

# The CITYFiED Methodology for city renovation at district level

## La metodología de CITYFiED para la renovación urbana a escala distrito

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The objective of the CITYFiED Methodology is to support city authorities along the process of working towards a more sustainable and energy efficient cities. Moreover, it encourage the replicability and mass market deployment of energy efficient retrofit of districts, considering as a reference the CITYFiED demonstration actions, decision-making processes and business models. The CITYFiED Methodology is a procedure composed of several phases and a management process that aims to ease the decision-making tasks and what is more, the delivery of a specific plan for each city depending on its needs, vision and objectives. A customized Strategy for the Sustainable Urban Renovation (SSUR) at district level with the energy efficiency as the main pillar and local authorities as clients, will be delivered based on the objectives and needs identified during the analysis and diagnosis phases. The management process is supported by the creation of an External Consultancy Group (ECG) to collaborate with the local authorities, and by providing different tools and indicators that would enable the assessment of the suggested actions (Strategy for Sustainable Urban Renovation) as the comparison with the original situation and objectives. The Methodology is conceived within the context of the CITYFiED project and it considers as reference the three large demonstration actions that include building renovation, district heating networks, integration of renewable energy sources and monitoring, and which are located in Lund (Sweden), Laguna de Duero (Spain) and Soma (Turkey).

*Urban Renovation; Decision-making; Energy planning; Municipalities support.*

El objetivo de la Metodología CITYFiED es apoyar a las autoridades de las ciudades a lo largo del proceso de creación de ciudades más sostenibles y energéticamente eficientes. Para ello, la metodología fomenta la replicabilidad y el despliegue masivo del mercado de distritos energéticamente eficientes, tomando como referencia las acciones demostrativas del proyecto CITYFiED, los procesos de toma de decisiones y modelos de negocio allí desplegados. La Metodología CITYFiED es un procedimiento compuesto por varias fases y la gestión de las mismas, que apunta a facilitar el proceso de toma de decisiones y, además, a la definición de un plan estratégico específico para cada ciudad según sus necesidades, visión y objetivos. Una Estrategia personalizada de Renovación Urbana Sostenible (SSUR) a escala de distrito, con la eficiencia energética como principal pilar y las autoridades locales como clientes, que se define en función de los objetivos y necesidades identificados durante las fases de análisis y diagnóstico. El proceso de gestión de las fases está respaldado por la creación de un Grupo de Consultoría Externa (ECG) y por la identificación de diferentes herramientas e indicadores que permitirían la evaluación de las acciones sugeridas (Estrategia de Renovación Urbana Sostenible) en comparación con la situación y los objetivos originales. La Metodología se concibe en el contexto del proyecto CITYFiED y considera como referencia las tres grandes acciones de demostración que incluyen rehabilitación energética de edificios residenciales, redes de calefacción urbana, integración de fuentes de energía renovables y monitorización, y que se han implementado en 3 ciudades europeas, Lund (Suecia), Laguna de Duero (España) y Soma (Turquía).

*Renovación urbana; Toma de decisiones; Planificación energética; Apoyo a las municipalidades.*

### ABBREVIATIONS:

AHP: Analytic Hierarchy Process  
BEP: BIM Execution Plan  
BIM: Building Information Model  
ECG: External Consultancy Group

ECM: Energy Conservation Measures  
ESCO: Energy Service Company  
GIS: Geographic Information Systems  
IPD: Integrated Project Delivery  
KPI: Key Performance Indicator  
LCA: Life Cycle Analysis

LCCA: Life Cycle Cost Analysis  
MCDA: Multi-criteria Decision Analysis  
SEP: Sustainable Evaluation Plan  
SIP: Strategy implementation Plan  
SSUR: Strategy for the Sustainable Urban Renovation

## 1. INTRODUCCIÓN

The optimization and the particularization of the urban energy planning processes to each city is becoming an increasing necessity for municipalities. According to the literature, the specific dimensions covered by this concept can vary depending on its interpretation. However, most of the authors agree on the necessity of adopting a holistic perspective including the techno-economic, social and environment aspects when approaching to the problem.

During the last years, a great activity has occurred in this field. Many efforts have been made in the standardization of smart cities. An example of it, is the case of the Technical Committees and Working Groups of the ISO TC/268 Sustainable cities and communities. Nevertheless, most of these works are focused on the definition of several common criteria and a methodology for measuring the level of smartness and the sustainability of cities. Although this is a relevant part of the energy planning process, which provides a better understanding of the initial situation and the evolution of the performance of cities, several aspects such as the relation with the decision that are made during the energy planning process are not clearly established.

From another point of view, the advances occurred in the field of the energy modelling and the scenario development at city scale need to be also mentioned. This practice has been traditionally more used for energy planning issues at national scale but nowadays the interest for applying this approach to the regional and city context is increasing rapidly. However, as described by Park [1] the scope of city planning includes also a range of interdependent decisions at the nexus of the private and public spheres. Besides, as in the cases of the sustainability assessment frameworks of cities, the way of considering the role of the main stakeholders during the entire energy planning and more specifically in the decision-making process is difficult to understand when focusing the view in the detailed technical aspects of the energy modelling.

Despite all this experiences and activities in the field, energy planning of cities is still a challenge. An important part of the complexity relies on the necessity of combining many different technical and non-technical phases in which the role and the interaction of a number of different stakeholders need to be properly considered. Besides, in most of the cases little information is available about how and in which phases the decisions are adopted. Moreover, many municipalities do not have the needed specialized and diverse capacities required to cover the entire process. Most of them depend on external consultancy groups that guide them.

