EPC^{HC}- ENERGY PERFORMANCE CONTRACTING (EPC) MODEL FOR HISTORIC CITY CENTRES

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Highlights
- funding model for energy retrofitting projects in historic urban areas of cultural heritage importance
- analysis and recommendations for approaching urban historic districts with EPC
- The EPC model which encompasses multi-stakeholder approaches and cultural heritage preservation at the district level

Abstract
The current predominant obstacle for the implementation of energy retrofitting projects at the neighbourhood level is attributable to restricted funding options, which is especially relevant for the expensive renovation of buildings of cultural heritage importance. The first aim of the article is to articulate and identify the main characteristics which influence the funding processes for energy retrofitting historic urban districts. The second objective is to build a comprehensive approach/procedural funding model based on these identified specifics/characteristics. The “energy performance contracting model for historical city centres” (EPC^{HC}) is constructed with procedural processes (steps) associated with the main specific characteristics of urban central districts. The principal attributes which define and influence EPC in historical city centres are “district-level retrofitting”, the “multi-stakeholder approach” and “cultural heritage preservation”. First demonstrated are the benefits of the district level EPC’s “economy of scale”. Secondly, city centres are specific neighbourhoods with several public (municipal, governmental) and private entities, necessitating a particular tailor-made EPC approach is necessary for each stakeholder. Thirdly, the article focuses on the issue of higher retrofitting costs because as a result of historical building status and finding an optimal solution to overcome the conflict between sustainable renovation and cultural preservation. The procedural model for EPC^{HC} in historical city centres offers step-by-step guidelines with suggestions to be followed in order to approach and involve all the various stakeholders. EPC^{HC} could open a new perspective on district green retrofitting and could facilitate municipalities’ decision-making processes upon deciding to retrofit historical central districts.

Keywords
EPC; energy performance contracting; historical city centres; multi-stakeholders; cultural heritage preservation; district energy retrofitting; procedural funding model.

Introduction

Conservation, renovation and the revitalisation of buildings’ cultural heritage represents a font of community empowerment and can also generate economic benefit [1]. Historic city centres can be considered heritage assets, or economic goods which have significant, immeasurable cultural value and are irreplaceable [2]. Planning for sustainable urban restoration of urban city centres should incorporate policies aimed at preserving the unique characteristics of historic urban areas and at stimulating their functionality for contemporary urban purposes, such as housing and commercial activities [3].

The process of the sustainable urban renovation of historical city centres is a complex matter that should be approached from several different perspectives involving environmental, social and economic dimensions [4]. There should be a holistic approach, taking into consideration the built environment and the social structure of the local community; conjoining the approach of the energy efficient refurbishment of residential buildings with integrated urban development concepts, the modernisation of the energy infrastructure, and the identification of innovative financing instruments [5]. Buildings represent 40% of the EU overall energy consumption [6], and as such the recent EU “Renovation Wave Strategy” target is to double the yearly energy renovation rates

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in the next decade, and explicitly underline the necessity of developing neighbourhood-based approaches with integrated renewable solutions [7]. Consequently, it is crucial to create new holistic energy renovation methods and systems. Some relevant studies [8,9] have focused on the development of a simplified holistic sustainability decision-making support framework and a holistic multi-methodology, which includes the involvement of different stakeholders. However, there is need for further studies focusing on the retrofitting of urban districts.

Currently, the prevailing barriers to the implementation of effective energy saving measures on large buildings stock with historic relevance are attributable to the limited funding for an extensive and costly retrofit. Limited time and money exclude the possibility of conducting a detailed analysis on all retrofitting solutions. Local administrations often cite these difficulties as reasons why they are unable to intervene [10]. The article focuses on defining the appropriate funding model for energy retrofitting projects in historic urban areas of cultural heritage importance. The first aim of the article is to articulate and identify the main specific characteristics which influence the funding processes for energy retrofitting historic urban districts (* the use of the term “districts” is meant to be understood as a synonym for “neighbourhoods” and does not imply any administrative connotation). The second objective is to build a comprehensive approach/procedural funding model based on these identified relevant specifics/characteristics.

Research background and methodology

Historic districts (which are often situated in city centres) symbolise the heart of each city and at the same time represent dynamic and complex neighbourhoods with unique specificities. Historic city centres usually include several different public and private stakeholders [11,12] and are generally very difficult to energy retrofit due to the age of the buildings and the fact that they are protected by cultural heritage status [13,14]. Several studies have identified a “conflict relationship” between the degree of sustainable retrofitting and cultural heritage preservation [15,16]. The complexity of energy retrofitting derives from two main aspects which define historic urban districts: (1) multi-stakeholder ownership (multiple public and private owners) and (2) higher refurbishment costs for cultural heritage preservation where it is necessary to strike a balance between sustainable renovation and preserving cultural integrity.

Streimikiene and Balezentis [17] identified several barrier categories for large scale (district) energy renovation: economic/financial barriers (ratio of investment cost to value of energy savings); hidden costs (cost or risks that are not captured directly in financial flows); market failures (market structures and constraints that prevent a consistent trade-off between specific EE investment and energy saving benefits); behavioural and organisational barriers (behavioural characteristics of individuals and companies that hinder the implementation of energy efficiency technologies and practices); information barriers (lack of information provided on the energy saving potentials of large scale energy renovation); political and structural barriers (structural characteristics of political, economic, energy systems which make efficiency investment difficult). Jowkar et al. [18] as well as identified several barriers for sustainable building renovation such as long-term payback period, a lack of information about its economic and social benefits, knowledge of how to engage and become involved as well as personal benefits (regarding better indoor quality or reduced energy costs); and pointed out that the most significant barrier is the high investment cost. When undertaking the renovation of multiple buildings in a neighbourhood, financial barriers can obstruct energy refurbishment [19]. Funding the implementation of sustainable energy measures remains one of the major challenges on the path towards sustainable energy communities. Barriers also include high initial costs for the development of sustainable energy projects, as well as low profitability for certain developments, even though these projects may bring a great number of socio-economic benefits [5].

