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Cities as key players for the Transition towards a Post-carbon society: A French perspective

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Publishing director: Jean-Paul ALBERTINI, Commissioner General for Sustainable Development

Editor-in-chief: Nathalie CECUTTI-ETAHIRI, Head of the Foresight Mission at the French Ministry for Ecology, Sustainable Development and Energy

Authors: Éric VIDALENC, French environment and energy management agency (Ademe)

Antoine RIVIÈRE, Foresight Mission at the French Ministry for Ecology, Sustainable Development and Energy

Jacques THEYS, Former Head of the Foresight Mission, French Ministry for Ecology, Sustainable Development and Energy, France

Contacts: antoine.riviere@developpement-durable.gouv.fr

eric.vidalenc@ademe.fr

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Cities as key players for the transition towards a post-carbon society

A French perspective

Abstract

Through the Europe 2020 strategy, the EU identifies climate change and energy sustainability as top priorities of its political agenda. In this context, the idea of a transition towards a “post-carbon society” is gaining momentum. This concept can be defined as the achievement of three main objectives by 2050: dividing GHG emissions by four compared to 1990 levels, being almost self-sufficient regarding fossil fuel use (more specifically oil) and having the capacity to adapt to climate change. Of course, this has to be realized in line with a sustainable development.

Futures studies often lack territorial approaches when dealing with climate and energy challenges. This article is a contribution to fill this gap by answering two main questions: what is the role of cities in this transition? How could they lead to a post-carbon society?

The first question raises the point that cities are both guilty and victims of climatic changes and fossil fuel dependence, and shows in the same time that local level offers unique triggers to engage a territory in towards this transition. The second question was treated through the quest of current and future opportunities cities could mobilize to transcend urban inertia. To do so, an interdisciplinary foresight and research program involving academics, experts and local authorities, has conducted some research, focusing on the French case. Six various scenarios, i.e. six contrasted transition paths, from today to 2050, were designed using a combination of both forecasting (for global trends) and backcasting methods (for levers and policies). The outcome is twofold. Not only the way the scenarios have been built intend to reflect the complexity of urban metabolism, but their qualitative and quantitative assessments also detail the role urban stakeholders could play in various trajectories.

As a result, three issues clearly appear to be crucial in the transition towards a post-carbon society. The first one is that combination of technical and social innovation will be required to address the challenge of sustainability. The role of changing behaviors and lifestyles is also important, particularly in short term as an insurance to face uncertainties and a way to develop resilience. Third, more consistency shall be given in transition processes between time horizons (short, medium, long terms) on the one hand, and spatial scales (from the individual to global level) on the other hand.

Above all, this research is built on the myriad of initiatives that already exists in exemplary cities across the world. Unfortunately, these isolated actions will not be enough for moving to a post-carbon society, and a more massive shift is required. In this perspective ‘Rethinking cities in a post-carbon society’ aims at gathering local experiences in order to foster their diffusion at a wider scale.

Keywords

France, Scenarios, Post-carbon, Cities, Transitions

1. Introduction

Our current socioeconomic model, based on natural resource exploitation and technical progress, is shaking. This general statement is especially relevant in Europe, and more specifically regarding the climate change issue.

The Fifth Assessment Report published by the Intergovernmental Panel on Climate Change reaffirms that climate change is occurring, and is caused by anthropogenic activities (IPCC, 2013). Business as usual is definitely not going to keep global warming under the politically agreed +2°C target, which was stated at the Rio Summit in 1992 (IPCC, 2014). Indeed, it is commonly accepted that, to do so, global greenhouse gas (GHG) emissions shall be reduced by at least 50 % by 2050, in comparison with 1990 levels. Taking into account the common but differentiated responsibility of nations in climate deregulations, industrialized economies shall – at least – divide by four their GHG emissions in comparison with 1990 levels.

If no legally binding agreement has been reached since the end of the first phase of the Kyoto Protocol, the European Union moved forward and identified climate change and energy sustainability as top priorities of its political agenda. In 2011, the European Commission published its "roadmap for moving to a competitive low carbon economy in 2050" (EC, 2011), where it draws a cost-effective pathway to cut EU emissions to 80% below 1990 levels. The 2008 Climate Energy Package, which sets up objectives to reduce GHG emissions and to be more independent from the use of fossil fuels by 2020, is a first milestone that shall be followed soon by its extension to 2030.