But the specific process to be followed is still unclear and there is a need of holistic methodologies and tools that consider a global approach and that define clearly the procedure for considering in each phase the participation of the stakeholders

identified for the city. This will provide a clearer vision about how the decisions have contributed to the achievement of the final results. In this context, under the umbrella of Sustainable Strategic Urban Planning, a novel methodology for urban renovation at district level is proposed and validated by the European Smart City project CITYFIED (Grant Agreement N° 609129).

## 2. CITYFIED METHODOLOGY FOR CITY RENOVATION AT DISTRICT LEVEL

Meeting the ambitious targets set by the European Union (EU), i.e. reducing greenhouse gas emissions 20% by 2020, 40% by 2030 and 80% by 2080 respect to the values of 1990 is essential to reach the objectives of the Paris Agreement [2]. This agreement aims to limit the temperature rise this century below 2 degrees Celsius above pre-industrial levels. The role of cities in climate change mitigation is currently acknowledged, particularly in European cities where more than the 70% of the population lives in urban areas [3]. Besides, it is expected that two third of the world's population will be living in an urban area by 2050 [4].

More specifically, small and medium sized cities are the ones that represent the highest improvement potential considering that they represent the 83% of the European cities [5]. Besides, around 45% of their buildings were built before 1969, 32% between 1970 and 1989 and only 9.3% in the 90's, what represents a huge opportunity due to the massive amount of buildings that are susceptible to be refurbished.

Therefore, the energy consumption reduction in cities and particularly in the building sector is a theme of interest for the European Union. However, it is still a challenge for municipalities to decide how to define and prioritize the different measures that can be implemented in the different zones of the cities. In this regard, one of the first steps is the identification of the areas of the city that are susceptible to be intervened. This is precisely the step in which the city analysis through the evaluation of its districts is useful and necessary.

Among other benefits, the evaluation at district scale facilitates developing a more detailed analysis covering aspects such as; the identification of the current situation, the identification of the specific objectives and necessities, the modelling of the different scenarios for the energy, social and economic analysis, the prioritization of measures and the identification of the optimum scenario.

On the other hand, it is relevant to remark that in the context of the sustainable urban renovation, the decision makers are generally political and social players who establish goals and who define priorities for the city according to the information that they have available. Taking this into account, the role of methodologies and tools that provide a comparison of the existing alternatives is essential to support the decision makers

during the prioritization phase. Here, both the need of innovative methods and the collaboration of municipalities with external consultancy groups that can guide them in the application of these methods is a key issue.

The CITYFiED Methodology is a procedure composed of 7 phases and a decision-making process. The methodology aims to cover the entire planning process of the sustainable urban renovation from the city understanding to the final improvement scenario selection, implementation and monitoring considering as the main pillar the energy efficiency and as the main client the local authorities. With the base of the experiences in the large CITYFiED demonstration cases in the cities of Lund (Sweden), Laguna de Duero (Spain) and Soma (Turkey), the CITYFiED Methodology ensures the effective dialogue among all stakeholders in all its phases increasing the transparency of the decisions made. In the methodology, the process is supported by different tools and levels of indicators.

### 3. HOW CITYFiED METHODOLOGY SUPPORTS THE MUNICIPALITIES MANAGING THE CITY RENOVATION AT DISTRICT LEVEL?

#### 3.1 INVOLVING THE MAIN GROUPS OF STAKEHOLDERS

City renovations are usually promoted by the public administration, representing citizens' interest, to improve the sustainable performance of an urban area. The municipality usually relies on external stakeholders to carry out part of the work for the activities development during the renovation. This model corresponds to a common organization in which also public participation is included, as it is shown in current methodologies for urban planning as Sustainable Action Plans

by the European Commission (2010) [6] or sustainable development studies by Dalal-Clayton, B. and Bass, S. (2006) [7], among others.

With the idea of establishing an effective dialogue between them, the CITYFiED methodology identifies three groups of stakeholders partially based on this common organization: 'Experts representing the Municipality', 'Consultant experts and stakeholders from the building, energy and financial sectors', and 'Citizens' and other stakeholders' participation'. As an innovative aspect, the methodology forecasts the involvement of an ECG to support the Municipality and facilitate the decision-making process. This organization, shown in Figure 1, is proposed to be followed during the methodology deployment to achieve the best management and communication results.

As explained before, Municipalities are included as potential users and promoters of this methodology.

#### 3.1.1 EXPERTS REPRESENTING THE MUNICIPALITY

The 'Experts representing the Municipality' corresponds to those professionals from the public bodies that would be involved in the sustainable renovation. According to the previous literature review – as [6], [7], [8] or [9] –, they are proposed to be organized in different committees that can already exist or be created for the methodology purposes:

- ♦ **Steering committee:** This committee includes the decision makers from the Municipality, as politicians, urban managers, representatives from energy or sustainability departments, etc. Decisions are expected to be made in favour of the citizens' interests with the support of the Technical committee and the ECG.