Financing the sustainable (energy) renovation of city districts such as historical city centres is quite complicated as it is difficult to calculate and anticipate all the possible (un)predictable risks. The main financial challenges that could obstruct green retrofitting (urban) projects are [20] a perception of substantial risk when investing in innovative solutions and energy efficiency measures, undefined energy price policies and uncertainty about fossil fuel prices, the large volumes of investment required, long-term delays before reaching maturity/profitability, limited capacity for public funding (high public deficits in municipalities and an inability to raise funding from capital markets). As previously mentioned, the main identified challenge to retrofitting large and complex districts such as historical central neighbourhoods is the “funding problem”. Despite political

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commitment at the local level, these projects are often not realised by municipalities due to an absence of financial resources and/or a lack of capability in applying complex financing mechanisms. Usually, municipalities and other local stakeholders do not possess enough economic assets to retrofit the entire district, especially complex districts comprised of several buildings under cultural heritage protection, which are more difficult and expensive to retrofit. Energy performance contracting (EPC) for district retrofitting seems to be a feasible funding solution, especially when stakeholders (private individuals, companies, public entities) do not possess adequate financial resources. The main driving force behind adopting EPC is that the energy retrofit would be completely free for all the contractors (there are no investment costs).

In the extensive study by Boza-Kiss et al. [21] regarding EPC performance it was noticed that the average EPC market within the EU has been on a constant rise in the last decades. The rise was noticed also in the EPC's traditionally ignored sectors, such as residential and SMEs. EPC at the district level is "already happening" and it is effective. However, EPC is very rarely applied/introduced to the central zones of cities, in part due to the complexity of such areas (as previously mentioned - issues with multiple stakeholders and cultural heritage preservation). The main research objective of the article is to identify "the adequate model/process to approach historic city districts with the energy performance contracting (EPC) funding scheme". The article proposes a procedural funding scheme which could connect all the involved public and private stakeholders in city centres to achieve a common goal. The article will further examine why the EPC funding scheme is one of the most appropriate funding schemes for urban historical districts. In addition, all the benefits that the EPC funding instrument could bring to a historic district's stakeholders will be highlighted.

Based on a comprehensive interdisciplinary literature review, analysis of different EPC guidelines, best-case analysis will be shown and explained, as well as the distinguishing characteristics of retrofitting historical urban districts. These findings will also be relevant for the "SWOT analysis for EPC implementation processes in historical urban districts" and especially for the innovative matrix of EPC processes (steps) that could be considered when EPC is performed in historical districts. The operational model for EPC implementation in cities' historical central districts (EPC^{HC}) combines the main characteristics/features/processes of the EPC funding scheme by encompassing/taking into consideration the main characteristics/attributes of historical urban districts. EPC^{HC} combines the theoretical and practical framework related to the cultural heritage preservation of buildings inspired by the Troi and Bastian [16] with "traditional" EPC processes partly based on the Transparency Guide [22]. In addition, the EPC^{HC} operational model is constructed with procedural processes (steps) associated with the main specific characteristics of city central districts with different suggested approaches for different stakeholder groups**.** EPC^{HC} could facilitate municipalities' decision-making processes upon deciding to retrofit historical central districts. The research approach is focused on historical city centres, but the final matrix could also be applied to other historical districts which are home to edifices which have been granted cultural heritage status. The main difference is that city centres usually have a higher concentration of municipal, regional and governmental buildings (especially in capital cities), which affects the whole EPC implementation process.

Results and discussion

<u>EPC - funding option for district energy retrofitting</u>

To surpass financial challenges (especially in relation to limited public funding) it is necessary to analyse all the financial instruments that could facilitate the implementation of green retrofitting interventions. There are several innovative financing mechanisms that can be utilised for urban renovation, for example [20,23] project financing, smart bonds, spread shareholding, crowd-financing, energy performance contracting for energy efficiency (EPC), etc. In their study, Bertoldi et al. [24] identified 13 financial instruments for energy renovations in buildings (according to the level of market saturation), of which three were classified as "traditional and well-established" (grants and subsidies, tax incentives, loans), three as "tested and growing" (energy efficiency obligations, energy services agreement (ESA), energy performance contracting) and seven as "new and innovative" (on-bill finance (OBF), property assessed clean energy (PACE) financing, energy efficient mortgages, energy efficiency feed in tariffs, incremental property taxation, one-stop shops, crowdfunding). In recent decades, EPC has emerged as a form of 'creative financing' for capital improvement which allows funding energy upgrades from cost reductions. Under an EPC arrangement, an external organisation (typically an energy service company - ESCO) implements an energy efficiency project or a renewable energy project and uses the stream of income from the cost savings to repay the costs of the project, including the investment costs [25].