In this context, many low carbon strategies have been set up at various levels. At the French level, this ambition was supported by the state through legislation. The Grenelle laws, passed in 2009 and 2010, consist in the core of this regulation. In their climate change section, they explicitly states the objective of reducing by 75 % GHG emissions in 2050, in comparison with 1990 levels – what is commonly called the "factor 4" reduction. In practice, this has led to the launching of many initiatives, in various sectors: improving the energy footprint of buildings, reducing the carbon impact of manufacturing goods, reducing GHG emissions from the transport sector, etc. In addition, another law regarding energy transition towards green growth is currently under discussion at the Parliament. As a planning act, its goal is to set medium and long-term objectives to fight against climate change while reducing France's energy bill.

However, a proper transition does not seem to occur yet. If national emissions have bended (MEDDE, 2013), current trends are not consistent with long term targets, and this significant gap can only be filled thanks to disruptive changes[1]. Indeed, "low carbon development" is, generally speaking, related to a narrow view, where solutions to problems are to be found in the current system. In other words, a low carbon development aims at decreasing greenhouse gas emissions (GHG) through incremental technological progress or through behavioral change thanks to price signals. The goal lies therefore in the optimization of current processes for the next 35 years. We believe following such a development could create lock-in situations without allowing sufficient (and efficient) GHG emission reductions (Vidalenc and Theys, 2011). To reflect the necessity of profound shifts and disruptive changes to fight against climate change and cope with its negative consequences, we advocate for moving

1 This is also true at the global level since GHG emissions have steadily been increasing over the last decades (IPCC, 2014).

towards "post-carbon" strategies. This concept assumes that all the facets of our socioeconomic activities will have to substantially evolve.

Designing strategies towards a post-carbon society is not only restricted to climate change mitigation. It first encompasses other energy-related issues, such as climate change adaptation and the independence from fossil fuels – oil more specifically. These challenges are impacting people and territories at various scales (from a potential rise in household energy bills to energy security) and at various time horizons (from day-to-day energy poverty to vulnerability as a result of climate change deregulations). Although they are complementary, these issues are not necessarily convergent; as a consequence, both a policy mix and a global thinking are required. In other words, a transition towards a post-carbon society must be framed in the more general concept of sustainability, that is to say all issues have to be screened through the environmental, social and economical points of view, in order to be part of a sustainable development policy set.

Based on these evidences, the Foresight Mission of the French Ministry for Sustainable Development and the French environment and energy management agency (Ademe) led together a four-year research program entitled "Rethinking cities in a post-carbon society" (2009-2013). It analyzed the role cities can play in a transition towards a post-carbon society, from today to 2050, through a comprehensive action research, combining thematic seminars, scenario building and applied territorial research. Even though the research conducted was focusing on the French case, it can be easily extrapolated to other European countries. We shall notice that 2050 is thirty-five years ahead; this can be considered both short and long terms. Short term when it relates to the lifespan of urban infrastructures, which often exceeds this period of time. But if we look back thirty-five years ago, this was approximately the times of oil shocks (1973 and 1979) and of the first environmental concerns (Meadows report *Limits to growth* (1972) as well as the Stockholm conference, which occurred the same year). Environmental and energy issues have substantially been impacted for this length of time; for instance, France developed its electronuclear program. In other words, retrospective view helps us saying that 2050 is also about long term.

This article aims at presenting how this issue has been addressed and what its main outcomes are. The structure of this paper is the following. After this introduction on the relevance of the concept of a post-carbon society (Section 1), we will see that some cities are already key players in the transition it requires (Section 2). Then, we will focus on the six transition paths that were drawn for a city's post-carbon future (Section 3), before presenting to what extent the outcomes of this research program can help to design a new and relevant framework for policy-making; this is the seventh scenario (Section 4).

2. Cities for a post-carbon society

A post-carbon society would have achieved three main objectives by 2050: dividing by four its GHG emissions, adapting to climate change and almost not relying anymore on the burning of fossil fuels (especially oil). Solutions must be compatible with a sustainable development, so that suggested measures are effectively driving towards a better future.