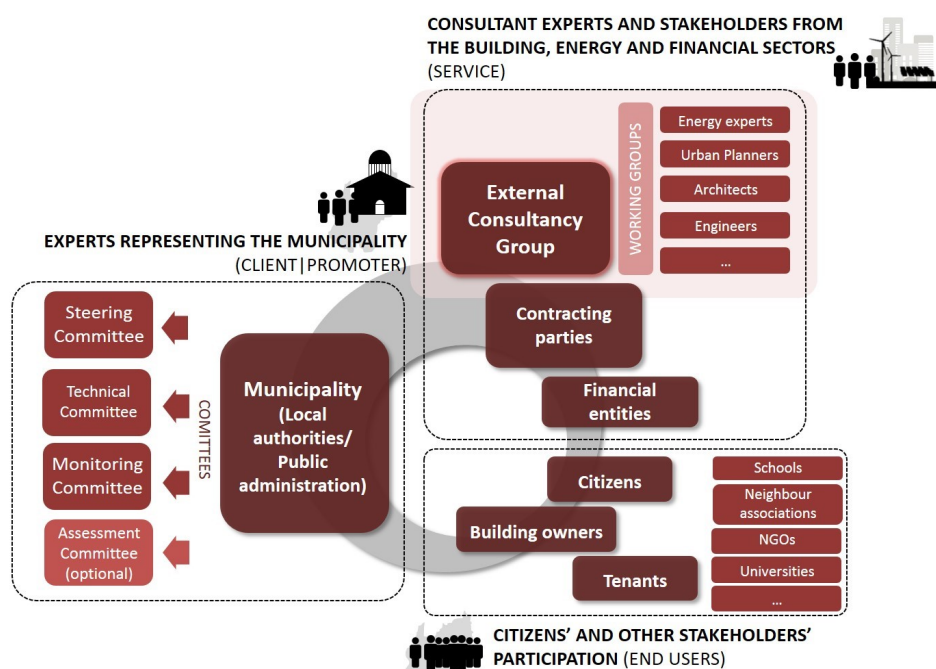


Figure 1: Stakeholders defined in the CITYFiED methodology

Their participation is focus in the first stages of the process, the decision-making and the final evaluation:

- Establishment of the objectives for the city considering citizens' feedback.
  - Selection of the scenario to be implemented, advised by the ECG and the Technical groups.
  - Definition of the business model for implementation.
  - Ensuring long-term commitment and monitoring process.
  - Provision of the necessary tools for public participation.
- ◆ Technical committee: This group consist of urban planners, engineers, architects, energy experts, etc. as professionals from the Municipality with the necessary background. They could be organized in turn in different working groups.
- Establishment of the general technical criteria.
  - Collaboration with the ECG during analysis of the city and district, measures and scenarios selection.
  - Technical definition of the measures to be implemented for the selected scenario.
  - Follow-up and quality control during implementation.
- ◆ Monitoring committee: These technicians could be the same from the Technical committee. They are in charge of supervising the commissioning, monitoring and final evaluation, and defining the protocols.
- ◆ Assessment committee: This optional committee can be formed with decision makers from higher levels of the public administration, supporting the establishment of the objectives and, the scenario selection or the corrective actions.

### 3.1.2 CONSULTANT EXPERTS AND STAKEHOLDERS FROM THE BUILDING, ENERGY AND FINACIAL SECTOR

The 'Consultant experts and stakeholders from the building, energy and financial sector' provide services to the Municipality during the renovation, as a response to the technical, financial or execution demands:

- ◆ External Consultancy Group (ECG): This is a multidisciplinary group of professionals expected to establish a fluent dialogue with the Municipality along the process. It is formed by professionals from different sectors attending to the city and the project needs: energy and environmental consultants, technicians, engineers, urban planners, financial analyzers, policy makers, etc.

Its participation is remarkable during the first part of the process during phases I to V, to achieve the sustainable strategies definition as will be shown in section 3.3. It collaborates to the city and district understanding and

supports the measures feasibility analysis and the scenario prioritization, in coordination with the Technical committee. The scope of their work would depend on the Municipality needs or requirements. The main advantages of having this group since the beginning of the process are:

- Wide knowledge and expertise in energy and sustainable project, what decreases risks and costs.
  - Multi-criteria analysis of measures and scenarios, supporting the prioritization and easing the decision-making.
  - Inclusion of economic and social perspectives (wide perspective).
  - Support on tools defined in the methodology, as the CITYFIED indicators.
- ◆ After the scenario selection and definition, it is necessary to count on the participation of the 'Contracting parties' for the strategies implementation. They provide materials and equipment or services to the Municipality according to the specifications defined on an agreed time and cost. These are construction companies, suppliers, providers, etc.
- Usually the selection of these entities is required to be done through a public tender/bidding process and according to the method of procurement and project delivery method selected.
- The scope of their work is:
  - Technical definition of the measures, if it according to the procurement process selected.
  - Provision of materials and equipment.
  - Implementation of the strategies supervised by the Technical committee..
- ◆ Financial institutions: can be involved in the methodology deployment in relation with the financing mechanisms to upfront the investments and business models to be followed during the renovation.

### 3.1.3 CITIZENS' AND OTHER STAKEHOLDERS PARTICIPATION

'Citizens' and other stakeholders' participation' is essential since they are considered the end users of the renovation. Inside this group, it could be distinguished between citizens, building owners and tenants, and other institutions (NGOs, universities, etc.). The Steering committee is in charge of including this participation through different techniques and mechanisms to their engagement.