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According to the EU Energy Efficiency Directive 2012/27/EU (EED), Energy Performance Contracting "means a contractual arrangement between the beneficiary and the provider of an energy efficiency improvement measure, verified and monitored for the entirety 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" [26]. The contract between ESCO and the building owner(s) contains guarantees for cost savings and takes over the financial and technical risks involved in the implementation and operation for the entire duration of the project, typically 5 to 15 years [5]. Energy Performance Contracting (EPC) can provide substantial energy savings for building owners using the principle of repaying the energy efficiency investments directly from the saved energy costs [22].

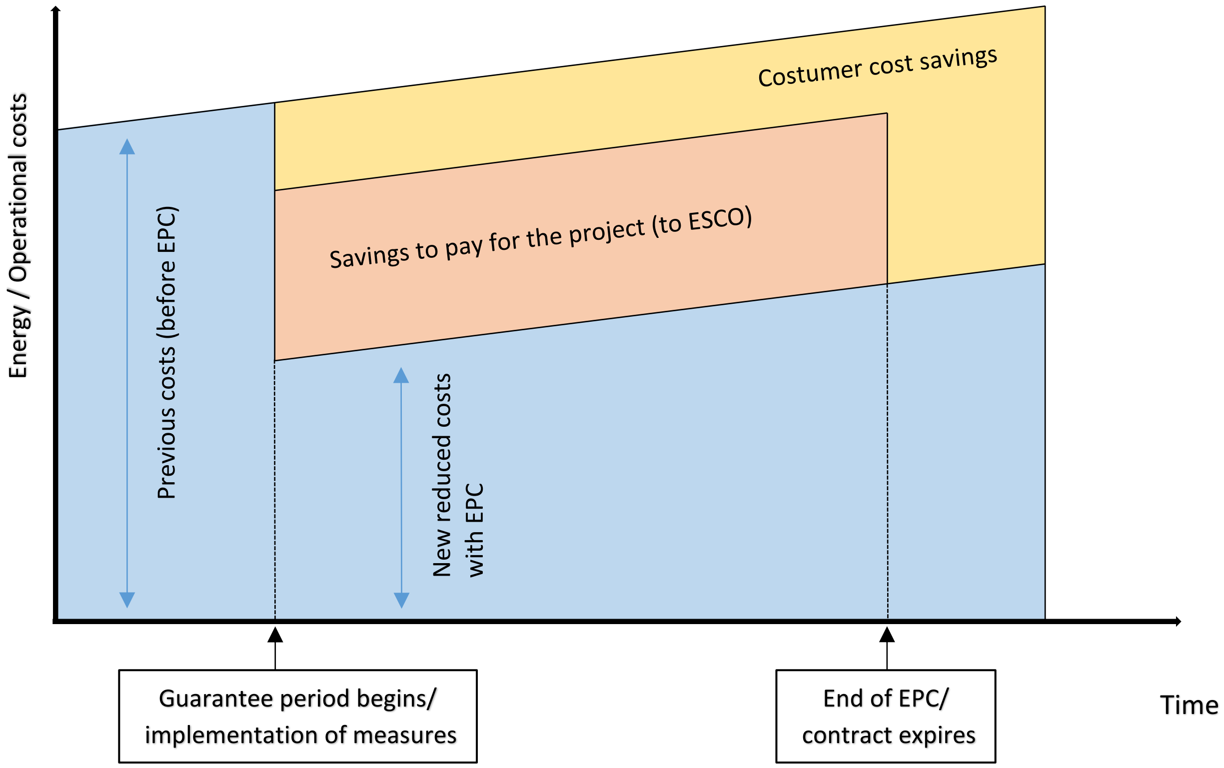

Figure 1. Energy Performance Contracting (EPC). *Source: Transparense.eu [22].*

In their analysis of EPC stakeholders' interviews, Davies and Chan [27] identified the most common perceived benefits of EPC, namely energy cost savings, guaranteed results and savings, and the elimination of up-front capital. Within the same research study, they also identified the most commonly encountered barriers/problem of EPCs, which are setting up and agreeing upon an energy baseline, mistrust, and a lack of commitment. This implies that is advisable to opt for an experienced energy savings company in which the stakeholders may have confidence. Bertoldi et al. [24] highlighted that the main advantages of EPC are no upfront costs for consumers and knowledge of ESCOs; the main challenges of EPC are performance risk and the high fees charged by ESCOs.

Approaching urban historic districts with EPC (analysis and recommendations)

In this section, the main attributes of historical city centres (district level retrofitting, multi-stakeholder approach, cultural heritage preservation) which determine and influence EPC implementation are first explained. Acknowledging these key determinant aspects is fundamental in order to establish the EPC^{HC} model which might facilitate the expansion of EPC funding typology in urban centres.

The complexity of retrofitting historical city centres

There are two main differences in the EPC procedural model between an "ordinary district" and a historical urban centre. Historical urban centres are characterised by (1) multi-stakeholder (public and private) ownership; (2) higher retrofitting costs because of historic building preservation. The subsequent subchapter will deepen the analysis of these two aspects which are crucial to determine the specific processes of retrofitting historical neighbourhoods. However, it is above all necessary to point out what the benefits of neighbourhood level (multi-block) energy retrofitting with EPC are in comparison to the retrofitting of a single building.

- Benefits of district energy retrofitting with EPC.

