Residential buildings as expanded territory for ESCOs

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Abstract
To meet the targets for a Low Carbon Economy in 2050, all new and existing buildings will have to significantly reduce their energy consumption, and/or progressively transition towards low carbon energy supplies. Although the EPBD-"recast" has set targets for new buildings and future definition of "cost effective thresholds" for existing ones, the work developed so far in IEA EBC Annex 56 shows that deep renovation actions still face significant barriers.

Energy Service Companies (ESCOs) already evolved strategies and methodologies for their native hunting ground, industry and large scale service buildings, where high energy consumptions yield acceptable paybacks, decisions are centralized and risks known. Although these methods are still being perfected for assessment, design, validation and optimization, the competitor's population is growing and the fattest preys scarcer: this expected curve of growth and decline will surely hamper new investments, and delay the needed results.

This paper proposes that there is a place for ESCOs in European historic city centres – almost one in each city – where architectural constraints limit the installation of energy conservation measures like insulation and renewable energies. The provision of Energy Efficiency Services by ESCOs in the residential buildings is still limited despite the considerable potential for energy savings: long-term and complex contracts, disperse ownership, small consumption and low investment capacity compromise the financial viability of projects.

Considering the renovation options for an ancient residential building located in the historic centre of Coimbra, a UNESCO site and a highly constrained context, an analysis of costs and impacts of large-scale "deep retrofit" actions is presented. ESCOs' capacity to explore barriers as challenges, and to perform "deep assessments", is then used to demonstrate area based/neighbourhood approaches that can reduce costs, alleviate energy poverty risks and foster engaged communities through widespread socially inclusive participation in the energy efficiency goals.

Introduction
In Europe residential buildings represent 75 % of the built area and 68 % of total buildings energy consumption (BPIE, 2011) accounting, in large estimates, for around 27 %[1] of the European energy consumption in bulk. In Portugal residential buildings represent 77 % of the built area and an estimated at 16.6% of the total primary energy consumption, from which 43 % rely on electric based sources (DGEG, 2014). Appealing numbers, commonly used state that Europe can reach the 75 % emission reduction (EC, 2014) goals by "greening" the energy sources, named as "Supply side" measures, and/or by reducing the "Demand side" of the equation.

In existing buildings it is assumed that "deep renovation" of the building stock towards "nearly Zero Energy Buildings" (nZEB) levels (EED, 2012) only lacks funding to occur (Bul-

1. Authors calculation using (BPIE, 2011) data. A helpful mnemonic is to associate the percentage of total energy consumption in Europe to the number of European members. Obviously each member specific consumption varies widely in specific contexts.

lier & Millin, 2013), but the diversity of the built reality tells another story (Brito, 2014a). A deep assessment carried out for an ancient residential building in the historic centre of Coimbra, in Portugal, recently classified as World Heritage site by UNESCO, demonstrates that misconceptions about ancient buildings still endure, and that enhanced knowledge is needed to harness a wider renovation potential: energy efficacy as a driver, not a goal by itself (Brito, 2014b).

Findings from the ongoing Ph.D thesis on "Upgrade Opportunities for Ancient Buildings (in City Centres)" (Brito, 2014b) confirm that thorough assessments (3D tools, thermography, Indoor Environmental Quality) and Building Information Model (BIM) depictions are relevant and viable if applied to neighbourhood scale. Five intervention options, evaluated using a methodology adapted from the IEA EBC Annex 56 on "Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation" project (Brito, 2015), provide an insight of alternative strategies, associated risks, advantages and costs – economic and environmental.

Opportunities to play concerted actions towards effective transversal results are presented as neighbourhood scale interventions, but are there teams capable to play within these varied levels and future perspectives?

The authors state that, if adequately favoured, ESCOs are particularly tailored to recognize the opportunities for energy improvements in ancient building and historic city centre renovations and overcome the obstacles for establishing ESCO projects in the residential sector (Irrek, 2013). Even acknowledging the early stage of ESCOs market in Portugal (Transparense, 2014[2]), the authors emphasize that the business potential exists, although the optimal technical solutions will vary in each context. Besides aggregating demand and managing supply, the approach presented herein fosters good relationships with customers, improves the historic centres for local citizens and tourism and demonstrates ESCOs potential to create varied jobs in local companies.

This paper starts exploring the specificities of the historical centre using data from a specific "Demand point" to engage the reader with ancient residential buildings context, and decision-making process, presenting renovation options and associated economical/environmental costs. Then their "scaling up" potential is evaluated in the neighbourhood and expected funding estimated: even with potential 50 % European/national funding, how many owners would pay the extra costs, or have the will to act?

In "Goals, rules, roles, teams, players and the need for engaged spectators", a short overview of ESCOs is presented for increased perception of ESCOs as facilitators, engaged middle-actors within communities.

In "Residential buildings as expanded territory for ESCOs", ESCOs' approaches to the Montarroio neighbourhood exemplify strategies for overcoming the usual barriers, and the advantage of having alternatives.

Although risks exist and contexts may change over time, this paper proposes ESCOs as "middle-actors" between local needs/engagement and collective policies; and that the "learning stories" (Janda and Topouzi, 2013), either failures or achieved goals, are more enriching than what "could have been", and "was not" pursued.

2. European IEE Project aiming at increasing the transparency and trustworthiness of Energy Performance Contracting (EPC) markets throughout Europe: http://www.transparense.eu/eu/home/welcome-to-transparense-project.

Demand point at Montarroio Case Study: setting the scene

The Montarroio street and its' buildings are already reported in the XIVth century; the case study higher level stone-embellished windows and a chimney portray XVIth century exterior signs of comfort (Trindade, 2002). It still stands in the ancient city centre of Coimbra, within the UNESCO "University of Coimbra –Alta and Sofia" (in http://whc.unesco.org/en/list/1387) and "Jardim da Manga" National Monument protection areas. Stacked masonry walls provide peripheral support to wooden floor levels and ceilings, protected by ceramic roof tiles on a wood structure. Wood doors and simple glazing sash windows with interior shutters exist, with high infiltration due to lack of maintenance. Thick walls, reducing towards the upper levels, define growing internal areas: 13,7 m² (p00) in a semi-buried level with separate entrance, 15,3 m² (p01) on the intermediate level and 20,6 m² on the top level (p02). Only 35.9 m² are inhabitable, as level (p00) suffers from severe humidity issues.

Due to its location, energy efficiency improvement strategies are limited: street width, fire risk and architectonic constraints hamper exterior insulation approaches, while small useful area makes interior insulation inadequate. Similar constructive solutions and restrictions occur in over 800 nearby buildings, in millions across Europe's city centres, and many more outside these virtual borders. Accounted together, ancient buildings represent massive energy consumptions in the most visible areas of our cities, in the places that signify their essence.

RENOVATION OPTIONS: TOWARDS EMISSION REDUCTION?