The integration of this group since the beginning of the process guarantees the long-term acceptance and makes it more transparent, avoiding future barriers. There are different social aspects included along the phases of the methodology,



as the social indicators, the evaluation of social acceptances or the non-technological barriers, among others. Their participation is included in almost all phases:

- ◆ Feedback from the city understanding: collaboration in the definition of city and district needs.
- ◆ Reception of information during the analysis of measures and possibilities.
- ◆ Participation in the decision-making process when the scenario to be implemented is selected.
- ◆ Feedback about the renovation and lessons learnt.

In this framework, it is recommended to follow a collaborative work approach. This means to take into account organizational and management aspects (periodic meetings, reports, etc.), but also including other drivers to achieve a fluent cooperation. In this sense, it is recommended to follow Integrated Project Delivery (IPD) principles [10] - to the maximum extent that the public procurement allows – and Building Information Model (BIM) tools and approach that provide a common communication and work environment.

### 3.2 PROVIDING SUPPORTING TOOLS FOR DECISION-MAKING

The CITYFiED project aims to develop a methodology that supports local authorities in implementing holistic strategies to move towards energy efficient districts. As previously mentioned, the collaboration between stakeholders plays a key role in the decision-making phase of district renovation, but another aspects that can support and ease this process is the integration of a set of tools that can be implemented through the whole project.

The utilization of available tools in selecting energy-efficient measures and interventions assure more accurate analysis and allow to avoid mistakes and waste of resources. In CITYFiED methodology, several tools have been proposed, as they are collected in the following paragraphs, as CITYFiED Key Performance Indicators (KPIs) for district renovation, Energy Simulation Software tools, Geographic Information Systems (GIS) tools, Life Cycle Cost Analysis (LCCA) tools and the proposal of the CITYFiED Replication Model. (Figure 2)

#### 3.2.1 CITYFiED KEY PERFORMANCE INDICATORS (KPIs) FOR DISTRICT RENOVATION

In recent years, different frameworks for performance measurement have been developed in order to evaluate urban systems. CITYKeys, SCIs and CONCERTO are only examples of the several initiatives and projects that have been carried out to elaborate efficient methods to collect, monitor and compare data across European cities.

CITYFiED project aims to give its contribution proposing a set of Key Performance Indicators that supports the validation of the innovative methodology for city renovation at district level and the assessment of the retrofitting processes in three demonstration cases.

Since the CITYFiED methodology aims to facilitate the decision-making process towards the development of Strategies for Sustainable Urban Renovation, CITYFiED KPIs consist in an assessment framework that covered the seven phases of the procedure. Because of that, this assessment framework is divided in three levels:

- ◆ City indicators (Level 1),

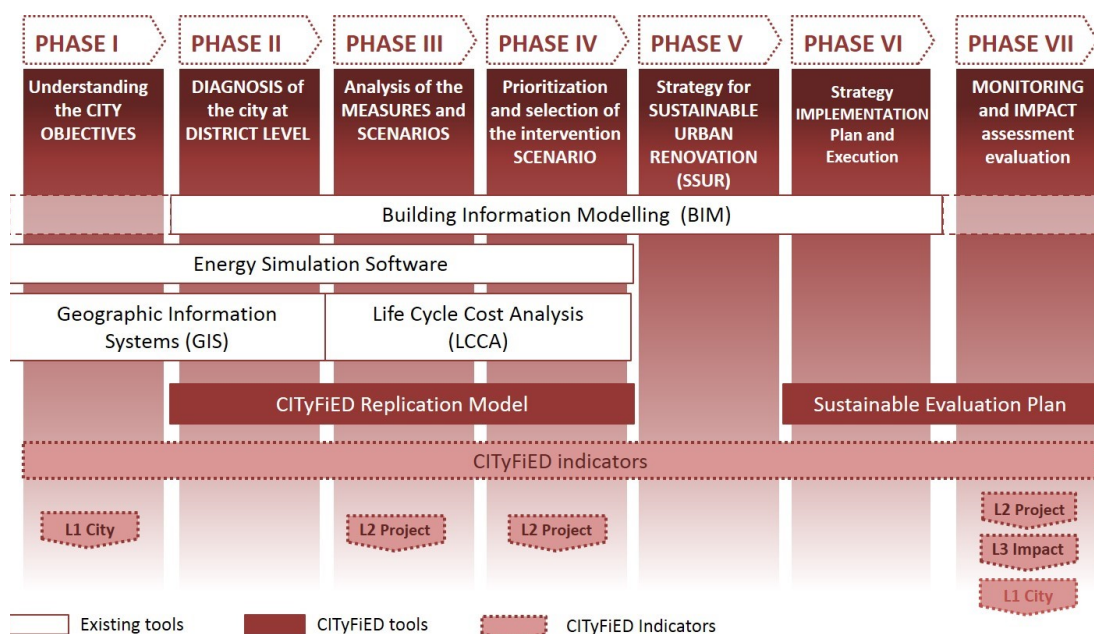


Figure 2: Proposed tools for the decision-making process

- ◆ Project Key Performance Indicators (Level 2),
- ◆ Impact Assessment indicators (Level 3).

Level 1 indicators help to analyse the city at the early stage, to evaluate different measures and scenarios according to the city needs, and finally to measure the impact at city level to assess the sustainable renovation with respect to the initial targets.

Furthermore, Level 2 embody a key-role in the definition and deployment of the SEP in which protocols and methods are defined in order to evaluate the success of the implemented actions. Gathering information about Energy, ICT tools, Quality control of interventions, Economic evaluation, Social acceptance and Life Cycle Analysis (LCA) will allow the comparison between the status of the project before and after the intervention.

