Improving the (energy) performance of (historic) buildings and communities: towards "neighbourhood Energy Performance Certification" (nEPC)

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Abstract – Energy Performance Certificates (EPCs), a "one size fits all" comparison initially designed to know more about European buildings, suddenly became a prescriptive energy efficiency strategy/funding metric and a "shadow" European Norm. To favour European buildings' comparability centuries of local empiric knowledge are ignored towards "linear cycle" strategies (adding materials, trashing/replacing equipment, …) that only deliver costs, letters, and virtual energy savings. As mandatory "minimum energy performance standards" are proposed, are EPCs the solution? Or the source for social unrest/disbelief fuelled by populist stakeholders? Acknowledging that every existing community has a history, specific needs and expectations, diverse buildings and people, this paper proposes that effective results require collective engagement. Neighbourhood scale EPCs—framed with/within the communities, scales (*micro, meso, macro*) and commitments they are part of—can be matched with 21st-century strategies/technologies to deliver what the EU needs: real decarbonization, energy security/poverty prevention, resilience, and a circular economy—with engaged citizens.

Keywords – Historic buildings; Neighbourhoods; Energy Efficiency; Decarbonization; Circular Economy

1. INTRODUCTION

"*At the current pace, the decarbonisation of the building sector would require centuries. (…) Numerous barriers stand in the way of higher renovation rates.*" [1].

Collective problems cannot be solved individually, yet the European Union (EU) residential building decarbonization strategies favour individualism: from EU members' Directive transposition to home-by-home Energy Performance Certificates (EPCs), improvement measures, advice, financing, and local aid, almost all are processed and measured individually. This bureaucratic individualism imposes excessive costs, unneeded worries, reduced negotiation capacity and millions of European citizens' wasted hours while scattering the scale needed for robust circular business opportunities.

To illustrate 20 years of EPCs' failure "Introduction" exposes the oversimplified residential "science" that delivers fragmented practices/virtual results. "Arguments for neighbourhood scale approaches" identifies the advantages of tackling existing/historic buildings with(in) their background, constructive solutions and problems—well beyond energy— using 21st-century strategies. "Discussion" will focus on the challenges to include users and multidisciplinary teams—from programmers to experienced craftsmen—in the quest for contemporary ways to optimize the past, tackle neighbourhood scale issues, and mass customization to deliver more value with the same investment. "Conclusion" will propose "neighbourhood (Energy) Performance Certification" (nEPC) as local strategies to identify, validate and intertwine Traditional Knowledge with progressive decarbonization, towards the future we anticipate in the European 2050 long-term strategy [2].

1.1 ENERGY PERFORMANCE CERTIFICATION: 20 YEARS OF SELF-RECURRING SIMPLIFICATIONS

The Energy Performance Certificates (EPCs), designed back in 2002 “for consumers to compare and assess the energy performance of the building” [4, p. L1/68] opted for a division between large-scale office/service buildings (over 1000sqm) and residential buildings/small service buildings. This division assumed that only large stakeholders could afford the teams/ calculation capacity required to accompany the evolving science and legislation, dispatching residential buildings with a simplified version. In the Portuguese residential EPCs this residential certification process assumes, for all households—ancient, contemporary, or innovative experiments—many simplifications:

- Number of users defined by “number of rooms +1”: if someone can sleep there (9sqm and a window), then this room, even if not used as such, defines the water consumption baseline.
- all these virtual users are always at home spending energy, and ubiquitously at work too: if one office/school building assumes their virtual presence, they are also there from “9 to 5”.
- households are considered as fully heated/cooled 24h/365 days while assuming that users will not adequately act to improve their comfort by correctly operating windows/shades.
- Energy consumption beyond acclimatization and domestic hot water is averaged nationally.
- Overall values divided by floor area: a family living in a small historic house with lower energy consumption often gets worst EPCs letters than equivalent families in new suburban houses.
- “Energy Efficiency Measures” (EEMs) are calculated from these overestimated consumptions while excluding maintenance costs. A state-sanctioned document induces its “clients” in error by publicizing a “payback” that does not include significant annual maintenance costs.
- only these EEMs are considered for financial support, and only replacement (linear cycle) is supported, with maintenance or improvement (circularity) strictly excluded from financing.