The Montarroio Detailed Case Study (Brito, 2015) compiles the evaluation of five alternatives for the renovation of ancient buildings in Historic Centres, including demolition and reconstruction. It reports economic indicators like "Initial Investment Cost"(IIC) as well as 30 years (DR-EU-244, 2012) "Life Cycle Cost" (LCC). Co-benefits, resulting from the intervention and other details are also portrayed for the following options:

- **Opt.0_*_Reference Case**: The building "as it is", with the works to render it inhabitable, tagged as "Anyway Measures" (IEA A56, 2014), including materials/equipments maintenance and replacement;
- **Opt.1_*_Common "rehabilitation":** "Business as usual" (BAU) neighbourhood practices where interior insulation under plasterboard is placed to hide existing pathologies, with serious Indoor Air Quality risks;
- **Opt.2_*_Demolition & Reconstruction**: the primary choice for many, as it reduces surprise factors, uses common new construction techniques and increases useful space: economically unviable in most locations;
- **Opt.3_*_Upgrade without extension**: Detailed assessment to optimize the inherent building characteristics to achieve efficacy with users. Solar thermal heating and DHW require primary energy only for backup;

Figure 1. Panorama view of the Montarroio case study, located in Coimbra, Portugal (source: author).

- **Opt.4_*_Upgrade with extension**: previous strategy (**Opt.3)** with structural seismic reinforcement made financially viable with an area extension (IEA A50): safer users/ investment, and space for a small family.

Table 1 compares energy efficiency (**EE.**) related renovation options (**EE.Ren.Options**) describing their non-energy efficiency related costs (**Non-EE.costs**), necessary to render the building inhabitable, and Initial Investment Costs for the building envelope (**IIC_EE.Envel.**) and energy efficient equipment (**IIC_EE.Equip**).

Equipments, accounted with full installation on site, are denoted by suffix notations: "**bio**" for biomass; "**erh**" for electric resistance heater; "**hp**" for heat pump; "**gas**" for gas combustion; "**st**" for solar thermal, and conjunctions like "**st-bio**" when the backup is provided by biomass. The energy costs and the return of investment calculations are based in the Portuguese Energy Performance Certification process that assume a full occupation and comfort levels maintenance across the seasons. Statistical data (see Table 3) tells otherwise, and local interviews confirm that the table values per person are higher than reality. Table 1 also acknowledges available individual incentives through mechanisms like PPEC[3], explored further ahead to account for funding.

The over cost of EE. related measures (**%EE.OverCost/m²**) compares the **investment on EE measures** with the **Reference Case** Opt.0_erh (€217/m²), the local non-energy efficiency related renovation current practice.

Figure 3 graphs the Initial Investment Costs (**IIC**) per square meter of renovation area, the value payed upfront, and the Life Cycle Costs (**LCC**) comprising the IIC, the equipments maintenance/replacement costs (each 15 years) and the energy costs during 30 years, divided by 30 as if paid annually.

To facilitate comparison, the analysis will focus on similar useful area scenarios: **Opt.0_erh,** that portrays the "Anyway Scenario" accounting for the costs to render it functional (see IEA EBC Annex56, 2014), **Opt.1_erh** portrays "Business as Usual" regulation-inspired practices and **Opt.3_st-erh** that insulates only the horizontal portions of the envelope and integrates solar thermal heating to achieve "nearly Zero Energy Buildings" levels, mandatory for new buildings in 2020 (EED, 2012).

Comparing both graphs demonstrates that higher IIC in efficient equipment reduces energy consumption (electricity and/ or gas, as solar thermal and biomass are accounted as neutral in emissions in Portugal) and is, most of the times, favourable on the long term LCC. Nevertheless, comparing Opt.0_hp with Opt.1_hp casts doubts on wall insulation options, and conclusions only emerge when tackling the LCIA analysis.

In the residential sector, the energy efficiency European discourse (EED, 2012) refers the need for "deep renovation" of existing buildings as the solution. Are the above IIC and LCC enough to make a good decision?

"DEEP RENOVATION" OF ANCIENT RESIDENTIAL BUILDINGS: MISLEADING (EXPENSIVE) APPROACHES

The increasing concern on Energy Security and Climate Change issues is pressing renovation interventions on ancient buildings to adopt new construction milestones which they were never meant to provide or endure. This stress is relegating "Traditional Knowledge" on building construction and use to a secondary role: centuries of local evolution are dismissed over their present inadequacy to one (energetic) prevailing perspective of the future (Brito et al, 2014b). Although published studies (English Heritage, 2013) recognize the inherent value of the building and community to properly foster interventions, "deeply blind" energy efficiency intentions see renovations as solutions, forgetting that "Buildings don´t use energy, people do" (Janda, 2011).

An example is the "Factor Four" expression used "to refer to a 75 % reduction in greenhouse gas emissions by 2050 compared to 1990" (Bullier & Milin, 2013), formulated by (Weizsacker et al., 1998) in a wider context:

> Changing the direction of progress is not something a *book* can do. It has to be people. It's consumers and voters. It's managers and engineers. It's politicians and communicators. People don't change their wants unless they have good reasons to do so. And it must be *strong* reasons. Otherwise there won't be enough momentum to change the course of direction of our civilization. Reasons for changing the course can be either moral or material or both. *Both* apply in our case. (Idem, p. 2)

A paradigmatic example of "Factor Four" saving measures may be in the origin of misconceptions on windows. **Windows replacement in American glass façade service buildings demonstrates** that, in specific conditions and locations, retrofitting fixed (non-operable) windows reduces heat gains, cooling needs, the size for the HVAC unit and the dimensions of the ducts, thus reducing costs, materials and area use, and