EPC projects deal with numerous uncertainties such as energy price oscillations, uncertain future energy consumption of the buildings, and unpredictable investment costs [28]. Several aspects influence the fulfilment of projected energy savings, e.g. quality of system operation and maintenance, environmental conditions, accurateness of predicted savings, etc. [29]. With EPC district-level retrofitting it is possible to overcome these issues by achieving the benefits of the economy of scale and diminishing the risks related to a single building's erroneous energy restoration audit. This is particularly true for historical urban neighbourhoods, where each building is unique and the mentioned risks are higher, and it is therefore advisable to intervene on a larger scale rather than on individual units [10]. Restoration at the district scale is defined as the contemporaneous renovation of several buildings situated in the same district to achieve common benefits such as cost savings, cost-effective funding advantages, effective use of renewable energy sources, etc. [30]. It is possible to save a considerable number of financial resources in several areas such as procurement of energy analyses and construction due to the "economy of scale" - achievable with the refurbishment of several buildings at the same time. In addition, it is possible to employ renewable energy sources more efficiently for local heating, cooling and electricity production when the local energy systems supply several buildings instead of one single building [31]. In comparison with the district refurbishment, single building EPC retrofitting projects are usually too small and cost savings do not always compensate for all the administrative work [12]. Efficient EPC management requires a neighbourhood-level approach [31]. Apart from the recognisable benefits of district level retrofitting there are also some barriers. Häkkinen et al. [30] identify the three most important barriers related to district level EPC, which are (1) the presence and collective agreement of several building owners to start district-level retrofitting projects, (2) absence of an initiator/activator/facilitator to initiate district-scale projects and (3) institutional and legal barriers associated with urban planning.

- Multi-stakeholder ownership with public and private entities

Historic city centres are very specific and unique neighbourhoods as they encompass several distinct stakeholders (commercial, governmental, municipal, and residential) and because most of the main public/civic buildings are usually concentrated in a city centre. EPC could be performed in city centres with the cooperation/involvement of all the above-mentioned stakeholders (from commercial - industrial buildings to residential buildings, covering single houses/single buildings and blocks with multiple owners). There are good examples of multi-block/building regeneration with EPC, especially for urban agglomeration where there is one individual entity which owns several units (e.g., a social-housing neighbourhood where the proprietor is the municipality). Single ownership simplifies the drafting of an EPC contract and consequently the renovation of the buildings. Le Gentil [12] points out that in the case of multiple privately owned buildings it is very complicated to draft the EPC contract with each owner. One of the main challenges of district-scale energy refurbishment is the necessity to involve several actors/stakeholders in the value chain. It is rare for all residents to share the same values, and this can affect urban development. As private occupants tend to base their decisions on financial issues and short-term preferences, the role of a public partner in the partnership is vital [11]. Several municipal and state buildings owned by (one) public stakeholder are usually situated in historic centres. The publicly owned buildings are usually municipal offices, parliament, ministries, government institutions, hospitals, nurseries, public elementary and high schools, universities, etc. The high concentration of public ownership (which in theory represents a mono-ownership typology with one stakeholder) in historic centres represents a significant advantage in the EPC renovation process. The public sector (in the EU) has, in general, a positive attitude towards EPC. In Germany, for example, 95% of all the EPC clients are public authorities and hospitals [32]. The municipality of Paris has used EPC to retrofit more than 600 public schools [33] and in Milan, 98 public buildings were renovated with just one EPC tender by the Covenant of Mayor [34]. One of the most famous and massive urban regeneration/retrofitting with EPC was done in Berlin through the municipality program called "Energy Saving Partnership". Within this special partnership more than 1400 buildings in Berlin have been refurbished [32]. These examples confirm that it seems less complicated to apply the EPC funding scheme to public buildings.

- The complexity and higher costs of retrofitting buildings with cultural heritage significance.

It can be argued that a vital component of sustainable urban development is the preservation of cultural and natural heritage [13]. When aiming to reduce the environmental impact of historical building stock, special attention is required in relation to the conservation of heritage status[14]. While protecting the cultural heritage of historical buildings is essential for local community development, the protection of natural resources is important for the citizens' well-being and for long-term environmental sustainability. Heritage management includes edifices, sites, and other assets of historical, cultural, political, artistic, and/or religious importance in addition to community-related cultures, skills, knowledge, and traditions which should be preserved for future generations [13].

The historic building stock is heterogeneous and comprises constructions from different time periods, created with various techniques and building materials. These demands differentiate energy retrofitting strategies in historic districts to balance energy and building conservation. Consequently, better knowledge about the specificity of the historic building stock is needed [35]. For example, an energy audit for historic buildings requires an understanding of original construction methods, heritage principles, changes that have been made over time, performances, possible threats, and retrofitting solutions. This knowledge is essential to avoid possible pathologies and physical damage which can be achieved using non-destructive technologies (NDT) that should be applied in historic urban areas [36]. In addition, the renovation of historic constructions is understood to be a cultural risk, and public legislation usually restricts the modification of the heritage building stock [6]. Consequentially, there are some fundamental aspects related to cultural heritage preservation that should be considered when retrofitting historic centres. First, each unique historic building needs its own tailor-made set of solutions which respect its cultural heritage specificities. Consequently, the investment effort will usually be greater in comparison to the "standard" retrofitting.