Finally Level 3 indicators were defined for impact assessment of retrofitting actions, in order to evaluate the impact of the measures and projects deployed in the districts.

### 3.2.2 BUILDING INFORMATION MODELLING (BIM) FOR DISTRICT RENOVATION

Building Information Modelling consists in a collaborative work methodology for the creation and management of a project and allows sharing information in a database within a platform. The innovative aspects of using BIM is that all the involved stakeholders can access to digital information, not only the 3D model (graphical information) but also non graphical information stored in the model and modify it in real time. The use of BIM finds a wide range of application through a facility's life cycle from its programming and conceptual design, passing for construction and operation phases to its demolition or renovation.

In CITYFIED project, the use of BIM is proposed through all the phases of the project: in particular, BIM Models were created and a key-aspect for its utilization was the definition of the BEP (BIM Execution Plan) in order to manage processes, workflows and people involved on BIM. Using BEP as guide during the process assures that all the partners involved are aware of opportunities and responsibilities associated to the BIM implementation.

### 3.2.3 ENERGY SIMULATION SOFTWARE TOOLS FOR DISTRICT RENOVATION

Energy simulation software are relevant tools when it comes to energy renovation projects at district level, since the diagnosis of the energy performance of a building is the starting point to proceed with the implementation of energy efficient measures that produce energy and cost savings.

In CITYFIED methodology, energy simulation tools are proposed to estimate the energy performance of the buildings

before the retrofitting in order to allow an accurate study and select the most effective energy conservation measures to be implemented. Energy simulation tools are used to compare different design alternatives and scenarios in order to facilitate the selection of the most efficient one. However, these tools generated exhaustive technical data about energy demand and energy consumption, CO<sub>2</sub> emissions but non-technical data have been considered separately. Furthermore, energy performance simulation results are valuable data but in any case they should be validated with the assessment of real performance.

### 3.2.4 GEOGRAPHIC INFORMATION SYSTEMS (GIS) TOOLS FOR DISTRICT RENOVATION

Geographic information system are tools that have for the capability to capture, store, manage, retrieve, analyse, and display spatial information and this functionality represents a relevant potential for planning and managing district renovation.

The utilization of GIS tools allows collecting quantitative and qualitative data that can be geo-referenced and visualized through web-mapping. Furthermore, crossing the storage information could provide additional data that can support the decision-making phase in district renovation.

### 3.2.5 LIFE CYCLE COST ANALYSIS (LCCA) TOOLS FOR DISTRICT RENOVATION

Another tool, which in the last years has become more relevant, is the Life Cycle Cost Analysis, this type of methods allow making a cost effectiveness estimation of the alternatives and scenarios that can be implemented in a district retrofitting project. The LCCA focuses on a long-term study that takes into account all the investment costs from the first steps of the project as planning and design, the operation and maintenance costs to the last phase of the project as demolition and renovation.

In CITYFIED, a LCCA had been realized and it gave support to the ECG and technicians during the definition of the most suitable alternatives and scenarios.

### 3.2.6 CITYFIED REPLICATION MODEL

The Replication model is one of the main results of CITYFIED project and consists in a time-saving tool developed in order to evaluate and maximise the replication potential of CITYFIED technologies and strategies already implemented in the three demonstration cases.

The Replication Model has the goal to support stakeholders interested in implementing energy saving measures and strategies in their cities. Furthermore, the replication model offers a framework for a virtual feasibility study for assessing

the replication potentials of energy efficient actions in other districts.

The Replication Model consists in a dual approach: a quantitative energy model approach where the current energy demand and supply, including energy sources and smart grid solutions, are analysed and a qualitative approach in which methods for investigating non-technological barriers and possibilities as well as possible business models for retrofitting are considered.

Since energy efficiency at district level is the main pillar of CITYFiED project, the Replication Model is deployed at district scale and can be associated at several phases of the CITYFiED methodology (Phase II, III and IV). This time-saving tool finds its application as:

- ◆ Tool for diagnosis district, supporting the identification of the needs and objectives of suitable districts;
- ◆ Tool for exploring energy efficient alternatives and scenarios, evaluating which are the most suitable actions of CITYFiED basket technologies measures according to the city's needs;
- ◆ Tool for prioritization and impact assessment, allowing the selection of the most efficient scenarios that achieves the specific objectives of the selected district.

### 3.3 DEFINING A SYSTEMATIC PROCESS

The Methodology is deployed in seven phases as can be seen in Fig. 3. Each phase ensures an effective dialogue among all the stakeholders previously defined in order to ease the decision-making processes.

It combines both district and city scales, starting with the city and district analysis, proposing initiatives at district level and pursuing the impact of the renovation and the accomplishment with the initial objectives at both scales.

#### 3.3.1 PHASE I: UNDERSTANDING THE CITY

This phase addresses the initial diagnosis of the city with the aim of understanding better its initial situation and the current problems. This analysis, combined with the definition of the long-term city vision provides some clues that can facilitate the identification of the needed transition pathway for the city as well as the definition of its general objectives.

This phase is guided by the Municipality in cooperation with the ECG. Both of them need to interact with other city stakeholders that can contribute during the different steps of this phase especially for the city context information facilitation and for the definition of its general objectives.

