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The Energy Justice Tool Suite: an interdisciplinary and comprehensive method for energy transition territorialization

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Abstract: Within a French context of Energy Transition, the “Energy Justice Tool Suite” project aims at designing, experimenting and optimizing what we call an interdisciplinary and a comprehensive “tool suite” dedicated to energy justice. At the urban, technical and socio-economic levels, the idea is to design a “tool suite” to characterize, assess, evaluate and co-construct an inclusive energy and socio-territorial justice - with the actors of these territories. This research is based on an interdisciplinary approach, combining engineering sciences with social and spatial sciences, in order to co-construct an inclusive territorialization of energy transition, leading to energy justice. For this purpose, the “Energy Justice Tool Suite” project aims at designing, not buildings archetypes, but multiscale energy complex systems archetypes: physical phenomena to design the energy poverty assessment model at the block scale, and human behaviour, within an empowering perspective, through the animation of learning workshops. This experiment will be conducted on two fields of observation: Grenoble-Alpes Métropole and the region of Compiègne, to establish a transect of energy poverty situations. The “Energy Justice Tool Suite” project also aims at designing, experimenting and optimizing a transversal tool to aid decision making and a tool to aid consultation making for energy and socio-territorial multiscale justice.

Keywords: energy transition, energy poverty, energy justice, decision support tool

Introduction

In the French context of the energy transition, fuel poverty demonstrates the existence of deadlocks and impasses, linked to the implementation of the transition, through territorialized public policies, but also linked to the non-adherence of the users or prescribers concerned. Indeed, the fight against fuel poverty involves multifactorial responses between different actors: households, owners, energy suppliers, public actors, specifiers and professionals in the field of thermal building renovation. Often these tensions are posed in a compartmentalized way: either through technology, public action or participation, and in a normative way by neglecting the constraints of past energy and economic choices (incentives to change without understanding how it came to be). At the urban, technical and socio-economic levels, one of the

challenges is to design with the actors of these territories a "set of tools" to characterize, evaluate and co-construct a more effective fight against fuel poverty, with the objective of energy transition.

Our research is based on an interdisciplinary approach, combining space sciences, social sciences and engineering sciences, in order to co-construct an inclusive territorialisation of the energy transition, which will bring about energy justice. We are working on two areas of observation and experimentation: Grenoble-Alpes Métropole and the region of Compiègne, France.

This article aims to present the French context of the territorialisation of energy action, the scientific, technical and socio-economic challenges of the fight against fuel poverty linked to housing, the methodology that the project team wishes to set up and test on two complementary fields of study. The objective of this article is to submit to scientific discussion a methodology for characterizing, writing, evaluating and co-constructing an inclusive energy and socio-territorial justice - with the actors of these territories, through the creation of tools to support the energy transition.

The territorialisation of energy action in the French context

The French energy sector has long been organised around a dominant player, EDF (électricité de France) and centralised production based on nuclear energy. However, this configuration is the result of a historical process that ignores the long-standing presence of cooperative forms in this sector (Artis *et al.* 2017). These characteristics have marked the energy market in France: energy pricing is highly regulated by the public actor; access to energy has long been inexpensive due to subsidised nuclear production. Nevertheless, since then, the landscape has changed somewhat; it has even changed incredibly and become more complicated as part of the construction of the European market. Indeed, the European construction has led to a transformation of the organisation of the energy sector. Today, the energy sector is composed of competitive activities (e.g. customer supply) and regulated activities (transmission and distribution of energy), which has also transformed the price of energy for the consumer. Although the production of a quasi-public service persists in the sense that there is an obligation to provide and connect to public infrastructure, the competitive tendering process has transformed the competitive logic of the players, by developing specific offers (in particular for green offers).

Today, the new configuration of the energy landscape is radically different from the old one. It is characterized by:

- - the multiplicity of actors: public companies, private companies, production and/or distribution cooperatives, management companies, village power plants under various statuses, investors, local authorities, private individuals and producers... and, of course, always the States and Europe; with local and national actors;
- - the multiplicity of possible technical solutions, and in particular the development of renewable energy production;
- - the complexity of the socio-political regulation to be put in place, from national regulatory authorities to the conciliation of projects in the same municipality (with or without municipal control), and not forgetting to reduce fuel poverty (in the North and South), or even areas where there is no connection or supply (in the South) (Artis, 2017).

As a result, several points of tension that were erased in administered energy regulation in the post-war years are emerging. These points of tension are related to the multiscalar entanglement of decision-making

locations, competitive logics between operators and the injunction to a cleaner and more sober energy. These tensions are reflected in the implementation of macroeconomic policies at the territorial level.