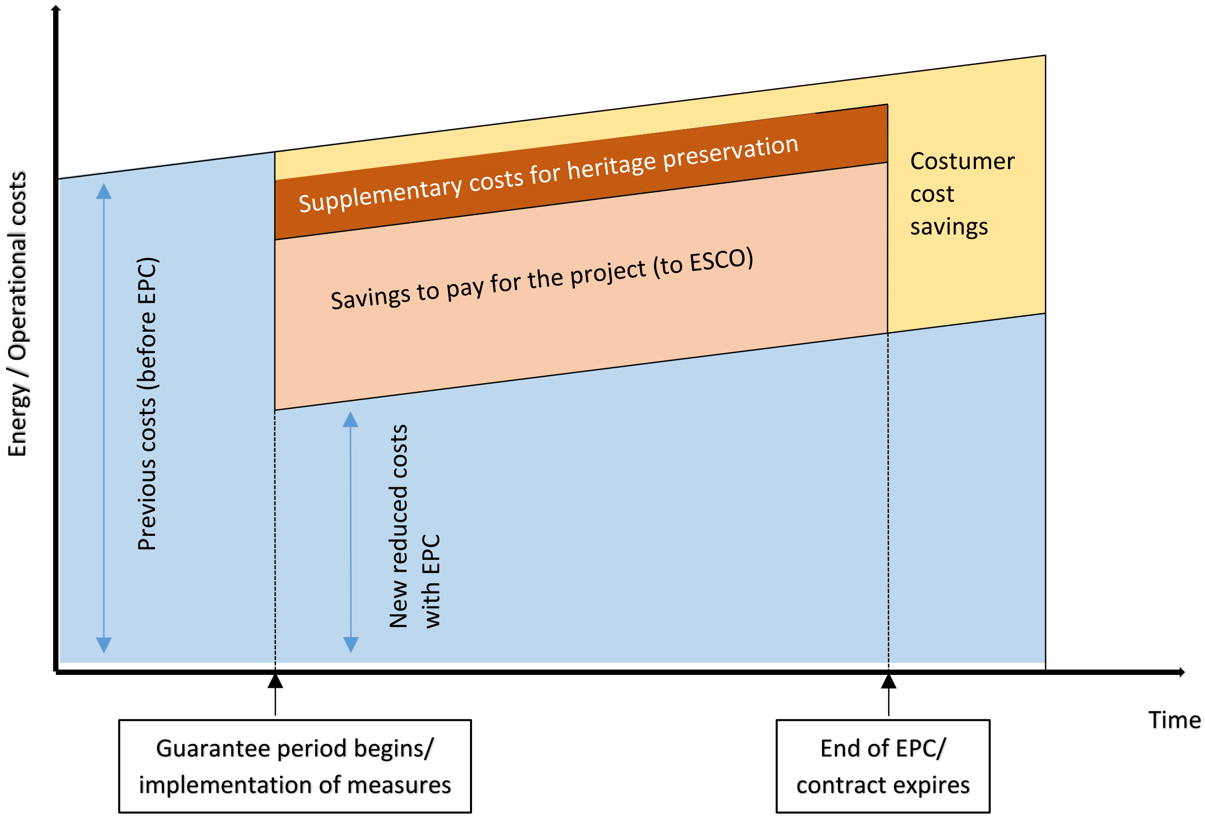

Figure 2. Supplementary investment costs for the heritage preservation of buildings in EPC projects. *Source: Author.*

Because of the supplementary investment costs for heritage preservation, the savings are lower in comparison with a "typical" EPC investment (see Figure 2). This could potentially render the EPC investment less attractive to building owners. However, even with the extra costs the owners would still profit from the investment (lower monthly costs, retrofitted building, better aesthetics, higher property values, etc.). Secondly, historic buildings which undergo an energy retrofit that respects their cultural value will not reach the equivalent efficiency levels in comparison with highly efficient new buildings [16]. These two arguments show a conflict between implementing energy efficiency measures and the preservation of buildings as "heritage" [14,15]. Conservation experts are often concerned that the application of energy efficiency measures could compromise the heritage value of historic constructions. On the other hand, energy consultants complain about overly restrictive building conservation authorities obstructing energy efficiency improvements. (Over)protecting urban heritage could cause local antagonism to urban development, while urban development is at times thought to threaten cultural heritage assets. The main challenge is how to find adequate compromises between the qualitative benefit (heritage significance) and quantitative benefit (environmental sustainability) [14].

Improving the energy performance of historic urban areas signifies finding a balance between heritage significance and energy efficiency measures [37]. Troi and Bastian [16] identified a frequent lack of interdisciplinary communication/cooperation between various specialised authorities**.** All these challenges could be overcome with proper planning, clear communication and mixed interdisciplinary teams. Energy retrofitting should be considered a tool for protecting cultural heritage rather than a process that generates conflicts [38].

It is advisable that the ESCO (within EPC projects) should not be alone in financing the entire energy retrofitting interventions of cultural heritage buildings, for which the costs for pre-design (prior analysis and diagnostic costs), and construction costs (particular techniques to safeguard the heritage characteristics) are particularly elevated [39]. In order to cover the extra/additional costs for cultural heritage preservation, there should/might also be available some targeted national/transnational funds such as municipal subsidies, governmental subsidies, EU funds, etc. The role of governments and transnational entities could be essential in order not to negotiate and divide these additional costs between the investors and the ESCOs. In addition, Filippi [39] suggests that it is necessary to make use of "off-balancing sheet financing" for the green retrofitting of such buildings, such as joint ventures, research and development partnerships or operating leases.