3. In PPEC: http://www.erse.pt/pt/planodepromocaodaeficiencianoconsumoppec/ppec1314/Paginas/default.aspx

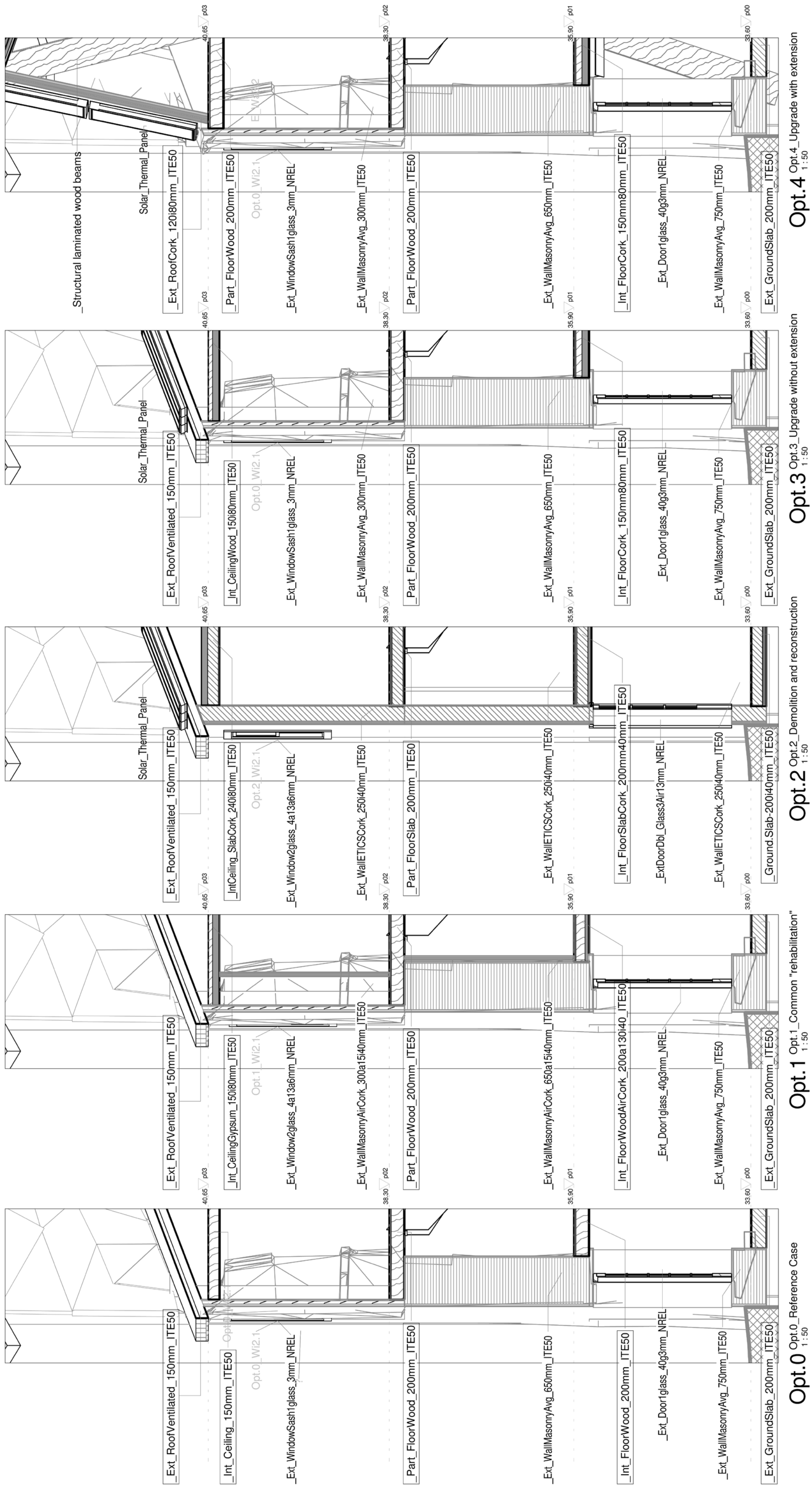

Figure 2. Montarroio Case Study intervention options scheme of studied options (source: Brito, 2015).

Table 1. Renovation options: Initial investment (IIC) and lifecycle costs (LCC) per option and equipment.

EE.Ren.Options:	Opt.0		Opt.1		Opt.2		Opt.3		Opt.4	
Equipment type:	_erh:	_hp:	_erh:	_hp:	_erh:	_hp:	_st-bio:	_st-erh:	_st-bio:	_st-erh:
Useful area	*36 m²*	*36 m²*	*31 m²*	*31 m²*	*63 m²*	*63 m²*	*36 m²*	*36 m²*	*46 m²*	*46 m²*
Non-EE.costs (€/y)	7,801	7,801	7,801	7,801	45,039	45,039	7,801	7,801	12,545	12,545
IIC_EE.Envel. (€/y)			6,906	6,906	4,957	4,957	1,188	1,188	2,733	2,733
IIC_EE.Equip (€/y)		2,120		2,120	1,874	3,719	4,840	2,975	5,490	3,475
%EE.OverCost/m²	**0 %**	**27 %**	**119 %**	**150 %**	**280 %**	**293 %**	**77 %**	**53 %**	**108 %**	**88 %**
Energy costs (€/y)	1,546	423	811	218	160	44	36	92	32	82
Yearly LCC (€/y)	2,321	1,642	2 192	2,042	5,724	5,735	1,924	1,591	2,686	2,314
EE. Payback (y)	**no ROI**	**2 y**	**9 y**	**7 y**	**5 y**	**6 y**	**4 y**	**3 y**	**5 y**	**4 y**
50 % EE. incentive?	no fund	1,060	3,453	4,513	3,415	4,338	3,014	2,082	4,112	3,104

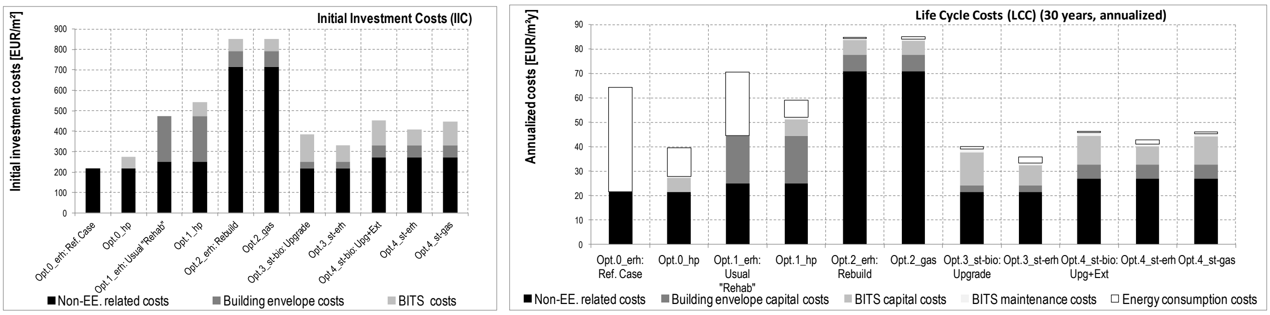

Figure 3. Initial Investment (IIC) and Life Cycle Costs (LCC) in 30 years, annualized. Building Integrated Technical Systems (BITS) are characterized in LCC to include maintenance. More information in (Brito, 2015).

improving comfort. **Windows replacement on ancient buildings does not work the same way**: the windows to walls ratio are different, no HVAC systems exist originally, the wall inertia plays a specific role in the comfort and the *operable windows* and shading systems play a role in proper ventilation, lighting, heating and neighbourhood relations. Historic Scotland (Baker, 2010) demonstrated, in laboratory and on-site that, **if properly maintained and used, single glazed windows can perform as well as newly installed double glazed windows** while reducing known risks such as wall condensation and poor Indoor Air Quality (IAQ): they are part of a functional system.

Moreover, keeping and upgrading the existing windows is a sustainable practice that promotes local jobs in maintenance practices, reduces waste production and costs. In the Montarroio case study repairing the existing windows and doors would cost around €800, while full replacement would cost at least €2,500: the new windows base price, extra works for fitting in the irregular original spots, and costs of disposal in land fill (Brito, 2014a).

Findings from the Montarroio case study investigation (Brito, 2015) and other sources also clarify that:

- Energy Performance Certificates equate ancient buildings with new buildings perspectives: although ancient buildings have specific characteristics (Brito et al., 2014b), the new building´s energy approach is used;
- Air temperature is only one part of the equation: in cold days people find comfort on sunny spots. Irradiative comfort also occurs on high mass heated walls, so "operative temperatures" should be used instead;
- Exterior insulation destroys character, shrinks already narrow streets, increase fire-risk and impose unknown consequences to the existing walls; Interior insulation, (EED, 2012) suggestion for ancient buildings reduces useful area, inhibits inertia and may even foster unwelcomed life forms in-between walls;
- Montarroio "Opt.3_st-erh" uses no insulation on the walls and keeps existing single glazing windows, yet achieves "nearly Zero Energy Buildings" levels using solar thermal heating and cooling (Brites et al., 2013);

There is a space for "deep renovation" interventions, and for "Scaling up" (Bullier and Milin, 2013), but the considerations above demonstrate that *ex-ante* "deep assessments" must validate the proposals' assumptions.