What is the role of cities in such a transition? Why does the concept of "post-carbon cities" matter? These are the questions we will answer in that section.

Cities both perpetrators and victims of climate change

Defining a city is not as easy as it may appear, since there is no international agreed definition. In this article, the term cities will refer to urban areas, and they will be thus used in an interchangeable manner. The research conducted covered all types of cities, either small or big[2], and studied them as entities connected to and integrated in their territories. As already mentioned, the focus here is on French cities, although many case studies from Europe – and more generally industrialized economies – have fed the research program "Rethinking cities in a post-carbon society" (MEDDE and Ademe, 2013).

Two main explanations make the city an important player at the national level. The first one deals with its demographic weight, since about 80 % of the French population lives in urban areas, the latter representing about 20 % of the whole French area (Clanché and Rascol, 2011). Naturally, urbanization trends are quite different from emerging countries, but we can expect its share to be increasing, as it was the case for the past decades (Clanché and Rascol, 2011). Therefore, since cities are mainly already built, what is at stake is the transformation of the city itself rather than its *ex nihilo* creation. The second explanation lies in the economic impact of cities regarding national economic activity. More than the half of French GDP is achieved in the 15 biggest metropolitan areas[3], while they also contribute to 75 % of GDP growth (OECD, 2013). Eventually, it appears that, in France, 95% of the whole population lives in a sphere of urban influence (Brutel and Levy, 2011).

As a consequence, cities play a major role in global energy consumption and GHG emissions. This is true at the global level, since the International Energy Agency (2008) estimated that cities were responsible, in 2006, of two thirds of the world primary energy consumption, and over 70 % of global CO_2 emissions, although they were only accounting for half of the world's population. However, data remain scarce and not harmonized, which make comparisons among cities not easy. Differences exist in the definitions of the urban area, the scope of the assessment, or in methodological issues (OECD, 2010). As an example, the GHG emission assessment of New York City (USA) and Angers (France) are of the same order of magnitude although Angers twenty times smaller in terms of population (MEDDE and Ademe, 2013). This is due to the fact that one city considers only territorial emissions (NYC) while the other one (Angers) takes not only into account territorial emissions but also consumption-based emissions.

If cities are on the one hand a major contributor to energy consumption and GHG emissions, urban areas are on the other hand exposed and vulnerable to climate change, as well as to the expected rising scarcity of fossil fuels.

Indeed, they can be struck by direct impacts of climate change: global warming, change in precipitation patterns, higher frequency and intensity of extreme events (heat waves, floods, droughts, etc.) or sea rise. These expected risks are extremely likely to increase, and will be borne by local authorities which will have to face their cost (ESPON, 2010) and to adapt to them (World Bank, 2011). More specifically, urban heat islands are one of the high concerns for large metropolitan areas. As an illustration, it was assessed that Paris may face urban heat islands up to 10°C (APC and Météo-France, 2013). Regarding energy availability and its price, this issue is essential for French cities, which import almost all their primary energy

2 To give an order of magnitude, at the French scale, this goes from 100,000 up to a few millions of inhabitants.

3 >500,000 inhabitants.

needs. Again, beyond this direct impact, the most important issue is that urban areas will have to deal with uncertainties since they are hardly able to predict to what extent they will be affected by these sorts of events (Hallegate *et al.*, 2007). Energy issues and sensitivity to its price (expected to rise and be more volatile) will also have clear negative socioeconomic impacts on inhabitant's well-being. Constrained mobility, energy poverty and vulnerability consist in the main troubles they will face. These consequences may improve inequities since they tend to have negative distributional impacts across revenues (Symons *et al.*, 2002), and may be more severe for people leaving in semi-urban regions (EEA, 2011). In other words, the whole urban metabolism may be threatened in a medium term.

Cities as a key driver for moving towards a post-carbon society

To sum up, cities – in industrialized, emerging and middle economies – are bearing a considerable responsibility in climate change and are likely to still bear some if they do not change radically their development. Despite some obstacles to overcome, great opportunities still exist.