Following the Kyoto Protocol, France has committed itself to reduce its greenhouse gas emissions by a factor of 4 (MEDDE, 2013). To meet this commitment, the French government has put in place legislative and regulatory measures to ensure that all local and regional authorities take action to reduce greenhouse gas emissions (Chanard, 2011, Chanard *et al.* 2011). This territorialization of energy action (Bertrand and Rocher, 2011, Chanard, 2011, Godinot, 2011, Theys and Vidalenc, 2011, Bertrand and Richard, 2014, Durand *et al.*, 2015, Poupeau, 2016) must be based on quantified objectives (Godinot, 2011) and global territorial action at three levels of public intervention: the exemplarity of its heritage and services, public policies and awareness (Chanard et al., 2011); as well as scenarios for energy transition in cities, linking actors, regulations and technologies (Debizet and Dupuy, 2015).

However, at the local level, to fight against this fuel poverty (Guyet, 2015), which would affect nearly 6 millions people in France (ONPE, 2017), we observe that territorial public action is facing difficulties in setting up:

- - because of the difficulty of working on the real energy efficiency of urban forms at the scale of a city - and not just a building (Maïza, 2007, Arantes *et al*., 2016),
- - and because of the difficulty of reporting on fuel poverty, on a small scale, through indicators and criteria (Devaliere and Teissier, 2014, Charlier *et al*., 2015, Thomson *et al.*, 2017).

Fuel poverty and its interdisciplinary modelling

Through its socio-economic and ecological challenges, the issue of fuel poverty is now an important element of the social question because it brings together residential and individual (Fijalkow, 2013, Deffobis, 2015), biographical and social forms of vulnerability with issues of access to resources and the distribution of wealth and sustainable development (Griggs *et al*, 2017), reinforced by a need for "ecological empowerment" in the territories. All these challenges involve the public authorities and institutions in charge of implementing the public policies planned in this regard. It requires their decompartmentalization and permanent monitoring, necessary for their readjustment over time.

In a way, we can think that the question of fuel poverty and its counterpart in energy justice (Guyet, 2015) are today a perfect expression of the challenges that will structure the future of our societies because it already questions the forms of governance at the territorial level, the role of institutional actors, companies prescribing solutions, and ordinary citizen-users (Heffron and McCauley, 2017 Jenkins *et al.*, 2016). Responding in an equitable and inclusive manner (Clément and Valegeas, 2017) to the challenge of fuel poverty, "for a just transition" (Lavelle, 2015) becomes a major focus of tomorrow's policies at both global and local levels. These new policies must integrate social issues into decision-making, planning and implementation practices (in the sense of technicality), and be accompanied by the large-scale social pedagogies needed to activate the collaborative capital of users - and in particular users identified as "vulnerable" (Lees, 2014, Lees, 2016).

Beyond this obvious vulnerability, fuel poverty remains difficult to quantify, on a small scale, by indicators and criteria (Devaliere and Teissier, 2014, Charlier *et al*., 2015, Thomson *et al*., 2017) - and consequently, to support (Guyet, 2015).

The thermal quality of a building and the low income of its occupants are two of the three interrelated factors that lead to a household's fuel poverty (Devalière, 2007, Réseau RAPPEL, 2011, Charlier *et al.,* 2015). Indeed, excessive energy consumption, linked to poor housing insulation, will be all the more harmful if the people concerned have modest incomes. In some cases, poor housing insulation therefore increases the risk of fuel poverty. On the other hand, the thermal renovation of buildings, by reducing the energy consumption of residents, while maintaining - or even increasing - the quality of the "energy services" they receive, is an effective means of combating climate change (Dubois, 2007). It is therefore important to target as a priority geographical areas with homogeneous areas of high energy loss, as well as a high percentage of vulnerable people (Devaliere, 2008, Henriot and Molines, 2016, Molines and Henriot, 2017a, Molines and Henriot, 2017b, Molines and Henriot, 2019). It will also be necessary to set up appropriate awareness and information campaigns targeting all the actors concerned (inhabitants, owners, landlords, craftsmen, etc.). Indeed, improving the energy efficiency of built stock leads to the implementation of new practices, new materials and new financial aid that must be supported in order to make them more efficient and limit their drift.

On the other hand, as they do not themselves own the properties to be rehabilitated, local authorities have a heavy task of raising awareness and consulting with all stakeholders: inhabitants, donors, craftsmen (Bertrand and Rocher, 2011, Chanard, 2011, Godinot, 2011, Theys and Vidalenc, 2011, Poupeau, 2013, Bertrand and Richard, 2014). In this consultation work, it should be noted that serious games have proven their effectiveness in concerted projects (Poplin, 2011). Serious games are also found in urban programming projects (Molines *et al.,* 2018) and in projects to raise awareness of the energy transition (e.g. "islands of the future", "SIMU renov" or "Electricity 2050").