"SCALING UP": COMPARING COSTS, ECONOMIC AND ENVIRONMENTAL

Real data from a case study is *important to become empathetic with building owners*, and realize why apparently straightforward solutions fail to happen. Moreover, the Life Cycle Impact Assessment (LCIA) evaluation of environmental impacts, ex-

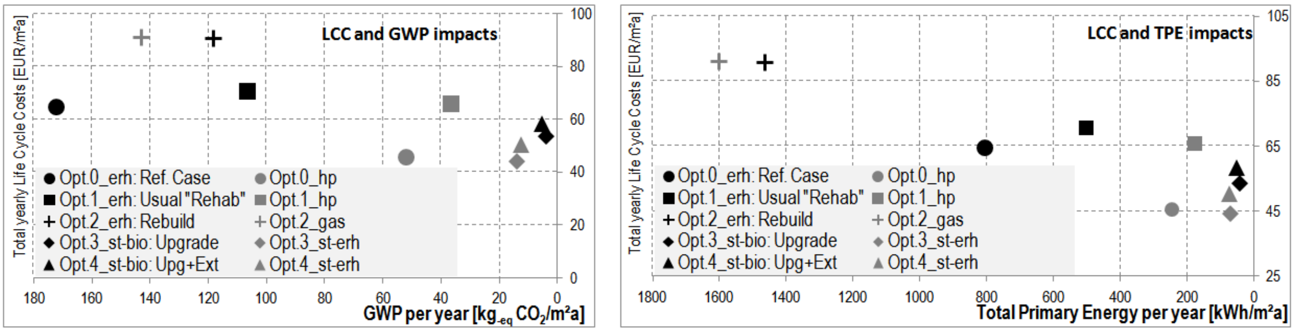

Figure 4. Life Cycle Impact Assessment using (EcoBat, 2014), recognized for the Swiss calculation methodology.

pressed in parameters like Global Warming Potential (GWP), and "Total Primary Energy" (TPE),[4] demonstrate that in this climate **deep renovation interventions**, **recommended and/or imposed by regulations**[5] as interior insulation with windows replacement, Opt.1_erh, (black square), have **worst long term impact on environment,** and owners pocket, than Opt.0_hp (grey circle), a lower price option.

For ancient buildings in Mediterranean climate, installing heat pumps for acclimatization (air-air) and DHW (air-water)[6] is cost-effective, even considering their replacement each 15 years. These findings confirm proposals for a generalized use of heat pumps in a session of the European Association for Heat Pumps (Banhardt, 2015), but what would be the consequences of placing exterior units in each façade of the UNESCO historic centre?

75 % emission reductions (nZEB?) and increased energy security are achievable in Opt.3 and Opt.4: **Opt.3_st-erh (grey diamond)** uses insulation only in the building envelope horizontal cavities (ceiling and floor over the basement, easy to install), and solar based DHW and heating with electric resistance heater backup.

Even presenting advantages like reduced tariff price exposure, guaranteed domestic hot water and heating in the majority of the year (Brites et al, 2013) and very low environmental impacts, visible in the graphs of Figure 4, **how many building owners would pay extra 53 % (Table 1)** in such a 36 sqm intervention?

To overcome these high renovation costs, several authors propose "bundling" or "pooling" small energy efficiency projects together" (Pantaleo et al., 2014), and solutions for "scaling up 'bankable' deep renovation of buildings" (Bullier and Milin, 2013). What are "deep renovations", and what would be their large scale impacts?

Table 2 presents data from the Montarroio building and other collected from assessing[7] the "Inquisition bloc" in Figure 5 (more in topic "ESCOs scouting the territory") to question the deep renovation "scaling up" potential. It assumes **Opt.3_st-erh option, the lowest cost nZEB proposal** (the grey line in Table 2) as the primary choice, making its energy related renovation costs probably eligible for funding at a 50 % rate, with the rest of the investment at a special tax of 2 %/year. For the calculations it is assumed that, if collectively organized – another ESCO capacity – installation prices can be lowered with scale (10 % savings for 47 systems, 20 % for 282), with maintenance costs kept at a 2.5 % yearly rate, an assumedly low cost for solar thermal systems in Portugal.

Statistically (see Table 3) in Portugal each person uses around €8,25 of energy per month for the domestic hot water and heating needs. Calculations show that Opt.3_st-erh would cost from €12,5 per person/month in the individual intervention, to less than €6 per person/month if implemented in group. Even aware of this collective advantage, how many of the 282 building owners would increase costs to provide better comfort for the tenants? And from those few, how many would be able to apply for funding, and control good implementation?

The high initial investment costs and potential visual impacts of "scaling up" projects in Coimbra's UNESCO protected historic centre lead the authors to study alternative scenarios and consult with public officials about their opinions. This paper acknowledges a collective effort towards viable community based solutions for final energy services supply, and/or community driven alternatives towards the 75 % emissions reduction goal.

ESCOs in the residential sector emission reduction game: goals, rules, roles and the need for spectators

Independently of what we are playing at, every game has stakeholders that range from those directly involved in the play to those who (simply) act as spectators: with their presence, the game evolves and continues by progressively attracting more players, trainers, managers, sponsors, statistic analysts, theorists, researchers, and (renewed) audience. Like in all games, the emissions reduction game has its own specificities: it is played at varied fields and levels, deals with several sectors and sensibilities and only makes sense if played by the majority of those who, directly or indirectly, contribute with (significant) emissions worldwide.

The purpose of this metaphor is clear: it illustrates the complexity of the problem – if it was simple it would already have been solved – and emphasizes our collective role as middle-actors (Janda, 2013), able to engage others into the play. Energy Service Companies (ESCOs) can make the Energy Efficiency game evolve.

4. 30 years primary energy calculation including material collection, product fabrication, all transports, installation, maintenance, energy use, substitution and final disposal, annualized dividing by 30.

5. (EED, 2012) and national building/renovation codes with possible exceptions only in historic centres.

6. "All in one" large systems are available, but prices double that of the two equipments approch chosen.

7. A deep assessment to evaluate the real impacts and potential should be mandatory before European funding is allocated to projects, to make sure they are in line with long term emissions reduction goals.

Table 2. "Scaling up" Opt.3_st-erh: roof & floor insulation, solar thermal panels and electric backup.

	Housing data			"Scaling-up" Opt.3_st-erh				Owners' fixed costs after renovation			
Scale	Buildings	Actual Inhabitants	Probable Inhabitants	IIC_EE. Envelope	IIC_EE. Equipment	Potential funding (50%)	Energy costs (y)	Maintenance (2,5%/year)	Mortgage/y (50% @2%)	Sum of yearly costs	Average cost person per month
Montarroio bldg.	1	0	2	1,188	2,975	2,082	92	104	103	299	€12,46
Inquisition bloc	47	106	200	50,269	125,843	88,056	4,323	4,403	4,841	13,567	€5,65
6 similar blocs	282	600	1,200	268,100	671,160	**469,630**	25,939	23,482	29,046	78,467	€5,45

Building renovation is a good opportunity to develop energy efficiency services (EES). The public recognition of the need to invest in EE in the building stock renovation unblocked significant EU funds, the legislation exists, the potential for energy savings is well identified but acts are missing, particularly in the residential sector.