If radical change in development passes through thinking differently urban forms, changing people's behavior and, therefore, urban metabolism, cities are still facing strong inertia. Childers *et al.* (2014) describe for instance a multifaceted inertia through three components. The first one is the physical component; this is probably the most obvious one since built structures and cities' infrastructures are often the city's exoskeleton. Not only it is complicated to change what has already built, it is also costly. This is why we can consider that much of the built environment of French cities in 2050 is already standing here. Institutional inertia is the second component, and deals with the stove-piped governance of cities. Indeed, local authorities suffer from an "in silo" thinking which is inappropriate when it comes to sustainable development – and more specifically climate change – issues. More generally, we could say that governance at local and national levels is somewhat inadequate since it lacks a long term vision, as well as a proper articulation across various layers – from the city to the European Union.

Finally, the third component is the social one and refers to people's preference to *statu quo*, or change as long as they are not impacted by it. We can extend this component to more practical social and societal barriers, such as the lack of information about energy and climate issues, the weak acceptability of environmental taxation (and other additional costs relating to environmental issues), the strong gap between environmental concerns and pro-environmental actions across people, etc.

The research conducted in the foresight program "Rethinking cities in a post-carbon society" (MEDDE and Ademe, 2013) underlines one additional type of obstacle, linked to the decision-making process in a context of a multifaceted uncertainty. As understood here, uncertainty covers climate policies (e.g. no clear long term vision on GHG emission reduction targets), technical feasibility (e.g. limited experience on smart grids, energy storage or positive-energy buildings leads to a lack of information on the cost and performance of these processes) and finally economical and financial aspects (public finance is constrained, high unemployment rates, lower purchasing power for households, etc.).

However, cities offer great opportunities for the transition towards a post-carbon society. First of all, territorial action at local level is likely to be more efficient than at the national one since responsibilities are easier to establish, monitoring and compliance more simple to enable, and both interactions and interdependence across parties easier to

take into account (MEDDE and Ademe, 2013). More specifically, cities have a key role to play in the implementation of technological solutions that were designed at a wider scale. As an example, in energy systems, electric vehicle deployment requires some new infrastructures that cannot be developed without a strong commitment from local authorities. Furthermore, cities are key players thanks to their unique institutional role. Indeed, they have an authority on land and urban planning through regulation, which allows setting up a long term vision on what they will look like in the future. In addition, they are able to organize urban metabolism through public transportation and local mobility management, or make coherent and sustainable choices thanks to their competence in social housing, urban heating and natural hazard protection. Finally, cities can make use of their economic and financial power. For instance, differentiated taxation depending on land use may be a tool to raise revenue for the municipality and in the same time gives incentives to change selected behaviors (e.g. alleviating urban sprawl, promoting energy retrofitting of buildings and/or energy savings, etc.). Of course, this considerable power has to be nuanced due to the private sector's influence on many of these triggers. The practical goal probably lies in the creation of a constructive and dialogue, between actors of territories, on ambitious targets for sustainable development (Anguelovski and Carmin, 2011).

An increasing literature (Bulkeley and Kern, 2006; OURANOS, 2010; Bicknell *et al.*, 2009; Bulkeley *et al.*, 2009; Meeus and Delarue, 2011; Castán Broto and Bulkeley, 2013) focused on the modes of urban governance on climate change issues. It comes out that cities can be involved through five levels of action. The first and most basic one is self-governing, where the city can show some leadership by being exemplary, for instance regarding the retrofitting of its public building management or the use of a zero-carbon fleet. Second, it can endorse the role of public services provider (public transportation, recycling, distribution of energy at local level, etc.) and give fiscal and/or economical incentives to facilitate similar choices among territorial actors. A further step was already discussed, and is coming from the regulatory authority the city uses for urban planning. A fourth step would be the role of the city in the coordination of collective action. This can be achieved thanks to wider planning tools, private-public partnerships or even support to social and technical innovation. As a result, in an ultimate step, the city may influence and mobilize an important diversity of actors (private sector, civil society, experts, national administration) at various scales (from local inhabitants to international actors, thanks to potential interventions in appropriate networks).

