTICULARITIES (Volume 3)**

#### **4.2.1 Introduction**

This Volume reflects some of the most relevant differences and particularities such like how different European Governments lead and promote building energy renovation projects, and the common contractual partnerships that can be usually found in the different EU Markets. Optional reading, interest to see differences and commonalities.

## **4.2.2 Territorial Particularities**

Europe is not a homogeneous territory. If technical solutions may be quite similar, professional habits and practices, laws and regulations, standards and policies differ from country to country. The most relevant differences will be listed and considered, in terms of their impact to the methodologies approached in this guide.

## **4.2.3 Example of a One-Stop-Shop (OSS) in Switzerland**

The goal of the one-stop-shop is to help and guide the building owner in all the retrofit process. It gives a guarantee on the works quality. It does not operate under the EPC model.

# **4.3 TYPICAL PROJECT PHASES & MANAGEMENT PROCESS ( Volume 4)**

## **4.3.1 Introduction**

This Volume is one of the most important of the BMK as it describes a common renovation process that can be followed for any type of renovation project. It considers the consequences of choosing contractual routes that are based upon guaranteed energy savings.

An important part of the BMK approach lies in the proposed four different “contractual” routes or schemes that condense an appropriate set of responses for most of the NZEB renovation projects.

Its reading is a must for understanding the project segmentation (in terms of time, responsibility shares, risk shares).

## **4.3.2 Typical Refurbishment Project Phases**

This section details a proposed project phasing structure that has been developed and refined in several Pan-European Guaranteed Savings Projects, and which will form the skeleton of the methodologies described in this guide. It takes its roots from a research project GRE (Guaranteed Results in Energy performance) initiated by the French Organization “Fondation Bâtiment Énergie”

## **4.3.3 Project Management Process**

This section describes the four contractual “routes” that may be chosen depending upon various considerations regarding the project’s target. Each route has its pros and cons, and may be selected after considering multiple dimensions such as financing sources, risks, initial technical and project management knowledge, project expectations in terms of coverage and savings magnitude, etc.

#### 4.3.4 Net Present Value Methodology

The NPV is a common financial tool to evaluate an investment profitability. This section details an approach that can be taken for the preliminary evaluation of the project. Although this method can be used in any type of project, it is a real bonus for the owner in guaranteed energy savings projects, as most of the conceptual risks are deferred to the Contractor, leaving only energy costs escalation risks, savings measurement risks, and of course, risks linked to a contractor business insolvency. All these risks are within the scope of a project management team and may be early analyzed for mitigation procedures.

### 4.4 PROJECT DEVELOPMENT METHODOLOGIES AND TECHNICAL COMPANIONS (Volume 5)

#### 4.4.1 Introduction

This Volume is the methodological companion of Volume 4. It describes the most important technical tools and methods to be used in conjunction with the processes and routes developed in it.

Volume 5 is to be read by anyone willing to develop a project along one of the routes described in Vol 4.

#### 4.4.2 Methodologies

*Some important concepts need to be explained in order to understand both the proposed project phasing and the different contractual routes. This section may be skimmed through or simply skipped in a first reading. It is however recommended to spend some time understanding the technical aspects before launching a project. These topics cover:*

- *The Technical Assessment (when, who, what, which Tool, at what depth, with which granularity).*
- *Least Cost Method and how it integrates into the Technical Assessment.*
- *Measurement of the effectiveness of the refurbishments (Measurement & Verification).*
- *Risk Analysis or avoid jumping into a nightmare.*
- *Is EPC a possible solution?*
- *How IPD and Alternatives may be implemented.*
- *Energy Contracting.*

### **4.4.3 Technical Companions**

#### **4.4.3.1 Risk Assessment & Mitigation analysis**

One of the most important aspect of any project is a proper risk analysis. This section details generic aspects of any risk analysis project and then describes some of the most relevant points for NZEB renovation.

#### **4.4.3.2 Measurement & Verification: How to assess the true performance of the NZEB ?**

M&V is a key element in energy management. It is also the key to compensate the risks taken by the NZEB renovation investor in guaranteed energy savings project. M&V will allow to assess the “true” savings results and thus allow for financial compensations to the investor in the case of underperformance. It will also allow for contractor’s compensation in the opposite case.

#### **4.4.3.3 Commissioning activities**

Project commissioning is a must whenever a project undertakes to address complex technical issues. This is often the case in NZEB renovation, where different trades and techniques are intermingled to produce the expected “energy savings”.

## **4.5 Contractual routes Selection Process**

### **4.5.1 Introduction**

This Volume is a “how to” guidance to use the WEB based Contractual Routes that are described in Volume 4. Any NZEB renovation project stakeholder may find its own interest in using this Tool.

### **4.5.2 Contractual Routes Selection Tool**

This Tool is a kind of dynamic SWOT, which allows for a quick check of the best combination of contractual solutions depending on the given inputs. The latter being represented by the answers of a multiple choice questions in order to assess the positioning of the stakeholders, the financial situation, the building, the expectations in a multidimensional space.

## 5 Conclusion

### 5.1 Intro

This section summarizes the most important findings of this study and gives room for further improvements and/or outlining avenues for further reflection.

### 5.2 Findings

The objective of this Guide and Toolkit has been to help owners aiming at renovating large residential buildings or large stock of residential buildings with a view of drastically reducing their carbon footprint. The approach developed was led by the idea that there is a serious gap to bridge between common basic property management know-how and the level required to properly analyse the risks attached to a NZEB renovation and, should the need arise, transfer them to the most adequate partner.

The essential renovation project process skeleton is described and serves as a guideline to understand the different constraints that are posed to the project promoter.

The guide has explored the most relevant combination of partnerships in function of different categories of input situation patterns. A metric inspired by the Wulz's Hierarchy (§7.2) has been introduced in order to illustrate the relationship between owner's autonomy and Design risk. While keeping a full variability within the Wulz's Scale, four "condensates" Levels were considered. Each of them may directly drive a contractual form of Partnership. From a case where the owner minimizes its risk while accepting to lose a certain degree of freedom to the case which gives a total autonomy to a well "knowledgeable" owner's organization able to evaluate and mitigate all risks within its own resources.

Different Project management, Technical and Organizational Companions are described with examples and territorial particularities. A particular emphasis is put on long-term commissioning and verification techniques for guaranteed savings approaches without a proper application of which the "guarantee" of the savings simply is a blur.

Some approaches borrowed from other industries like Lean Project Management and Integrated Project Delivery are described and incorporated into a "viable" scenario for NZEB residential renovation. The ISO 50001 standard and its virtuous "Plan Do Check Act" loop is at the heart of the project skeleton developed within this Guide.

Finally, a simple Tool attempts to facilitate the project promoter's decision in a multi-dimensional set of constraints, by establishing a score of probabilities attached to the four contractual scenarios.

At the end of this research, the authors, in a humble statement, declare that this multidimensional residential NZEB renovation problematic will not be sorted out simply by identifying and describing the best techniques in each field. The gap is so large, and the local supporting resources so thin and scarce that unless there is a quantum leap in terms of both organizational and financial resources at the level of the member countries, there is little chance to achieve a substantial portion of the European NZEB target.

## 6 References

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