Relying on assumptions instead of consumptions means that a better certification letter does not reflect lower carbon emissions. In two identical homes with 2 bedrooms the use patterns vary for a retired widow or a young family of 5, and so do the risks of technology. Nevertheless, similar prescriptive “improvement measures” are mandatorily proposed for similar home typologies.

1.2 EXPOSING THE IMPACTS OF THE ENERGY PERFORMANCE CERTIFICATION (EPC) LINEAR WORKFLOWS

The current EPC approach is a linear workflow, in process and results. Tackling each fraction of a building individually, requiring one EPC expert visit as it is sold/rented/rehabilitated induces excessive travels, hampers contextual approaches, and makes collective learning impossible. In almost 20 years EPCs evolved from comparing ancient buildings with new ones (comparing “apples to oranges”) to a strategy proposing orange’s peel and pith to better “protect” apples. The 2021 Revision of the EPBD [1] now proposes a “*phased introduction of mandatory minimum energy performance standards (…), and to extend progressively the requirements to other buildings*”, an alias for a "shadow"-standard proposing all apples to look like oranges. Are these prescriptive and mostly imported fossil-energy-based solutions the only way forward? Will investment in insulation plastics, leaky greenhouse gas emissions heat pumps, rare earth renewable energy sources, new suburban “green” Nearly Zero Energy buildings, high embodied energy electric cars, … cut European emissions? Will displacing our emissions to less “climate-engaged” countries solve our worldwide problem?

Figure 1 illustrates a map of EPCs issued for 25 residential buildings around the Montarroio case study within a universe of 76 buildings in the image. Between 2012-22 only one-third (25 in 76) were certified by 13 different experts on different dates. Assuming an average EPC cost of 400€ per building with 3 floors (all taxes included), and around 10 km drive per visit implies that certifying 25 buildings

twice (initial buy and after renovation) cost around 20.000€ and imposed 500km drive inside Coimbra. By regulatory imposition 13 experts, including the author, visited the area. Were they there, and aware of where they were? Searching for "Montarroio" in the EPCs portal [3] five decades old abandoned references to "Eastern"/"Western" streets of Montarroio, and an EPC for an inexistent "1st floor left" in the building this author owns. In short, an absolute absence of context.

The letters in Figure 1 represent the worst performing fraction of most buildings after renovation: an excessive cost for those results. The prescriptive improvement measures follow the European guidelines of exterior/interior insulation and double-glazing windows that would alter the image, thus mostly discarded in this UNESCO protection area. The proposed and/or applied measures are not available in the EPCs´ portal [3], yet Figure 1 shows no solar panels although regulations allow "5 % of total roof area (…) up to 3sqm", while forbidding heat-pump evaporators even if disguised [4].