Mainstreaming existing show cases

Cities, not only as local authorities but as local ecosystem of inhabitants, companies, public utilities and local governments, are today recognized at the international level for their key role in the fight against climate change (UN-Habitat, 2009; OECD, 2010; World Bank, 2010). Drawing support from associations or active networks such as Local Governments for Sustainability (ICLEI) in the 1990's, Climate Alliance and Energy-Cities, some cities voluntarily became involved in Climate Plans, energy-transition experiments, eco-district projects and, more recently, "resilient cities" (Emelianoff and Mor, 2013). Some of these initiatives and experiments have become symbolic[4], but the movement has far higher aspirations. As an example, almost 6,000 European cities have signed the "Covenant of Mayors" and have thus

4 We can think of Freiburg im Breisgau and Hanover in Germany; Vaxjo, Malmo, Gothenburg and Stockholm in Sweden; Bristol, Woking and the eco-district BedZED (Beddington Zero [fossil] Energy Development) in the United Kingdom; Copenhagen in Denmark; Boulder, Colorado in the United States; Masdar in the United Arab Emirates.

committed to exceed the EU CO_2 reduction target of 20% by 2020[5]. When considering the cities and districts that take part in the more grassroots "cities in transition" (Hopkins, 2008) movements, a strong momentum is clearly gaining ground.

The achievement of post-carbon societies depends on the successful collaboration between the national and local levels. In France, the Grenelle laws of 2009 and 2010 consist in a first step in this direction. They extended the local Climate-Energy Plans, initiated in 2004, to any city of more than 50,000 inhabitants and developed a wide range of incentives and standards to promote low-carbon mobility, thermal retrofit of buildings and the creation of eco-districts. Ever since, over 350 local Climate-Energy Plans, including a mostly complete "adaptation to climate change" section, have been implemented in France and some 400 eco-district projects have been launched. Even though these initiatives are sometimes rather technical, not enough participative, and are also currently facing the consequences of the economic crisis, they are still drivers of a changing “urban culture”. The difficulties, however, must not be ignored. Local authorities directly control only a small part of GHG emitted in their area – roughly some 2 % coming from local authorities’ buildings or infrastructures, as well as from municipal services (Ville de Paris, 2007; Ville de Rennes, 2011). This figure can be risen up to 25 % if we consider the broader role that city could embrace, which was previously discussed. The planning law on energy transition towards green growth, under discussion in the French Parliament, will hopefully embrace these problems through energy savings and the development of renewable energy resources.

To conclude this section, despite some practical obstacles, urban areas are not only legitimate, but have also in hands both the political and institutional capacity to make the difference in a transition to a post-carbon society. Beyond the role of cities, the articulation of policies across institutional layers, but across time horizons, is essential. In this context, looking at 2050 is highly relevant as, in addition to giving a clear vision of the post-carbon society, it is a time horizon at the crossroads of the climate and energy issues on the one hand, and of urban dynamics on the other one. We finally saw that some initiatives are already taken by cities to fight against climate change. Unfortunately, they remain at the stage of show cases and are not really mainstreamed, in spite of the action of international networks, like ICLEI or Energy Cities. Other voluntary commitments – such as the Covenant of Mayors – are gaining momentum but are not enough ambitious to engage urban areas towards a post-carbon society. This is why there is a clear need for designing scenarios consistent with its objectives.

3. Six scenarios to grasp the transition

The EU Climate and Energy Package, set up in France by the European Commission and Grenelle environmental laws (2009 and 2010), are very likely to be achieved by 2020 due to – or despite – the economic and financial crisis. Nevertheless, disruptive changes will be essential for meeting the challenge of a post-carbon city; they still have to be undertaken.

5 The Covenant of Mayors (for sustainable local energy) was launched in 2008, under the leadership of the European Commission. It requires signatory cities to submit, within one year, an energy action plan for reducing its CO_2 emissions by at least 20% by 2020. An assessment report of what has been achieved so far must be submitted every other year.