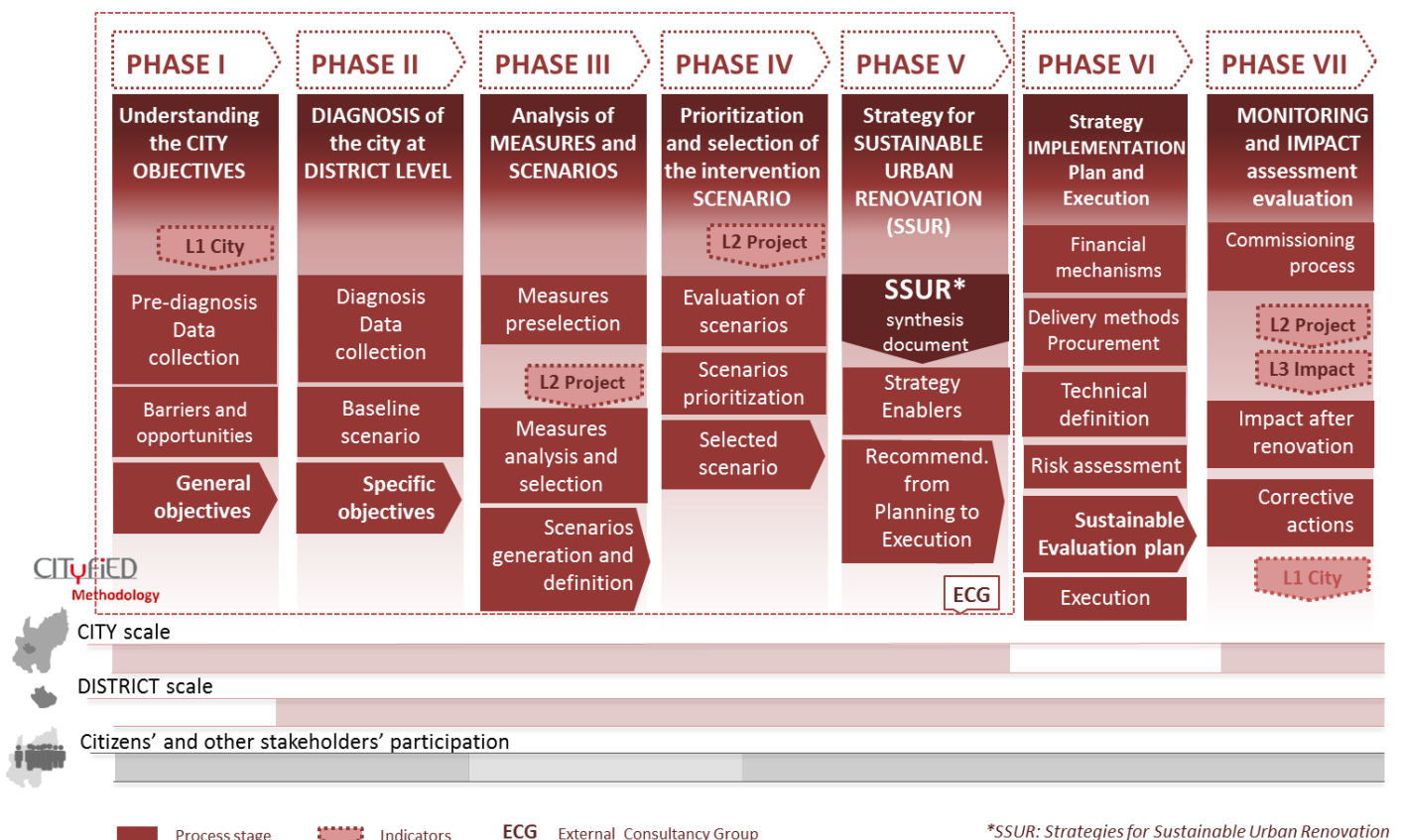


Figure 3: Methodological approach for urban renovation and planning.

In the first one, several stakeholders such as the technical experts of the municipality, or the utilities can contribute providing the data that is needed for the initial analysis. However, the municipality plays the key role in the definition of the objectives of the city.

Several steps can be distinguished in Phase I. The first one is the pre-diagnosis and the data collection in which the city is evaluated with the aim of understanding the current city context. Due to the complexity of the city energy planning, the methodology considers a multi-criteria and holistic perspective from the very beginning. This complexity is shown in the wide variety of city strategic areas (aspects that will be treated by the implementation of specific improvement measure at district and city scale) and application areas (sectors of the city in which the different interventions can be implemented) that compose the analysis matrix of the methodology.

The second step is focused on the calculation of specific City Level Indicators (Level 1) that, through the comparison of their values respect to other cities, allow getting a better understanding about the city's strengths and weaknesses. Level 1 indicators are composed by 17 mobility related indicators, 14 building related indicators and 14 energy related indicators that were the focus of a double validation process. The first one corresponds to internal validation by the cities involved in the CITYFiED project and the second one corresponds to the external validation by the City Cluster and the Community of Interest. The results of this analysis combined with other techniques such as the SWOT analysis or the Workshops, which include the main stakeholders of the city, help to define the general objectives and the long-term city vision.

### 3.3.2 PHASE II: DIAGNOSIS OF THE CITY AT DISTRICT LEVEL

Based on the results of the Phase I and on a new analysis of the city through the evaluation of its districts, the main objective of the Phase II is to define the specific objectives at district scale. This will help to defined in the Phase III the set of measures that will be part of the alternative scenarios.