- SWOT analysis

Table 1. SWOT analysis for the EPC implementation processes in historical urban districts. *Source: Author.*

Strengths	**Weaknesses**
▪ large project (district), with several building units, which diminishes the EPC administrative costs and at the same time diminishes the investment/ return risks. ▪ several public buildings owned by a single entity (municipality or state) ▪ buildings are situated and concentrated within one neighbourhood - the city centre, which makes the introduction of EPC easier ▪ historical urban districts are "privileged districts" - places of interest; the public authority is motivated to retrofit the main representative and tourist destinations	▪ protecting the cultural heritage of buildings in the retrofitting process lowers the efficiency level of the energy retrofit ▪ higher investment costs as a result of cultural heritage preservation of the refurbished buildings ▪ multi-ownership of the district - multi-stakeholders of public private buildings (residential, commercial, government, municipal) complicate the EPC process
Opportunities	**Threats**
▪ improvement of the urban (environmental) sustainability of the area (lower environmental impact) ▪ increasing the (touristic) attractiveness of the urban area which could consequently generate more jobs, services, etc. ▪ increase the price/value of properties (which on the other hand could also be understood as a threat if it leads to destructive gentrification) ▪ increase in the quality of life for the residents (better homes/domestic environment)	▪ new EU/state/municipal legislation that could change the district policies. ▪ bankruptcy of the ESCO ▪ inadequately executed refurbishment; the predicted energy retrofit efficiency would be below predicted standards. ▪ because of the higher prices of the buildings (after the retrofit) it could raise the rent; risk of gentrification ▪ possible conflicts between the municipal and regional/state authorities

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Based on the three main distinguishing characteristics which highlight the complexity of energy retrofitting historical urban districts with EPC, a comprehensive SWOT analysis was done (see Table 1). The SWOT analysis emphasises the main identified weaknesses, strengths, threats and opportunities of the EPC implementation processes for historical central districts. The energy performance contracting model for historic city centres (EPC^{HC}) will be presented in the next section, taking into consideration all the specifics of the EPC funding instrument and all the mentioned characteristics, barriers and facilitators in relation to retrofitting historic districts. EPC^{HC} introduces a novel approach for green retrofitting historic centres and at the same time could facilitate the future introduction and expansion of EPC in historic urban districts.

EPC^{HC} – operational model for EPC implementation in cities' historical central districts

In city centres there are usually three main stakeholder groups/typologies of building owners: public institutions (single ownership), private residential owners (rarely single ownership, generally multi-ownership of a building) and private commercial owners (single and multi-ownership). Among the owners and the implementer (ESCO), and with the possible collaboration of an "external" subject, the first question that arises is "who will be the initiator of the EPC process in a historical urban district"? There should be someone who would connect all the different entities, organise collaboration/networks and seek commitment from the different owners. It is crucial to define 'who' among the various stakeholders can be the most adequate 'activator' to initiate district-scale refurbishment projects. Another question which follows is "who will pay the activator?" National/federal/transnational incentives or subsidies are essential to compensate the expenses of the activator who would invite, assemble and manage the entire stakeholder group and organise a preliminary analysis for retrofitting possibilities for all the potential buildings in the selected area [30].

Häkkinen et al. [30] pointed out that when the activator comes from a private company, potential customers - especially flat owners - may be mistrustful. Therefore, the participation of the municipality at the beginning is essential to bring neutrality to the process. It is suggested that the municipality should take the role of initiator in the EPC process in the first phase, and the role of facilitator in order to provide constant support and collaborate with the entire stakeholder group (local owners, contractors and others). The municipality should create a special "urban facility management unit" (UFMU), which would take responsibility for the entire governance and management of the EPC project. UFMUs function as an "intermediator" which connects communities, municipalities and ESCO companies and interrelates various public and private sectors. The main functions of the UFMU are informing, consulting, involving, connecting and empowering different stakeholders within the EPC project [18].

The role of the UFMU is to expand the field of facility management from the particular organisation context to the complex urban context supporting new collaborations and encompassing urban community necessities [18]. In addition, as mentioned before, it has been shown that single ownership simplifies the drafting of a contract for the renovation of flats and that the high prevalence/concentration of publicly owned buildings in historic centres is beneficial for EPC implementation and represents a significant advantage. From these arguments it is evident that the most effective way to start the process of EPC implementation in historic centres is with public institutions. For the very first step of the innovative procedural EPC^{HC} scheme, it is suggested that the municipality (through the UFMU) takes the role of initiator and together with other public institutions present in the central district (provincial, regional, governmental institutions) should create a common special project-related public entity –a "local EPC public consortium" (see Step 1 in Figure 3).

This newly formed public entity would agglomerate and represent all the public buildings of the selected city central area (public schools, hospitals, ministry buildings, municipal buildings, and all other buildings owned by the state, region or city). In that way, it is also possible to encompass a critical number of buildings which consolidates the economic feasibility of the EPC project. In the second phase, the newly formed public entity should engage in public debate with other local stakeholders and promote the positive benefits of EPC through leaflets, brochures, media announcements and especially through local workshops with local residents/owners. The newly created public consortium should invite all private owners (commercial, residential) in the district to join the district EPC retrofit of their buildings. This "absolutely free" offer would be addressed to every building owner of the selected central urban area. The public consortium (lead by the municipality's UFMU) should be responsible for all the administrative issues related to the EPC processes. However, the confirmation to join the EPC project is primarily expected from buildings owned by mono-owners (especially commercial centres or other large real estate owners). Although they would be more than welcome, it is possible to predict that not all the private entities would join in for the first round of the EPC project. It is much more complicated to approach multi-flat/multi-family buildings as just one rejection from an apartment owner could stop the EPC process for the entire building. It is therefore essential to communicate/present the complete process adequately and sensibly to all private owners and to address all the benefits of energy retrofitting that they could benefit from with no investment costs (lower bills, the improvement of building quality and an increase in the value of the building).