ESCOS' GOALS

The core idea of the ESCOs business is to identify energy saving opportunities potential, propose solutions to the clients and tend for their implementation in exchange for a percentage of the savings: a win-win process.

Although there are opportunities for ESCO investments in the residential sector (Irrek, 2013), the current financial instruments are not yet adapted and individual actions are not bankable projects (Bullier, 2013). Knowing that ESCOs' business in big industry is on the way to its "peak", alongside with an increasing number of ESCOs, the fast reduction of the "fattest" preys, the largest "energy hogs", will urge ESCOs to find business elsewhere. The residential sector as an extended hunting ground is an opportunity to diversify the offer of products and clients, enhancing ESCO's resilience.

ESCO market for residential buildings in the EU is less developed than in other demand sectors, and market experts are quite sceptic about the possibility of a real development of energy efficiency services (EES) for the residential buildings in the near future (JRC, 2013; Irrek, 2013). Nonetheless, the potential for energy savings is large (Duplessis, 2010) while electricity consumption continues to increase (IEA, 2008; EC, 2014), a major concern across all EU countries and worldwide.

ESCOS' DRIVERS AND BARRIERS

Beyond profit expectations, the main driver for ESCOs' energy services are the EC legislation, the commitment towards climate change mitigation (Kyoto Protocol) and the restructuration and liberalization of the electricity and gas markets (Pantaleo et al, 2014), although with limitations. Existing EES are mainly driven by energy saving obligations for energy companies (UK, DK, Flanders, and GE), by white certificates (in FR and IT) and tax deduction schemes (FR). Public funding has been available in HU (municipal grants), RO (public funding programmes), BU and PO (subsidies, thermo-rehabilitation fund) especially targeted to residential buildings, involving heating, insulation, window replacement and thermal-rehabilitation of existing buildings. In Portugal, the EU legislation brought energy efficiency goals to the political agenda.

Several barriers hinder the deployment of EES in the residential sector. Besides usual barriers as low energy prices, long payback periods, high fragmentation of the residential market and decision making process, high transaction costs derived from an immature process – financing schemes, service standards, contracting procedures, monitoring and verification protocols – there are specific barriers for the residential sector that need to be tackled to ensure trust on the ESCO model:

- difficulty to establish a profile of baseline consumptions as habits and behaviour, person specific and influencing consumptions, include externalities like "rebound-effect" increased consumptions;
- split incentives issues and non-stabilizing EE. systems costs favour eternally postponed decisions;
- generic lack of awareness/availability of public subsidies or incentives towards energy efficiency;
- scarce residential sector examples to demonstrate ESCOs' model as a "win-win" intervention.

Portugal, currently facing a financial crisis, has accumulated a large public debt (also in Renewable Energy investments) and is restructuring its economy with strict austerity measures. Therefore, market liquidity is restricted and project financing is difficult in all sectors.

ESCOS' RULES

The European legislation is an example of game rules in evolution. The 2002 Energy Performance of Buildings Directive established Energy Performance Certificates as instruments for improved awareness of a built reality.

The 2010 EPBD-"recast" proposes "nearly Zero Energy Buildings" (EC, 2010) approach towards energy consumption reduction in new buildings as a multilayered, yet individual, approach. Existing buildings retrofits are since then subdue to **cost effective thresholds**, a concept that the IEA EBC Annex 56 on "Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation" is working on (IEA EBC Annex 56, 2014): systems integration issues, lack of specialized craftsmen and even users adherence are some relevant barriers.

Recently, the 2012 Energy Efficiency Directive (European Directive, 2012) (EED) gathers previous legislation (Directives

2009/125/EC, 2010/30/EU, 2004/8/EC and 2006/32/EC), in a clear message that the Energy Efficiency issue requires transversal approaches.

The EED establishes a set of measures for the promotion of energy efficiency within the EU, in order to increase its energy efficiency. The directive extends the provisions to encourage the development of energy services market and it also asks member states to remove regulatory and non-regulatory barriers (art. 18 and 19) to promote and support the Energy Services Market. The Concerted Action for the Energy Efficiency Directive (Core Team 5) further clarifies and supports the implementation processes, as reported in "Energy Services and ESCOs, energy auditing, solving administrative barriers" (CA EED, 2014).

Prospective legislative pathways already exist, and spark responses. "A policy framework for climate and energy in the period from 2020 to 2030" (EC, 2014) mentions "flexibility for Member States to help them meet common energy and climate challenges more cost-effectively while furthering market integration and preventing market distortion". (eceee, 2014a) disputes the "key role of energy savings, making energy efficiency the starting point in a renewed effort to counter the current economic, environmental and social crises in the most cost-effective manner possible" and the non-binding targets, that (Broc et al., 2014, p.6) further addresses by "Combining options 1 and 2 in order to harness the advantages of both", inspiring "strategies A + B" ahead.

Besides all these, ESCO´s intervention on the residential sector must be aware of the minimum Indoor Environmental Quality (IEQ) requirements, as energy consumption increase is expected in the locations where those levels were not achieved previously. In the residential sector Energy Efficiency Services supported on baseline definition may be doomed to failure, as the IEQ benefits[8] may actually require increase consumptions.

ESCOS' ROLE(S)

ESCOs provide all the services required to design and implement a comprehensive project at the customer facility, from the initial energy audit, in-house or external, throughout long-term Monitoring and Verification (M&V) of project savings. The ESCOs tailor a comprehensive set of measures to fit the needs of a particular customer, including energy efficiency, renewable, distributed generation, water conservation and sustainable materials and operations. The ESCO finances or arranges for long-term project financing that can come from internal resources or provided by a third-party financing company, typically a bank loan, providing a guarantee that the savings produced by the project will be sufficient to cover the cost its financing for the life of the project.

The **role of market facilitator** gains major importance when intervening within existing buildings located in historic centers, as the improvements to be carried out, renovation works and/or efficiency measures, require the agreement of different actors (complex decision making), strict requirements in terms of building retrofits, and a "never-ending story" of bureaucracies to be handled. "Middle-actors" (Janda, 2011) are essential to help in the aggregation of the buildings/clients; transactions costs, which are a major concern in the residential sector, can thus become much lower; and the investments become bankable.

The possibility of aggregating the demand or exploiting good relationships with customers has created interesting investment opportunities for ESCOs. Irrek et al., 2013, based on several examples, present two different models for the ESCO market in the residential sector: the community model and household model (Irrek, 2013). The community model presented in (Irrek, 2013) seems particularly interesting for ESCO market development in homes and buildings in the historic centers, as pooling small-scale energy efficiency projects together can make them achieve specific threshold investment levels (Pantaleo, 2014), for example the JESSICA and ELENA frameworks. The approach proposed in this paper explores both directions.