The main stakeholders involved in this phase are the Municipality, the ECG and the citizens. Their responsibility and implication is described for each sub-phase.

The first step of this phase aims to define the main focus of the analysis. Here, the role of the Municipality for the selection of the districts that will be renovated in the following years is critical.

The Municipality will have to interact with the ECG in order to understand properly the potential of each district in contributing to the transformation of the entire city. The diagnosis of the selected districts includes among other aspects the evaluation of the potential for integrating renewable

energy technologies or the socio-economic characterization of the area. Besides, the ECG needs to take into account the opinion of the citizens in order to foresee and prevent potential implementation barriers for each of the tentative technologies and measures.

Taking into account all the information gathered at district scale, the energy demand and consumption of the base case scenario are modelled for the district in order to compare suitable scenarios in the next phases. This is a complex analysis in which various methods and tools need to be combined by the ECG to obtain an appropriate characterization.

The output of this analysis will serve to define the specific objectives of the city as well as the specific targets for the improvement of the environmental, economic and social situation of the district.

### 3.3.3 PHASE III: DEFINITION AND ANALYSIS OF THE INTERVENTION AND SCENARIOS

While the inputs from this phase are the objectives from the city understanding and district diagnosis, the output is the definition of the retrofitting scenarios that could be implemented in the district in alignment with these premises. Phase III is a two-steps approach in which the energy measures are analyzed separately and those selected are combined in the scenarios.

In this phase, the ECG is in charge of the activities. Thanks to its multidisciplinary background, it carries out the feasibility analysis of measures and the scenarios generation supported by the proposed tools. It should be established a fluent dialogue with the Technical committee.

On the other hand, this is the only phase of the methodology in which 'Citizens' and other stakeholders participation' inclusion is minor. The reason is that this phase entails only technical aspects and the decision-making of the individual measures is an intermediate step in the process before achieving the scenarios evaluation and prioritization that will be carried out in Phase IV.

Energy Conservation Measures (ECMs) are defined as 'measures that are applied to a building or group of buildings to improve energy efficiency and are life cycle cost effective and also they involve energy conservation (...)' [11]. The ECMs identified as most cost-effective are shown in a catalogue within the methodology.

The initial step of the phase consists of applying a first filter on the ECMs according to the objectives to achieve defined in phases I and II, to discard some of them. To guide this process, the grade of relationship between measures and some sustainable objectives are shown within the methodology.

Secondly, the preselected ECMs are studied in detail to achieve a final selection, especially considering their energy



and CO<sub>2</sub> emissions savings keeping in mind the final purpose. In parallel, recommendations on the identification of different general barriers and drivers, as well as the synergies between the measures are provided in the methodology.

Finally, also to facilitate the decision-making process, the 'Level 2: CITYFiED project indicators' can be calculated for the selected district and the individual application of each measure to assess the impact of each ECM on the district.

Finally, the measures selected are combined in retrofitting scenarios that aid to predict the results of a package of ECMs application. These scenarios are proposed to be generated selecting the measures attending to their cost of emission mitigation [€/kg CO<sub>2</sub> emissions savings]. Three kinds of scenarios are defined according to this ratio: basic (for those minimum measures that accomplish with the regulation on energy performance), efficient scenarios and advanced scenarios.

#### 3.3.4 PHASE IV: PRIORITIZATION AND SELECTION OF THE INTERVENTION SCENARIO

The main objective of the Phase IV is the prioritization of the alternative scenarios defined for each district. This prioritization is also a complex process that needs to be guided by the ECG. In this phase, the methodology proposes several steps to facilitate the selection of the optimum scenario taking into account the various criteria, which are in many cases conflictive between each other.

Therefore, the municipality needs to interact with the ECG, other technicians and citizens in the different steps of this phase as it is described in the following paragraphs.

In a first step, the ECG evaluates each scenario according to the criteria defined, supported by the calculation of KPIs, which are called in the CITYFiED methodology the Level 2 CITYFiED indicators. These criteria are pre-defined in the methodology but each municipality can give their opinion about their relevance influencing the final selection. These indicators are calculated for each district by the ECG by using different methodologies such as the LCA and the LCCA among others.

In a second step and using a methodology of the Multi-criteria Decision Analysis (MCDA) theory, the weighting of each criterion is carried out. The methodology proposes to use the Analytic Hierarchy Process (AHP) [12] as main multicriteria methodology for the prioritization phase.

At this stage, the opinion of the Municipality, the ECG, the technical experts and the citizens is the basis for the calculation of the weight that corresponds to each criterion. As a result of this second step, each scenario will have a final punctuation which takes into account simultaneously the results of this scenario for each criterion. This provides a prioritization

order for the evaluated scenarios in a simple way that can be used by the municipalities for making the final choice.

#### 3.3.5 PHASE V: STRATEGIES FOR SUSTAINABLE URBAN RENOVATION (SSUR)

The main objective of Phase V is the definition of the Strategy for Sustainable Urban Renovation, according with the results obtained from Phases I to IV.

This strategy is materialized as a synthesis document, which includes guidelines and recommendations in order to support the strategy implementation and ensure its goals achievement in the following phases.

Moreover, the SSUR defines which groups of stakeholders are necessary for its implementation. Local authorities, especially the Technical committee – and the ECG if it is desired by the Municipality – are in charge on the development of this important document.