The modelling of energy losses offers concrete quantitative support to assist cities in their decision-making (Caputo et al., 2013). It is generally carried out at two different scales: the building scale on the one hand, and the neighbourhood or city scale on the other.

Building scale modelling is a well-developed field in the scientific literature and many calculation methods and tools are available: TRNSYS (Beckman et al., 1994), Energyplus (Crawley *et al.,* 2001), Pleiades-Comfie (Peuportier *et al.,* 1990). It is based on physical, empirical or statistical data (or a combination of all three) (Wate and Coors, 2015, Magyari *et al*., 2016). On the contrary, simulations of energy estimation at the city or neighbourhood level represent an emerging field of research, such as Citysim (Robinson *et al.*, 2009). At this scale, energy modelling is done in two different ways. The first, called top-down, uses macroeconomic data (energy prices, geography, social data, etc.) and statistical data to make future energy forecasts. The second, the bottom-up approach, models groups of buildings with similar technical and geometric characteristics (Kavgic *et al.*, 2010, Nielsen *et al*., 2013). These models require the construction of geometric and non-geometric data. The most commonly used data models are construction information models (BIMs), used for individual construction simulations, and geographic information systems, generally based on 3D technology (GIS), which are suitable for assessing larger territories have become an essential tool for improving dynamic energy modelling capabilities (Bahu *et al.,* 2013, Wate and Coors, 2015, Nowacka *et al*., 2018). Some models combine building scale energy modelling with urban modelling (Thomas *et al*., 2014, Martins *et al.,* 2017, Wang *et al.,* 2017, Osterbring *et al*., 2018).

Similarly, non-geometric data can be retrieved in two ways. Data can be collected, in real time, from sensors. This is the optimal solution but it is expensive and cannot be implemented over a large area. The other solution consists in developing a typology of the different urban forms present on the territory. We speak of building archetypes (Sousa Monteiro *et al.,* 2015, Ali *et al.,* 2018). It is the most commonly used solution in urban-scale energy modelling. However, these databases generally focus on national archetypes and do not integrate the building types characteristic of each region (Ali *et al.*, 2018).

Our case studies: Grenoble and Compiègne: areas of observation of fuel poverty and areas of experimentation with energy justice

These questions are developed on complementary grounds by their degree of urbanity and according to a transect: from the district in a large urban metropolis in Grenoble, to a medium-sized city grouping together urban, peri-urban and rural territories, within the région of Compiègne.

a) The case of Grenoble

The Grenoble area is often seen as a "laboratory", to use the expression used by Ambrosino and Novarina (2015). Even if the authors question this appellation, they retrace the specificities of the Grenoble territorial matrix around several structuring specificities for the territory.

- The first specificity concerns the role and place of the university actor, and in particular the science park. After the Second World War, several research infrastructures accompanied the technological transformation of the ecosystem by strengthening links with universities and companies (Ambrosino and Novarina, 2015). These actions mark the territory on two levels: on the one hand, the importance of innovation and the reference frame for innovation, which are deeply rooted in the logic of companies, academics and public authorities, and on the other hand, the interpersonal links between the academic and political worlds, given that several mayors of the City are engineers from this technopole.

- The second specificity concerns the public actor. In this field, Grenoble is often perceived as the laboratory of local democracy with the actions carried out by Mayor Dubedout and the municipal action group (GAM) which "seeks to develop citizen participation through the establishment of a privileged link with the "neighbourhood unions" (Joly and Parent, 1988, Novarina, 1993, Ambrosino and Novarina, 2015). Although the real weight of this management was limited, it had the particular consequence of forging strong links between political power and associations, in a semantic of co-management or instrumentalization according to historical periods and of building strong public actors on the social question, through the Communal Centre for Social Action (CCAS), then the houses of the inhabitants, establishments managed by the City. Today these two forces are still very active: on the one hand, the town council of the city centre has been supported by citizen networks and on the other hand, the CCAS of Grenoble is an essential actor in the social question. Thus, this specificity has the consequence that the territory is used to self-organizing by groups of citizens, that militant and political associative networks have a strong territorial network, and that the co-management or implementation of public policy is often participatory and bilateral.