THE NEED FOR SPECTATORS

In Portugal the ESCOs model is still evolving and energy services for the residential sector are almost non-existent. A recent survey (Transparense, 2014) indicates energy services diffusion in PT requires decision makers (ESCOs, clients, banks, government) consciousness, knowledge and trust about the advantages of establishing long term contracts; and the need to create financing mechanism that join efforts from government, EU funds, commercial banks and clients to develop long term financing solutions for EES. The lack of demand for energy efficiency investments (from clients and from ESCOs) is one of the most critical missing element preventing the allocation of resources from financial institutions towards this sector.

In this context, the game is condemned to fade away: demonstrations are needed to engage actors and spectators.

Residential buildings as expanded territory for ESCOs

The renovation options for the Montarroio case study demonstrate that typical "rules of thumb" must be properly evaluated to avoid costly misconceptions: "deep" assessments, together with economic and environmental costs evaluation, are essential for good decision making. This section exemplifies relevant savings in community-scale/area-based interventions, and ESCOs, private or public, as "the" relevant actors to make this happen.

The Montarroio case study neighbourhood is depicted in Figure 5 to illustrate the multitude of energy consumption types in this close neighbourhood. For simplification purposes, a 100×50 m side white dashed rectangle, named "Inquisition bloc", is represented for scale/initial threshold: a permeable limit, expandable according to the needs, viability, collective engagement and cost effectiveness of the pursued projects.

ESCOS SCOUTING THE TERRITORY

ESCOs' role(s) include deep assessment, investigation of adequate economic/environmental calculations (Brito, 2015) and implementation proposals. ESCOs normally investigate commercial benefits based on the future income stream from the cost savings to repay the investments, organizing initial ideas that are again reviewed for optimization. The majority of these tasks cannot be pursued by individual actors like residential customers, municipalities or governments, as they require

8. (Clinch and Healy, 2003) demonstrate the common benefits of reduced mortality and morbility.

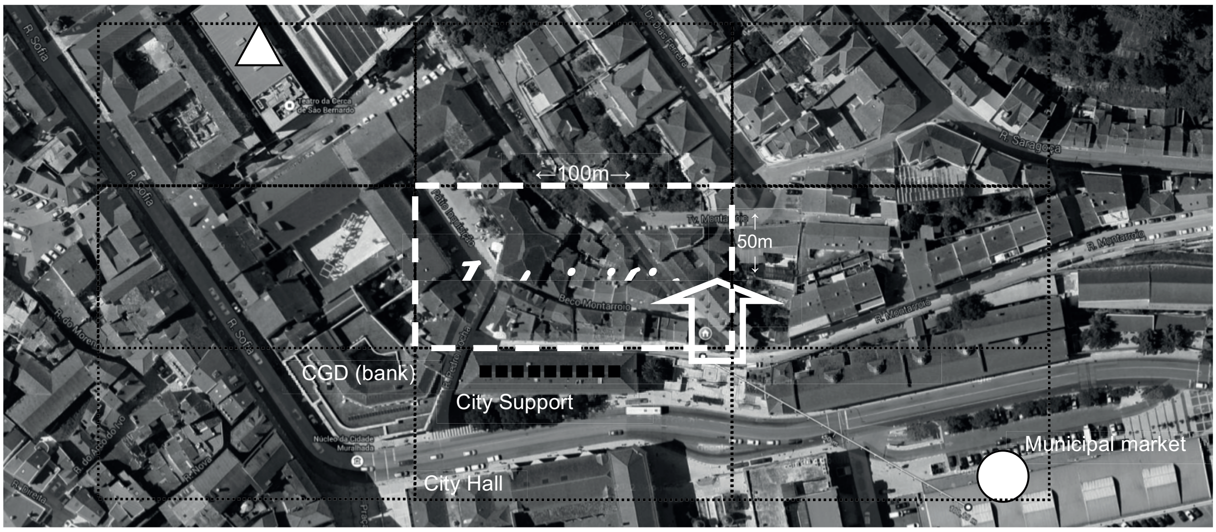

Figure 5. Montarroio neighbourhood, with the case study within a North pointing arrow. A circle, a triangle and black squares identify municipal buildings with renewable energy/efficient systems installation potential. Dashed rectangles (100×50 m side) are represented for scale (source: authors sketch over Google Maps image).

(hard to gather) interdisciplinary teams and specific "know-how directed towards the objective: the deep assessment of individual buildings is prohibitive, reaching €10,000 in this case study, but can be significantly lowered if performed in scale" (Brito, 2014a).

Informed with this preliminary knowledge, a walk-through assessment[9] **within the 100×50 m "Inquisition bloc" white dashed area** shows:

- Montarroio case study: occupation 0, potential occupation 2, one empty street level store;
- "Inquisition bloc": 47 similar (and bigger) ancient residential buildings, most under-occupied and 11 empty;
- 106 people are estimated to live in the white dashed square area, with a potential full occupation of 311;
- 21 street level stores for small businesses: 10 active, including 2 restaurants and 1 design shop;
- An old infrastructure and a jungle of wires (cable, telephone), with a recent water supply network update;
- Close-by amenities: City Hall; City Support[10] (black squares) with public services in an ancient building; Municipal market (white circle), a recent building with continuous cooling needs; Municipal Theatre (white triangle); Caixa Geral de Depósitos, national bank internationally recognized for sustainable practices.

ESCOS' PRELIMINARY STUDY FOR ENERGY EFFICIENCY SERVICES (EES)

For conceptual simplicity this preliminary study will rely **on hot water supply to final users**, both for heating and for domestic hot water (DHW). In this example the technologies will resume to individual or collective solar thermal panels[11] (st), water heat storage strategies (WHS) described in (UKERC, 2014) and air-water heat pumps (awhp) for DHW efficient production backup. Cost-effective individual systems may also recur to electric resistance heating (erh) or air-air heat pumps (aahp) electricity conversion to thermal energy.

Energy cost indicators per dwelling, area and inhabitant

To identify energy cost indicators, data from the survey on energy consumption in households (INE, I.P./DGEG, 2011, de Almeida et all, 2011) was gathered and processed in a spreadsheet, in permutations P_9^3 combining 504 possible variations on a set of nine energy sources (electricity; firewood; butane, propane, natural and piped gas; diesel heating oil; solar thermal and coal) to three energy end-uses (heating, domestic hot water and kitchen). Among these permutations, some are unlikely to occur (e.g. a household with different types of gas supply), but have been considered. The remaining energy end-uses (air cooling, electrical appliances and lighting) were not considered in these permutations, since their single energy source is electricity.

Crossing the information from Montarroio case study with Portuguese national statistics and neighbourhood interviews confirm that real local values are even lower: Montarroio is a socially unfavoured area, and fuel poverty is an issue. As the needs addressed in this study represent less than one third of the yearly cost (€99), *less than €8,25 is payed monthly per inhabitant for heating and DHW.*

Common billing strategy: "Flat-rate"

Literature and practice account for numerous barriers that hamper ESCOs' entrance in the residential sector: to the unknown baseline consumptions, expensive metering and other

9. Data recolected from a walk-through assessment carried out by one architect, 2 mechanical engineers, one eletrothecnical engineers and two social sciences investigators.