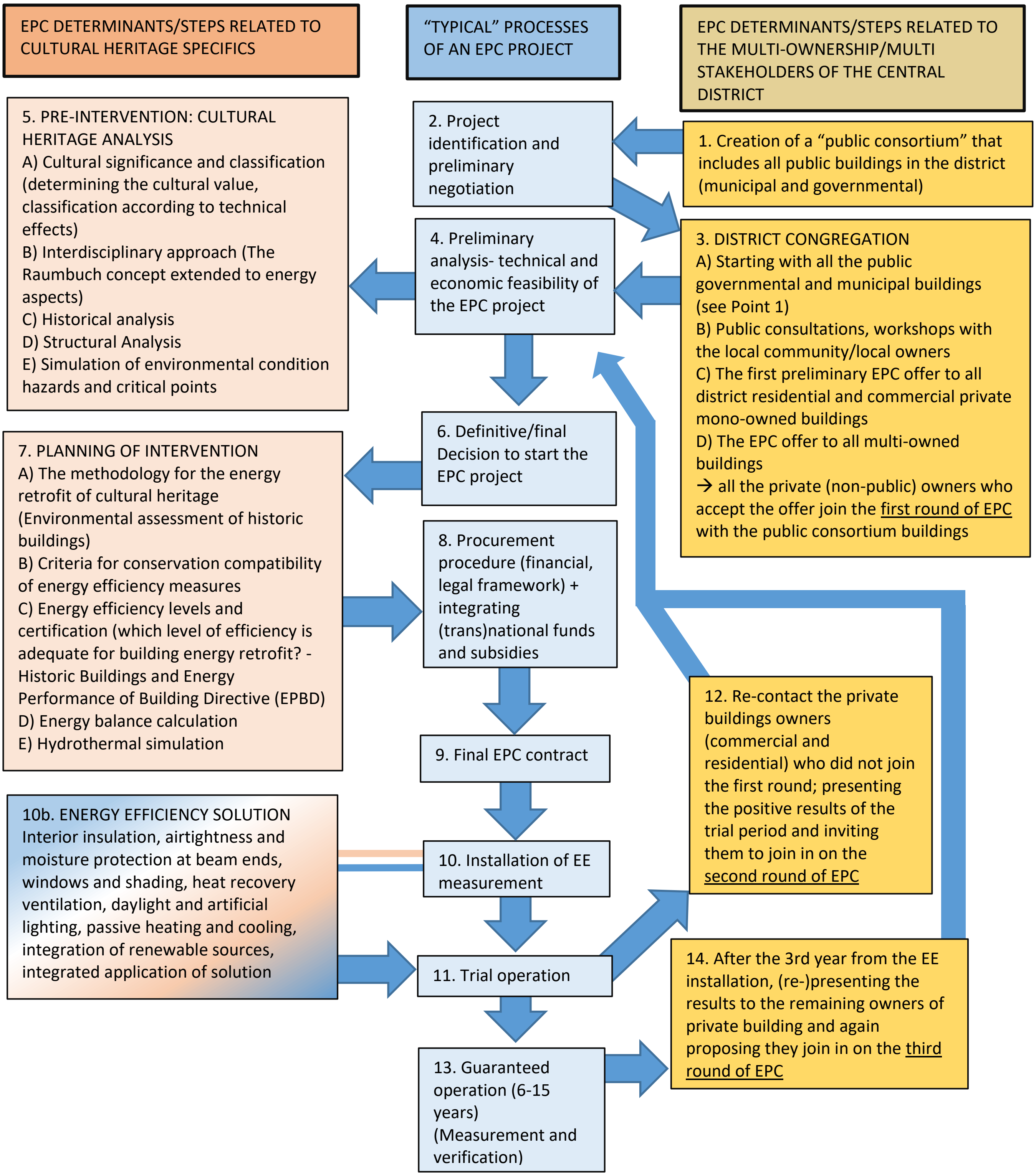

Figure 3. EPC processes for historical city centres (EPC^{HC}). *Source: Author.*

After clustering all the public and (hopefully as many as possible) private building owners, the next steps follow - the preliminary analysis for the technical and economic feasibility (see Step 4, Figure 3) and the especially important "pre-intervention cultural heritage analysis" (see Step 5). Pre-intervention cultural heritage analysis is an added process to "traditional EPC practices". At this point, it is essential to understand and carefully estimate the costs of the intervention.

If the preliminary technical and economic analyses confirm the feasibility of the project and if the cultural heritage pre-intervention analysis confirms its overall achievability, all the involved stakeholders of the central district can eventually accept the definite decision to implement EPC for the selected buildings within the district (Step 6, Figure 3). After the green light for the project, what follows is the creation of a concrete and detailed intervention plan that should consider the energy efficiency levels and the environmental assessment of the historical buildings. At the same time, it is required to start financial and legal procedures between the beneficiaries and the selected ESCO which would perform the district retrofit. If all the parties involved agree with the terms and conditions, they sign the final EPC contract and the ESCO could start the energy efficiency installation with the implementation of specific energy efficiency solutions for historic buildings (Steps 10 and 10b, Figure 3).

A final energy audit after the termination of the energy retrofitting could provide personalized information about the achieved energy reduction. Within the EPC^{HC} the use of special "feedback systems" is recommended which represent particularly prominent features within EPC projects. Exemplary feedback solution are smart meters and other building-monitoring systems, which follow the energy consumption for electricity, heating, cooling, and the usage of hot water [17,40].