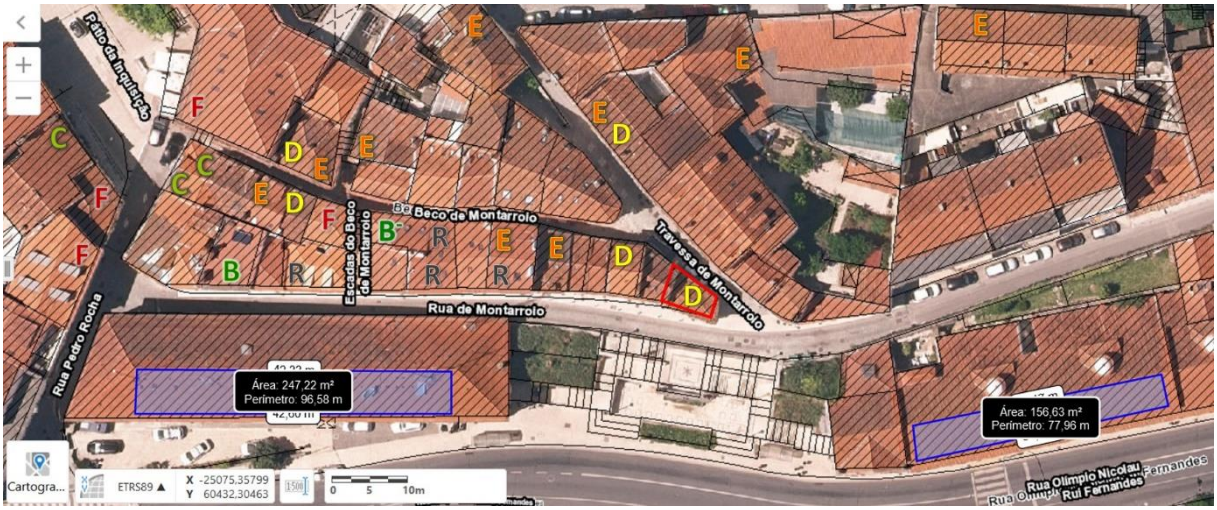

Figure 1: Energy Performance Certification (EPC) of Montarroio case study, boxed in red, and neighbourhood. In 10 years of EPC, only 33% were certified and none of the "rehabilitated" residential buildings includes solar panels, although allowed up to 3sqm. Source: author sketches over GIS [4] and Google maps.

Although the Montarroio Case Study leaflet [5] demonstrates that most prescriptive EE measures are inadequate for historic areas, there is no incentive for these 13 EPCs "Qualified Experts" to enforce scale and reduce installation/maintenance costs, nor to use the municipal roof space (in blue rectangles) for safe/aesthetic renewable energy installations, making use of the great potential in neighbourhood scale approaches [6]. In short, individualist approaches residential buildings increase technological risks, operation and maintenance costs— as more time is spent in scattered travels than in specialized work—, and lower owners' negotiation capacity. And all this individualism postpones community-scale approaches, able to solve local issues, hampers attractive win-win circular economy business opportunities, maintenance habits and local green jobs.

2. ARGUMENTS FOR NEIGHBORHOOD SCALE APPROACHES

Many historic buildings and neighbourhoods (HB&N) managed centuries of versatility and resilience with low energy needs by applying Traditional Knowledge [7]. When energy was expensive the use, reuse, and recycling of local materials, together with an investment in good construction and shared practices ensured negligible energy needs, and lower construction and operational costs. Together with their users, historic buildings and neighbourhoods (HB&N) already portray centuries of alignment with the New European Bauhaus [8] and Circular Economy goals.

The higher availability/lower cost of (fossil) energy sources favoured new contexts when Climate Change was not an issue, and nuclear promised never-ending energy. New constructive processes, uses for energy and forms of living evolved from high-embodied energy materials and linear cycle approaches, promoting urban sprawl and globalization. At that time reducing the exterior wall thickness favoured more interior space, decreased the use of materials/transportation, lowered construction costs and promoted higher urban density. At that time, it was the obvious strategy.

The recent awareness of collective environmental, economic, social and cultural objections to the contemporary *status quo* make space for renewed approaches to residential buildings. A 5W approach will guide the arguments for neighbourhood-scale approaches.

2.1 WHY ARE NEIGHBORHOOD RESIDENTIAL EPCS INTERESTING AND/OR FEASIBLE?

Individual residential EPCs are often oversimplified views (see 1.1) of individual homes: complex events are averaged to deliver streamlined economic "one size fits all" solutions, as detailed characterization would render individual EPC costs prohibitive. Air renovation rates, assumed as constant, are a useful example: prescriptive "air engines"—natural as stack effect or mechanically induced—"promise" indoor air quality 24 hours per day for a defined number of users, present or not. This "steady state" does not identify, nor react to, absence, a family party or simple failure.