10. Building scheduled for works to enhance accessibility though the East side, near to Montarroio building.

11. Coimbra has an average of 2,730 hours of available sun over 100 W/sqm, guaranteeing for all the DHW and heating needs in the summer, and for more than 70 % in winter time: exact numbers require full design with cost-effective technologies.

Table 3. Average Yearly Energy Consumption Cost Indicator in Portugal per energy use.

Average Energy Cost Indicator Values in Euro per year		€ per dwelling	€ per sqm of dwelling	€ per inhabitant per year
Space heating	21.5 % of the energy consumption for households (INE, I.P./DGEG, 2011), using mostly electric heaters (61.2 %), followed by firewood-based air heaters (42.3 %)	170	1.00	39
Space Cooling	Small fraction of the total energy consumption for the households, 0.5 % (INE, I.P./DGEG, 2011)	19	0.18	7
Domestic Hot Water	23.5% of the energy consumption for households (INE, I.P./DGEG, 2011), the second largest energy use in the households and uses all energy sources, except coal, with gas energy sources prevalence: 78.1% (INE, I.P./DGEG, 2011)	161	1.51	60
Kitchen Equipment	39.1 % (INE, I.P./DGEG, 2011), includes stove, oven, hob, portable stoves or grillers, microwave, exhaust fan / extractor, refrigerator (with and without freezer), freezer, dishwasher, washing and drying machine (combined or split).	105	0.99	39
Lighting & Electrical Appliances	15.3 % of the energy consumption for households (INE, I.P./DGEG, 2011), including vacuum cleaner, central vacuum system, iron, ironing machine, dehumidifier, TV, radio, stereo, DVD player, computer and printer/fax machine	122	1.14	45
Other Costs	Costs included in the calculation but not assigned to any instalment, attributed to unspecified uses, taxes and supply costs (INE, I.P./DGEG, 2011)	345	3.24	128
	Total Yearly Energy Consumption Cost Indicator	922	8.06	318
	Needs addressed in this study: **space heating and domestic hot water (Total)**	**331**	**2.51**	**99**

issues, Montarroio area will also require *increased consumptions* to achieve the adequate comfort levels (BPIE, 2015).

A "Flat-rate" may be a solution: for a fixed fee the service provider guarantees full satisfaction of needs, operational costs and must make a profit; and the client uses the service seamlessly. "Flat-rate" fees for heating and DHW are common in Northern Europe, included in the rent cost, but in Southern Europe examples are rare. The contracted flow would control consumption directly, while water consumption bills and community incentives for individual/collective energy savings (Gram-Hanssen, 2010) would indirectly influence savings.

To make it more attractive, ESCOs can bundle other services: an added service for doors/windows maintenance would reduce heat losses, the size of the backup equipment, the needed heat flow and aggregated energy consumptions, while guaranteeing enhanced comfort: a true "Factor Four" strategy (Weizsacker et al., 1998).

Common anticipated advantages

ESCOs collaboration with local actors addresses the information/budget/financing gap that hampers less privileged citizens to use national and European incentives, facilitating collective engagement, procurement and funding towards effective emissions reduction. Moreover, by avoiding/organizing all exterior heat pump units and/or solar panels installation in the façades and roofs, by bundling communications to favour adhesion[12] and to remove the jungle of wires that populates the walls, collective approaches respect local regulations and UNESCO requirements, fight energy poverty, increase comfort, touristic attractiveness and local business gains.

ESCOS' STRATEGY A: MUNICIPALITY PARTNERSHIP FOR COLLECTIVE HOT WATER DISTRIBUTION

(Wade et al., 2013) propose "Local energy governance" to overcome difficulties. Coimbra's municipality engagement is assumed to combine the sewage system renovation and ICT cables removal and ducting, common in historic areas to maintain the UNESCO protected aesthetics, with a district heating (DH) network installation, a solution that favours easy transitions towards the most favourable energy sources.

In exchange for full European funding, ESCOs/city hall guarantee an attractive network connexion rate for a number of years, mass-customized "deep" renovation works, described ahead, and **a "nearly Zero Energy Building" neighbourhood** solution. If not fully funded, the remaining investment costs can be procured in the nearby "Caixa Geral de Depósitos" national bank, whose concern on sustainability and new business models make participation interesting. Beyond loans, financing through **shared ownership** would be a social, cultural and economic strategy to reduce investment costs and integrate neighbourhood in the collective system: by motivating building owners to buy some panels, receiving on return a payment relative to their specific useful solar thermal production, there would be a direct and valid will to invite neighbours into the system.

The technology mimics a collective version of option "Opt.3_st-hp" where **all solar thermal panels are placed in one public roof** (for instance the City Support building, black squares in Figure 5) and a small **district heating (DH)** solution together with large heat storage tanks (UKERC, 2014) installed. Renovation costs estimated in Table 4 reflect costs similar to Table 2,

12. Contribution from the participants in public discussion: https://groups.google.com/forum/#!topic/sextasnovitoria/QaVtkJowqyY.

Table 4. Estimated costs for strategy A, using cost estimates from Table 2 and reduced maintenance costs.

	Housing data			Strategy A				Operation Costs			
Scale	Buildings	Actual Inhabitants	Probable Inhabitants	IIC_EE. Envelope	IIC_EE. Equipments	Full funding (100 %)	Energy costs (y)	Maintenance (1.25 %/year)	Sum of yearly costs	Average cost person/month	Sum of yearly income **(Flat-rate €10)**
Inquisition bloc	47	106	200	50,269	125,843	176,111	4,323	*2,201*	6,525	2.72	24,000 €
6 similar blocs	282	600	1,200	268,100	671,160	**939,260**	25,939	*11,741*	37,680	2.62	144,000 €

reproducing cost reductions from collective installation and cost increase from DH and storage, although assuming lower maintenance costs for a single location system.

By "pooling" the "Inquisition bloc" (47) residential buildings, the increased comfort conditions would attract more inhabitants (from 106 to 200), in the magnitude of an average size hotel and a simple solution to design.

By "bundling" the (~282) residential buildings within the 300×150 m area, "6 blocs" with the service buildings, fine-tuning would ensure over 80 % renewable-based winter needs fulfilment with efficient backup, and excess summer heat managed by adsorption chillers for cold water distribution to the close-by public amenities.

End-users **added-value to join** the DH network will be **improved comfort** with **free thermal renovation works** like **insulation installation** on the top and bottom horizontal boundaries and **windows maintenance**[13] (Brito, 2015) for a flat-rate of €10 per user for the duration of the contract, with a defined "loyalty period". For engaging users, community-related middle-actors (Janda, 2013) like the "Association for the Promotion of Coimbra Downtown" (http://ez-city.com/#/inicio/) can play a relevant role in bridging with local community.

Advantages from the community cooperation range from facilitated contracting and reduced maintenance costs, while the main risks reside on initial funding and the *absence of any of the involved stakeholders*.