- The third specificity is linked to urban planning and the various major urban projects (e.g. Villeneuve in 1968 or more recently the eco-neighbourhoods). These urban projects have the particularity of placing inhabitant participation at the heart of the approach (Ambrosino and Novarina, 2015). Today they are marked by the search for quality of life around the environmental issue and the vision of a post-carbon city (energy and mobility).

These specificities have marked the territorialization of energy in Grenoble with an international university expertise in this field (eco-sesa) together with public actors involved in this theme. In terms of combating fuel poverty, the city of Grenoble and its stakeholders have distinguished themselves early on, as evidenced by the Mur|Mur1 thermal insulation campaign, launched between 2010 and 2014, while the Mur|Mur2 campaign (2016-2020) is now underway, and the number of urban projects marked by the energy issue is increasing.

- The district of *Bonne* | In the Grenoble landscape of exemplary projects, the district of *Bonne* quickly acquires a very particular visibility. Launched in 2001, the project to upgrade the former Bonne barracks (8.5 hectares located in the immediate proximity of the city centre) is part of a guide plan entrusted to Christian Devillers, Grand prix de l'urbanisme 1998. The objectives of the Concerted Development Zone are to reconcile functional mix (housing, shops and public facilities) and social mix (rental and accession housing), urban density and quality of life (conservation of the military buildings existing around the Place d'Honneur, creation of an urban park) with a view to strengthening the main centrality of the urban area and with requirements imposed in terms of innovative energy management (bioclimatic design of buildings, optimisation of energy savings, coverage of electricity and hot water needs through the use of renewable energies and cogeneration). In 2009, as part of a call for tenders launched by the French Ministry of Ecology and Sustainable Development, it won the *Grand Prix national EcoQuartier*. However, today, fuel poverty is settling in for households that are not able to use the technological innovations implemented in this district.

- The district of *Presqu'île scientifique* concerns the requalification of an area previously mainly occupied by research laboratories specializing in nanotechnologies and the properties of the French Atomic Energy Commission. Designed to be the laboratory, symbol and artifact of metropolitan policy, the development of this new district has in fact become an urban demonstrator, a territory where innovations and experiments are developed that should eventually lead to the identification of good practices that can be replicated in the rest of the metropolitan territory. The district of *Presqu'île* offers the opportunity to develop technological innovations in favour of a sober and peaceful city, with cooperative energy management, smart-grids and the implementation of a pass-mobility. In addition to these innovations, actions in favour of an "inclusive city" and a "nature city" have to be planned. However, the constant quest for innovation has led to the search for technical solutions to solve social and urban problems. In order to achieve immediate and exemplary results, it led to a sectoral operational project being given priority over a metropolitan strategy and to a minimization of the importance of public debate in the establishment of strategies and the construction of projects. In this district too, fuel poverty is settling in for households that are unable to use the technological innovations implemented.

(b) The Compiègne case

The region of Compiègne and la Basse Automne (or Agglomération de la Région de Compiègne, ARC, in French) is an intermunicipal cooperation structure located in the department of Oise, in the region of Hauts de France, bringing together, since 1 January 2017, 22 municipalities and 81,000 inhabitants, over an area of 265,000 km². Almost half of the population of the ARC lives in the commune of Compiègne. Like Grenoble, the issue of fuel poverty is a significant one for the ARC. The lowest median incomes are found in the central zone (21% poverty in Compiègne, according to INSEE criteria). The other municipalities have rates of 10% or less. Some inner cities have median incomes well above the urban average (3,000 euros and above for an average turnover of 23,760 euros per consumption unit). According to the presentation report of the territorial master plan (SCOT), « at the level of the Compiegnois Country in 2006, 12,630 individuals, or 17.7% of the total population, are below the low income threshold (12.3% on the Oise), i.e. having received an annual income of less than €7,830 ». The low-income earner is generally young, on short-term or part-time contracts and works mainly in three sectors: operational services (cleaning companies, security guards, temporary employment agencies), health and social work, and retail trade. According to the SCOT, the municipality of Compiègne covers 70% of the population covered by the welfare tax credit in the ARC territory. The ARC's housing stock is composed as follows: 23.1% of social rental housing, the ARC concentrates 73% of its public stock on the city of Compiègne. According to data from the regional observatory GES / Energy ADEME-Region, the average energy consumption ratio of homes for heating and hot water production is 206 kwh-ep/m².

Faced with these poor results, the ARC has placed heating renovation as one of the major challenges in controlling energy consumption and wishes to implement policies in favour of the construction of new low energy building and the renovation of old buildings. The improvement of the old private housing stock is a major focus of the local housing plan adopted by the ARC in November 2009, and remains, with the approval of the Territorial Energy Climate Plan (PCET) in 2015, and the commitment of the Master Plan (Plan local de l'urbanisme intercommuncal, PLUI in French), a priority for the ARC.