Some months after the energy retrofit is concluded, when the results of energy reduction and the improved quality of life in the refurbished buildings are clearly visible, it is suggested that the private owners (additional local workshops) who had not joined in on the first round of EPC are again contacted and invited to participate in the second round, which would (again) be led by the same public consortium. Many private owners could appreciate all the benefits of EPC refurbishment and the improved quality of the microenvironment (at no cost), which are visible in their vicinity; and they may decide to join in on the second round of EPC (Step 12). It is also suggested that the same operation is repeated again after 3-4 years (Step 14). With this gradual non-mandatory EPC participation of different stakeholders in various stages, it is possible to achieve an almost complete green retrofit of an entire central district in a reasonable period of time.

Impact

The energy performance of historic buildings is a balancing act between heritage significance (preserving heritage values) and energy efficiency measures (achieving energy saving) [35]. This characteristic differentiates the green retrofitting of heritage neighbourhoods in comparison to the "regular" building stock [37]. In the last years, it was possible to experience a substantial development of new concepts focusing on rehabilitation of historic urban areas, which comprises a greater awareness of historic heritage, the role of public space, the intangible values of identity, social integration, etc. Heritage represents an essential resource in the cities where its rehabilitation should take into consideration the tangible and intangible features with special attention to the residents' quality of life [41]. Moreover, the energy retrofit of protected buildings in historic districts can also help attain EU climate targets [6].

The innovative EPC^{HC} could open a new perspective on district green retrofitting and could facilitate the approach of large-scale EPC implementation in historical city centres. The innovative procedural model EPC^{HC} offers step-by-step guidelines with concrete suggestions to be followed in order to approach and involve all the different stakeholders - from the initial pre-planning to the complete renovation of the historic district with EPC. Through this model, it is possible to obtain a wider picture/overview of possible obstacles and solutions for such complex refurbishment. Cities around the globe will undergo a radical transformation toward sustainable urbanism in the next two decades. We will experience the construction of hundreds of sustainable neighbourhoods and eco-cities around the world, and the main question will be how to finance the implementation of comprehensive sustainable urban features. One of the main answers is the EPC funding model, which could also be re-interpreted and applied beyond the energy retrofit purpose (for real estate) to other areas of interest in cities such as transportation, recycling or natural resource preservation systems.

Conclusion

Kyrö et al. [11] identified the need for a suitable process tool - governance model to be provided for all the stakeholders involved, which could enable effective and profitable refurbishment projects. The article presents concrete recommendations on how to approach historic urban districts with EPC. There are three different common aspects in historical central districts that are taken into consideration in the EPC^{HC} matrix: district scale refurbishment, cultural heritage preservation and multi-stakeholder governance/assembly. The involvement of a large number of buildings represents an added value and could boost EPC implementation. The economy of scale diminishes EPC administrative costs, and at the same time diminishes the investment risks. Apart from the funding issue, one of the main challenges for refurbishing historic buildings is finding an adequate balance between respecting cultural heritage and applying energy efficiency measures. Evidently, EPC in historical city centres is less profitable in comparison to urban areas without buildings of cultural significance. However, because historical city centres have symbolic and touristic relevance, the extra investment in cultural heritage preservation is undoubtedly worth the expense.

The other defining characteristic of city centres is that they encompass several very different building owners/stakeholders (commercial, residential, and public - municipal, regional, government). One of the main challenges for the EPC^{HC} model is, first, the achievement of the “collective commitment” of all the stakeholders involved. The limitation of the proposed model is that it necessitates a positive outlook on the part of multiple owners (from the public and private spheres, including regular citizens, companies and institutions) to join in on the project. A considerable proportion of state-owned buildings is an important advantage for EPC. Naturally, it is important to point out that public stakeholders should work together, even if there are different political interests between regional, state or municipal authorities. The public consortium should be the most cohesive and active stakeholder in the project, which could represent a challenge if particular ministries do not collaborate or if local public institutions do not cooperate with national institutions. It was identified that the public consortium which encompasses all the municipal, governmental and state-owned buildings, should be the initiator, facilitator and administrator of the entire EPC process in city centres.
The public consortium, led by the city authority (UFMU), might also be responsible for EPC related procedural steps, and (in collaboration with a selected ESCO) for the coordination of special tailor-made interventions related to the cultural heritage specifics of the buildings (cultural heritage pre-intervention analysis, energy efficiency solutions, etc.). In addition, one of the most important activities of the public consortium is to adequately promote all the benefits and to attract private commercial entities and residential individuals to participate. Another challenge represents the establishment of special “urban facility management unit” (UFMU). In their study, Polzin et al.[42] have identified that in general, municipalities do not possess enough internal human resources with the specific managerial capacities to deal with the complex energy refurbishment systems, and they would likely need to hire new employees. Although opting for EPC might reduce the need for in-house expertise to retrofit districts, trained and experienced employees are still needed to manage the whole contract process with the ESCOs. Inadequately trained personnel for the management of EPC represents one of the most important barriers for municipalities [42]. The question that could arise is where to find the additional budget for the new UFMU employees. The role of government and transnational bodies within the EPC^{HC} are expressed in two ways. Firstly, to finance the activator/facilitator, who organises the entire EPC process, supports, and connects different stakeholders. Secondly, through government and transnational funds/subsidies which directly target the refurbishment of historic urban areas and cover the extra refurbishment costs for the preservation of cultural heritage.

Conflict of interest
There are no conflicts to declare.

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