ESCOS' STRATEGY B: ACTING AS EXCESS OFF-PEAK RENEWABLE THERMAL STORAGE AGGREGATORS

This business model assumes ESCOs partnership with utilities to provide a service for individual household **off-peak hot water storage** (HWS) using the surplus of electricity in the night period from wind based renewable energy, often used for water dam pumping or sometimes exported abroad, or even electricity produced during off-peak nuclear power plants. Like in strategy A, ESCOs' role is to make the project cost-effective and achieve collective emission reductions goals. All strategies, stakeholders, community involvement and end-user added-values are similar, although with adapted roles, for the same flat-rate of €10.

End-users' added-value to join the HWS will be improved comfort and free thermal renovation works in the exterior horizontal boundaries and windows maintenance, in the same conditions as in Strategy A. The technical solution would rely on "green electricity" for household off-peak hot water storage (UKERC, 2014).

According to the household type and thermal needs, ~182 simple electric water deposit [(~282–100)×€350] and ~100 air-water heat pumps [(~282–182)×€1,500] would be installed for free, with a full solution costing about €250,000. Funding would cover most of the investment, while monthly returns (1,200 inhabitants×10) would pay for off-peak energy (and residual peak) energy consumption, maintenance, system control and generate a profit.

Advantages derive from the reduced costs, while the main risks reside on electric network dependence, low wind in off-peak hours, energy price volatility and the space occupied in each household.

ESCOS' STRATEGY A+B: THE VALUE OF MAKING THINGS HAPPEN

The best strategy, however, would be the third: to combine A and B using a solar thermal based district heating system with off-peak backup, together with household storage where network extension was unviable or include archaeological risks. Moreover, this approach gives ESCOs an edge, a negotiation power to make things happen: implementing strategy B without city involvement would lock-in other solutions until the contracts terminate.

In both strategies, in both scales, how to financially account for the **significant emissions reduction**, historical centre **image preservation**, improved comfort and **increased attractiveness** of an area that favours public transportation use, has all the infrastructures and amenities (Brito & Gameiro da Silva, 2012), and requires people to keep alive? What would be the return of investment in taxes, and from energy import reductions?

Historic centres as "double negative" locations: can too many "No's" become a "Yes"?

The "Old man from Restelo" episode from "Lusíadas", epic poem by Luís Vaz de Camões (1524?–1580), who studied in Coimbra, is a hero story (Janda and Topouzi, 2013) to the thrill and discomfort that marks each leap into the unknown. The scene is a seaside at Restelo, Lisboa by the 8th of July 1497, where a fleet was ready to sail towards the unknown. (Mickle, 1877) provides the historical context (p. lxvii) and a translation (p. 130):

13. This solution requires local handymen engagement, workers that will be the face of the system.

Now, on the lofty decks, prepar'd, we stand,
When, tow'ring o'er the crowd that veil'd the strand,
A reverend figure fix'd each wond'ring eye,
And, beck'ning thrice, he wav'd his hand on high,
And thrice his hoary curls he sternly shook,
While grief and anger mingled in his look;
Then, to its height his falt'ring voice he rear'd,
And through the fleet these awful words were heard:
O frantic thirst of honour and of fame,
The crowd's blind tribute, a fallacious name;
What stings, what plagues, what secret scourges curs'd,
Torment those bosoms where thy pride is nurs'd!
What dangers threaten, and what deaths destroy
The hapless youth, whom thy vain gleams decoy!

The text refers, with respect, a "reverend man" that is further characterized in the original text as beholder of knowledge made of experience. It symbolizes, without disdain, a built-in pessimism – or adequate caution – that every Decision-Maker (DM) feels prior to decision. Nevertheless, that fleet was no blind leap: investigation, consultation, preparation and investment anticipated the uncomfortable moment: four boats with 160 persons departed to India and, 26 months later, two boats returned, carrying only 55 aboard: a failure?

Without that leap, and others contrary to the "viability studies" of their time, things would not be the same today.

F(ACTS)

A paper from (Martins et al., 1998) "provides a general perspective of the problems associated with planning activities in historical centres", and concludes a methodological approach to a mid-term energy plan with a proposal for the historical centre of Coimbra, the same location of this study. Beyond its own value as a methodology with a prospective view, this "mid-term plan" is only one of many studies that, 20 years after their conception, were not implemented. Known reasons include the usual suspects – financing, political inaction, unwritten barriers, amongst others – but also a crowd of apathetic people and "Old men/women from Restelo".

Currently the lack of alternatives allows public decision makers to postpone for more than 20 years the implementation of mid-term plans and actions: the public sector has low capacity to launch and supervise ESCOs contracts, but there is also no exterior pressure for change. By promoting alternatives like Strategy B, and corresponding "lock-in" effect, a drive for change occurs.

This paper demonstrates that, individually, residential owners might not have advantages in renovating towards emissions reduction even with European funding. Moreover "business as usual" proposed "deep renovations" (Opt.1_erh/hp) can be less cost-effective/environmentally friendly than solutions that a "deep assessment" is able to reveal (Opt.0_hp; Opt.3_st-erh), only visible by multidisciplinary teams assessment.

Experience demonstrates that, against all odds and all team players – including our own –, "Supply side" or "Demand side" measures can dribble alone towards the 75 % emissions reduction goals, but what are the risks, transversal costs and collateral damages from solitary actions?

An effort to assume the potentials/risks is necessary, across all sensibilities, to transition from the competition between the "best" strategy to the **coopetition**[14] (alliance of parties) towards collective solidarity and resilience.

F(ACTORS)

What "factors" and "actors" can team literature and practice onto effective interventions? The choice of words goes beyond an easy mnemonic: "factors" and "actors" are intertwined contexts and agents that contribute to produce or influence a result: one of the terms requires the other to occur.

ESCOs are actors that can play a role in the "scaling-up" process, either by aggregating individual users into collective purchase and maintenance contracts, either by pooling and bundling buildings into collective solutions. Although most of the concepts and strategies are logic and some proven, results fail to appear in scale.

ESCOs role as "middle-actors" can factor "top-down" solutions (funding, long term policies, utilities practices) with the "bottom-up" requirements as increased comfort and simplified engagement into cohesive renovations of historical centres. Community level enrolment overcomes the issue that only informed and financially capable inhabitants are able to access the funding available for energy efficiency measures.

A "Flat-rate" service that includes hot water supply and energy-related effective renovations –minimal and mass-customized to reduce costs– alongside with regular maintenance and collective participation can transform a currently abandoned area into an attractive community, supplying additional comfort and democratizing the individual potential to become "greener": pride can be reinstated.

Challenges remain. The (EED 2012) signs the way when bundling energy efficiency related legislation into one Directive, pointing that all energy vectors are connected; Table 3 clarifies that the issues addressed in this paper, heating and domestic hot water, correspond to only one third of the total energy consumptions. If results are to occur, ESCO projects must be entitled to privileged funding: more money for more (and) inclusive service.

Historical city centres, and all the ancient buildings in unprotected locations, are a fleet that cannot sail towards the "unknown". Although investigation, consultation and preparation anticipates the departure, only a crowd of "Old men/women from Restelo" appear: can ESCOs be the new crews, or will that fleet rot within our sight?

14. The equation "energy cost = (energy use – energy savings) x energy price" is a subtle example: "Cost" can be maintained or reduced if "price" growth, a supply side expectation, is counter-balanced by effective energy "savings", a demand side measure.

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