The SSUR document should collect firstly, a review of the work done in the previous phases, therefore the definition of the city and district problems and the targets are summarized.

Secondly, the intervention area will be identified, and the measures of the selected scenario in Phase IV, are turn into a strategy within the pathway of the city, by identifying its risks, providing possible business models or financial mechanism, or guidelines to the Strategy Implementation Plan (SIP).

In order to ensure the organisational capability and stakeholders' engagement, different processes have to have been applied during the previous phases, and their main results will be reported also within this document.

Last but not least, SSUR document collect recommendations to guarantee the correct implementation of the strategy, for instance "Project delivery methods and Methods of Procurement" should be collected in order that the municipality select the suitable one. "Recommendations for Technical definition" should be provided ensure the achievement of the Strategy approach, such as the use of BIM methodology to enhance the collaborative work, or define the Stakeholders' responsibilities during the execution and evaluation phases.

All in all, Phase V reflects the concept of strategic planning, which "refers to a systematic decision-making process that prioritizes important issues and focuses on resolving them. It provides a general framework for action by identifying priorities..." [13].

#### 3.3.6 PHASE VI: EXECUTION PLAN

The strategies included in the SSUR are defined in detail and put into practice in this phase, according to a SIP developed in this phase. It includes the recommendations pre-defined from previous Phase V, acting as an overall execution plan that

includes different aspects as Risk management, Supervision and Quality Control plans. Also the BIM approach and BIM Execution Plan are considered during this phase.

All the stakeholders from the different groups, including citizens and end users, participate in this stage. Particularly, is remarkable the role of Contracting Parties that form part of the Consultant experts and that have not previously been involved in the process. They are usually selected by a tender/bidding process and their scope of works, supply, etc. is defined by the tender documents.

The Technical Definition of measures is developed within the BIM framework and related to the selected project delivery method and procurement process, considering that most part of the Municipalities need to face it to accomplish legal requirements. Chronologically, the order of these actions depends on the scope of services that the Municipality would want to cover during the process according to its technical capacity.

With respect to the Project Delivery Method for the contracting formats, it is recommended the application of the IPD to the maximum extent that the public procurement requirements allows. It is 'a collaborative alliance (...) to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction' [10]. It emphasizes BIM potential, the early involvement of stakeholders and it has a risk and benefits sharing approach. As recommendation for the Method of Procurement aligned with IPD, it could be followed the sustainable procurement in which the tender documents are performance based and not prescriptive document and the design is not detailed in tender documents [14].

The financial resources have to be clarified in this phase. It is recommended for some measures to follow the Energy Service Company (ESCO) business model, especially in the case of private ownership of buildings.

Within this phase it is defined the Sustainable Evaluation Plan (SEP) to be applied during phase VII for the monitoring and the evaluation of the measures.

### 3.3.7 PHASE VII: MONITORING AND IMPACT ASSESSMENT EVALUATION

During this phase the strategy and their actions are completed attending to their priority and they are commissioned when finish. For that purpose, a Commissioning Plan should be follow in order to test the correct performance of the ECMs installation and guarantee the operability of the system in terms of performance, reliability, safety, information traceability, etc.

Once the actions are commissioned, the SEP will be deployed, in order to assess the overall performance of the intervention.

At least, procedures for the energy performance and energy savings, economic analysis, social acceptance, and life cycle analysis should be defined. For instance, in order to evaluate the energy performance of the intervention CITYFiED Methodology recommend the use of IPMVP and ASHRAE protocols, which are focused on ECMs.

However, sustainability is not only energy and environment, but other issues play an important role, as Social acceptance, Economic issues, Quality control of the interventions, LCA, which all are included within the proposed plan.

The Technical Committee is the main responsible actor during Phase VII, deploying both the commissioning tasks and the Sustainable Evaluation Plan previously defined. Specifically the monitoring programme implementation is responsibility of the Monitoring committee in case of any, in order to gather the real data consumption from the metering systems.

The final impact that the renovation has on the sustainability is evaluated not only at district but also at city scale. On the one hand, level 3 indicators, which were proposed for impact evaluation target, are calculated again, but this time with real data from monitoring mainly, and the analysis carried out of the overall performance. On the other hand, the impact after renovation at city level is calculated in order to verify the accomplishment of the general and specific objectives defined during Phase I and II, through recalculating Level 1: City indicators and their results compared.

Finally, correction actions are deduced from the short to the long term and from all the strategies for future renovation actions.

## 4. CONCLUSIONS

The need of innovative methods and the collaboration of municipalities with external consultancy groups to guide them in their application is perfectly face in CITYFiED Methodology. As a holistic procedure for the city renovation at district level, it guides the municipalities under a multi-criteria perspective along the urban renovation process. The integration of supporting tools (3 level of indicators, SEP, Replication model, etc.) supports the decision-making process from the diagnosis, selection as well as final evaluation of measures and retrofitting scenarios, as a useful management and control tool.

The CITYFiED project aims to enable the replicability and mass-market deployment of energy-efficient retrofit of districts. Therefore, taking in advance the successful CITYFiED demonstration cases, in the cities of Lund (Sweden), Laguna de Duero (Spain) and Soma (Turkey), the methodology use them as a reference and a opportunity to validate and refine it through the active participation of the CITYFiED network of cities, assuring its flexibility and adaptability to different

European cities. Then, the future work is to complete its development, accordingly with the ending of the demonstration activities results and extract conclusions.

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