Large service buildings use software like Energyplus [9] and WUFI [10] to identify scenarios and sensors/actuators —meteorological stations, CO2 sensors, fans, filters, and heat recovery systems— to retrieve information and deliver dynamic comfort/safety while reducing emissions and bills. These would be too expensive in individual residential buildings, but at a neighbourhood scale a shared meteorological station, IoT sensors and actuators would deliver more comfort, safety and lower bills. Are there valid reasons to keep the current "individual residential EPCs" strategy?

Table 1 proposes a SWOT analysis based on information retrieved from the Montarroio area (1.2), a rising commercial-pressure historic area with renovation rates of 33%. In 20 years of EPBD (2002-2022) most certified buildings are those sold and renovated/under renovation, while the other two-thirds have no information. Can local governments act with no/inadequate information?

Table 1: SWOT analysis of the current European RESIDENTIAL Energy Performance Certificates strategy (PT)

Strengths	**Opportunities**
EPCs being issued daily for each rented/sold fraction 20 years of data (of varying assumptions and quality) Recognized (mandatory) document	EPCs require improvement and conceptual updates Growth: 66% out-of-market fractions uncertified To become more than a legal obligation/paper
Weaknesses	**Threats**
Low coverage rates: 33%, only when mandatory! Expensive & inefficient linear cycle approaches (1.2) EPCs are individual snapshots, not collective *loci* views Residential emissions stable since 1990 [11] Virtual EPC letters are useless for real investments	Virtual letters instead of real consumptions decouple investments from real savings/ability to react to risks Excessive dependence on imported products/parts "*lack of trust in the energy savings that renovation will achieve*" [1], and risk of social unrest if imposed;

There is space for improving the EPBD with 21st-century IoT low-cost approaches, to scale up lower carbon emissions neighbourhood by neighbourhood, and to extend value well beyond energy. Can it be done by making use of the already existing strategies and institutions?

2.2 "WHAT" & "WHEN": URBAN BUILDING ENERGY MODELLING (UBEM)

"Neighbourhood" EPCs are possible in EPBD [1] for repetitive multifamily residential fractions. Extrapolation to historic neighbourhoods can integrate constructive traditions, collective needs, and much more. Documenting complementarity, "pooling" and "bundling", is essential for "Alternative financing schemes for energy efficiency in buildings" [12]. UBEM uses representative buildings and their consumptions as archetypes for "bottom-up urban building energy models (UBEM)" [13], but the detail is needed to match low-exergy solutions with "the density and diversity of loads in urban systems" [14]. The legal frameworks, technologies and software are already available now, but only numeric parameters depict people and communities. Will humans (users, owners, communities, decision-makers, …) mobilize to change only with "spreadsheet" approaches?

2.3 WHO? ONBOARDING, NEIGHBOURHOOD BY NEIGHBOURHOOD

Innovation is often confused with a *tabula rasa*, yet its Latin etymology, *innovare*, points to 'renewed, altered' [15], a "re-usage" approach familiar to those who understand historic buildings. Continuity with evolution, including humans, will render more probability of success. Owners/renters would appreciate an EPC for a lower/no cost as long as "Minimum Energy Performance Standards" (MEPS)/aka mandatory "improvements" do not become a risk. Local communities' participation can deliver more than decarbonization, as change must be attractive to many. Business decision-makers need real information and a generic direction to better plan their future, and validate potential investments, as economical sustainability matters. And (local) governments need the information to prioritize investments to reach the 2030/50 goals. A "win-win" for all stakeholders?

2.4 HOW? A HUMAN ROLE IN DIGITAL TECHNOLOGIES

One home cannot afford multidisciplinary teams, but a neighbourhood can. Yet participatory processes often forget that most people cannot read architectural plans/cuts or understand the sustainability value of "shaving peak loads" by authorizing demand-side load control. Collective debates require context to make conversations attractive, and here digital technologies have great potential. Matching visually attractive illustrations of building physics (Figure 2) with 3D printed models and the knowledge of those who use spaces enhances proposals and ensures awareness of their advantages and limitations, essential for better use and future optimization.