Moreover, in 2015, with a *Territorial Air Energy Climate Plan* (PCAET), the region of Compiègne was recognised as a "Positive Energy and Green Growth Territory" (TEPCV). Several actions are being implemented. At the beginning of 2015, an aerial thermography campaign was launched to identify roof insulation defects. One of the actions carried out under the PCAET in conjunction with ADEME was the creation of an energy renovation platform from 1 January 2016. The purpose of this platform is to federate and coordinate the various actors involved in energy renovation. This "Renovated Housing" platform is a unique resource center to facilitate access to information and simplify the steps towards energy renovation.

As part of our project, the urban area has already expressed the wish that the analysis of fuel poverty should focus, as a priority, on :

- - The Royaumont Linières district in Choisy au Bac (individual housing in peri-urban areas);
- - The Aramont and Pierre Lamaresse districts in Verberie (individual housing in peri-urban areas) ;
- - The district of the great Gardens in Compiègne (a little individual but especially private collective and social landlord areas) ;
- - The Venette district (joint housing in peri-urban areas).

Overall, the interest of this land is to address fuel poverty issues in all types of neighbourhoods: existing buildings or buildings under construction, for Grenoble, or under renovation, rehabilitated or to be rehabilitated for Compiègne and its urban area.

Based on these grounds, selected by the academic team and its partners in Grenoble and prefigured in consultation with the Communauté d'agglomération de Compiègne, the project studies in particular the loop of the following actions: design-implementation-use-improvement/integrated innovation. The project combines the analysis of technical-environmental characteristics (materials, type of buildings, land, etc.) and the analysis of the dynamics of use of social groups marked by their forms of vulnerability linked to their socio-demographic characteristics, life courses and control of processes involved in the ecological approach (D'ercole and Metzger, 2009). These dynamics of use are also studied in relation to the evolution of building users (e. g. the historicity of buildings) and partnerships with social landlords and/or developers.

Conclusion

The objective of the "ENERGY JUSTICE TOOL SUITE" project is to evaluate the partnership process of energy efficiency of buildings and their stakeholders, while developing a modelling, decision-making and consultation tool to assess the efficiency and cost of the proposed scenarios - and thus to participate in the fight against fuel poverty. Through the project, we propose in particular:

- A global analysis of the fuel poverty of the Compiègne urban area and the city of Grenoble, which will provide decision-makers with a new tool for understanding their territory, assessing spatial discrimination between hyperurban and urban areas in Grenoble and Compiègne, urban and rural areas in the Compiègne urban area, and social discrimination between populations.

- To take a global, analytical and detailed look at the political decision-making processes, the sets of actors involved in these processes (both through rationality logics and ideological or imaginary logics), to analyse the technical and managerial implementation of these decisions and to question the socio-economic logics involved, finally, to be able to identify the postures of users who are faced with these technical achievements, to understand the difficulties they encounter, the fragility of postures that manifest themselves in the face of technical, economic and legal challenges, and finally to identify the needs felt to adhere to or validate their capital of "responsible citizenship".

- It is also a question of defining an interoperable and interdisciplinary multiscalar model for the evaluation of the energy consumption of an urban area's built stock. To this end, we propose the design, not of archetypes of buildings, but of "archetypes of complex systems" (Vorger, 2014) of multiscalar energy systems, combining physical phenomena (real energy performance, socio-economic statistics of INSEE data at the IRIS and INSEE grid scales - which is unprecedented), and human behaviour - by integrating not only users, but also the whole ecosystem working for energy and socio-territorial justice, and from an empowerment perspective.

- Beyond our territories of study and action, we propose the development of a collaborative database of urban typologies. This database will catalogue all the urban forms present in our two study areas. It can be completed and enriched afterwards. Each urban form will be characterized by the criteria necessary to feed the models. The database will present all the "optimal" energy variants of these archetypal projects, allowing urban planners and architects to be informed of a wide range of potentialities. This work would help them to manage the complexity and understand the influence of their choice on urban energy responses, both in terms of performance, but also in terms of the qualities of architectural and urban environments, as well as in terms of socio-economic impacts, and finally in terms of comfort.

- We also propose the creation of a serious digital game to raise awareness among all stakeholders on the issue of heat loss and energy renovations.

Finally, the project aims to characterize, write, evaluate and co-construct an inclusive energy and socio-territorial justice - with the actors of these territories, through the creation of tools to support the energy transition, either a decision support tool (collaborative platform) and a tool to help.

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