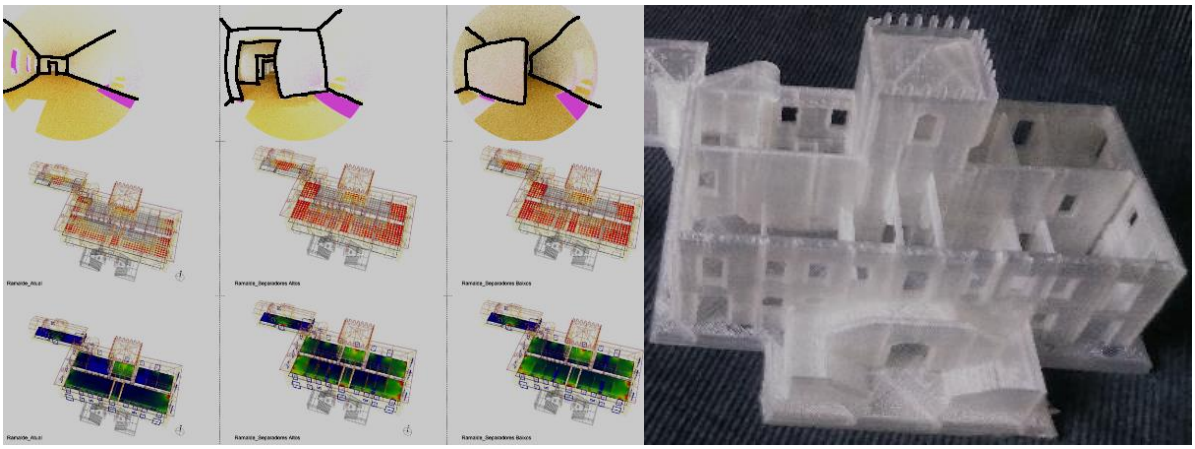

Figure 2: "Hardcore" building physics made simple. The columns to the left depict a graphic comparison of lighting parameters in the original open space (left), and for partition alternatives: complete (middle) and partial (right). Aligned with a 3D printed model and some explanations, graphical comparisons facilitate collective debate/experimentation with building users (Source: author, from data retrieved at DRCN)

Aligning graphic representations of the original with alternatives (Figure 2) allows untrained users to visualize change in parameters, whatever they are; while 3D prints facilitate a "birds-eye" view that triggers new thoughts and proposed actions with bits of paper: a "hands-on" debate.

In neighbourhoods, these "graphic approaches" can build upon EN16883 on "Guidelines for improving the energy performance of historic buildings" [16] to organise neighbourhood context. Using EN16883 for neighbourhood scale enforcement of good practices—from participatory diagnosis and digital approaches to optimization—can deliver new strategies to the *"decarbonisation of the building sector"* [1]. Yet this European Norm, a paid "paper" document, must become a free digital process, optimized to embrace contributions by all (local) stakeholders.

3. DISCUSSION: FROM EEHB TO DECARBONIZED HISTORIC NEIGHBORHOODS

Assuming buildings as an energy problem is a problem in itself, as "Buildings don't use energy: people do" [17]. Although the Energy Performance of Buildings Directive (EPBD) in revision [7] is a subsidiary of other higher-level European commitments, it is not clear how its goals, objectives, and performance indicators will align with global intents. As the "New European Bauhaus" [8] strives to reduce emissions by at least 55% by 2030 in desirable pathways (Energy Transition / Security, Circular Economy, …) within a "beautiful|sustainable|together" [8] path, improvement is possible.

The "European Cultural Heritage Green Paper**"** [18] illustrates the potential, scope and diversity of inputs that cultural heritage has to contribute to European commitments. Can a sector that traditionally focused on heritage landmarks now help (historic) buildings users and the communities they define? Can digital technologies already common in new construction/deep renovation overcome the resistance in heritage professionals that advocate all interventions in historic buildings as handcraft? Although nothing can replace the knowledge of artisans and heritage experts, technology can reduce costs by providing more and better information, reducing unplanned travels, optimizing repetitive tasks, accelerating delivery, and fostering a carbon-efficient operation.

Historic buildings and neighbourhoods (HB&N) were originally designed mostly in the way the 2050 goals of decarbonization/circularity are now aiming for. Adjustments—to buildings and ways of use—are necessary to fit current/future energy sources, increased density and comfort standards. Opportunities exist at the core of New European Bauhaus policies to match the EPBD with the Green Deal, Circular Economy, and citizen engagement efforts. From start to optimization, neighbourhood-scale streamlined processes liberate time/resources while matching global/local expectations. Better results for more people with smaller costs—economic and environmental—are possible by:

- evolving EN16883 to address neighbourhoods and digital approaches. Upgrading this norm into a "digital template" for (historic) neighbourhoods would guide most European municipalities into cooperative approaches, facilitate the work of project teams and favour traceability and measurable results, key factors for learning curves and optimization.
- matching low and high-detail digitalization at the neighbourhood scale to ensure that the "levels-of detail" depicts the needs/expectations of neighbourhoods well beyond energy and decarbonization. Health, quality of life and community engagement really make the difference.
- training interdisciplinary teams for applied investigation/practice to streamline replicable solutions—from design to better use— to optimize the value of community scale.
- Tackling energy (efficiency, sufficiency, action,…) [19] as addictive: aiming for energy sobriety?

- making use of Artificial Intelligence to better match centuries of tangible and intangible Traditional Knowledge with the complexity of new technologies, and the people using them.
- engaging with pilot communities/municipalities/industry to solve the "last mile": transforming an uninteresting "Business-to-consumer" market into attractive decarbonization strategies.

Neighbourhoods will only join if solutions solve local problems, enhance their resilience—not their dependence—and foster new perspectives. Matching our common 2050 goals with local community needs while engaging younger generations can deliver the missing diversity and scale.

4. CONCLUSION

"Europe needs results, not nice EPC letters. And Historic Buildings can help deliver." [20]

In the name of "Energy Efficiency", existing European buildings (historic, traditional, post-war, contemporary and those yet to be built) were framed by "one solution fits all" comparisons enforced by the Energy Performance Certificates (EPCs). This instrument, initially designed to know more about European buildings, became a "shadow" European Norm aiming to replace centuries of empiric knowledge, and future innovation, with reminiscences of 20th century "linear cycle past" characterized by the addition of materials and efficient equipment; and assumedly failed [1].

Aiming for a "performance" oriented future, Energy Performance Certificates (EPCs) imposed unified solutions to diverse buildings/communities while dismissing decades of neighbourhood adaptations and centuries of empirical knowledge, also known as culture. By tackling one household at a time, by proposing high-embodied energy "solutions", and by sourcing materials and/or equipment from outside Europe, EPCs are displacing European carbon emissions (and investment capacity) to less "climate-engaged" countries, delivering virtual letters instead of measurable results.

The Energy Efficiency in Historic Buildings (and Neighbourhoods) (EEHBn) must evolve from a niche to a leading stream. To acknowledge that all existing neighbourhoods, historic or not, have a history that makes them like they are, and not something else, is to admit that the EEHB community can influence over 98% of European neighbourhoods: the other 2% are still under construction.

As "Energy Efficiency" cannot be a goal "in itself", neighbourhood Energy Performance Certification (nEPC) strategies offer the scale and diversity to match interdisciplinary teams with local communities towards attractive decarbonised neighbourhoods. Matching the respect for buildings' history and their communities with 21st-century digital approaches can deliver what the EU needs: 2050 decarbonization, energy security, resilience, and a circular economy—with engaged citizens.

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