A quick state of the art of French foresight activities

To do so, the transition to post-carbon cities cannot be sought without the development of a prospective vision regarding the potential futures of the French energy system integrated within climate issues (i.e. reducing by 75 % GHG emissions in 2050[6], adapting to climate change and to the depletion of fossil fuels). Three main stakeholders worked in three different types of scenarios. First, the French Ministry of Ecology, Sustainable Development and Energy (MEDDE, 2011) analyzed the potential impacts of measures inscribed in the last important environmental law[7] (Grenelle laws 2009-2010) – if they were fully implemented – on GHG emissions and energy consumption. It comes out that a 30 % reduction of GHG emissions is possible by 2030, which could be in line with 2050 targets if policies and investments are more stringent afterward. Second, Ademe (2012) – Energy Management French Agency – developed scenarios (2030) and visions (2050) based on the National Debate on the Energy Transition led in 2013. It takes into account the implementation of all best available technologies and of existing regulations, as well as the extension of current innovative practices (e.g. carpooling), to estimate that final energy demand could be 20 % lower by 2030, while GHG would be 40 % below 1990 levels. Third, the NGO négaWatt (2013) is the most ambitious decarbonization scenario. Based on three principles – namely sobriety, efficiency and renewables – it drew a scenario where, in 2050, primary energy demand decreases by 65 % in comparison with 2010 levels, and CO2 emissions are sixteen-fold below 2010 levels!

Beyond the policy framework already set[8] and foresight activities already conducted, the array of solutions that has emerged at the local, national and European level is impressive. However, a quick assessment of the projects underway (Climate Plans, eco-districts, new mobility services, etc.), as realized by some cities themselves (Emelianoff and Mor, 2013), shows that we usually remain very far from the efforts needed to achieve the 2050 targets. Indeed, after having reached the 20 % threshold, the question “how can we get further?” arises. As a consequence, backcasting scenarios were developed to answer – a part of – this question, and more specifically to determine how it is possible to articulate technologies, urban organization and lifestyles, which are partly determined by policies and technical measures, to reach an ambitious target (here the post-carbon transition).

Using a backcasting method for the scenario building

Among other activities, the foresight program “Rethinking cities in a post-carbon society” developed scenarios applying backcasting – or strategic – methods (Lovins, 1976; Robinson, 1990) in articulation with exploratory methods (De Jouvenel, 2000). The theoretical process consists in the exploration of the consequences of a set of various assumptions, which depend on different contexts. In other words, this led to create, compare and partly evaluate a number of possible strategies for achieving a post-carbon society (i.e. the three objectives mentioned before for 2050). The aim was not only to produce and describe pictures of the post-carbon city in 2050, as this would only have limited significance given the wide variety of

6 Otherwise stated, the base year is always 1990.

7 Following the National Debate on the Energy Transition led in 2013, a law is supposed to be passed in 2014 or 2015, but the content is not yet fully set (main objectives currently discussed: a 30 % decrease of fossil energy consumption by 2030; 30 % of renewable in the French energy mix and 40 % in power generation by 2030; halve energy consumption in 2050).

8 Furthermore, new targets to 2030 are currently discussed in a new Climate and Energy Package.

Type of component	Items	A	B	C	D	E
Context	**C1. International regulation (climate-energy)**	Climate Skeptical	Copenhagen vision	European climate policy	Climate-compatible	Climate region
	C2. National and international economic context	Crisis and big shift	Stop-and-go and competitive debt reduction	Green New Deal	Socio-ecological protectionism	New technological revolution
Transverse	**C3. National public policies**	Priority to deficit and oil bill reductions	Continuation of Grenelle and green growth	Carbon taxation and economic regulations	Policy for an ecological transition	Priority to social and employment policies
	C4. Decentralization and local governance	Good governance and institutional simplification	Alignment with the “European model”	Metropolitan power	Local autonomy and energy decentralization	Selective recentralization
	C5. Urban systems (city hierarchy and organization)	City-region and urban sprawl	Archipelago of digitally interconnected medium-sized cities	Network of densely populated cities	Tight-knit rural communities and geographic division	Urban exodus
	C6. Lifestyles and values	Green consumerism and economic rationality	Self-preoccupation and rise of a nationalist sentiment	Ethnic segregation	Simple and eco-friendly society	Socially responsible urban living
	C7. Adaptation to climate change and global warming	Raising of public awareness	Regulation through insurance	Bioclimatic regional development	Protection and defense	Business transition and lifestyle changes
Thematic	**C8. Production systems**	Specialization and concentration	High technology (including green ones) and innovative SMEs	New service economy	Network of local and regional economies	Use of regional revenues and resources
	C9. Energy systems	Centralized and high-carbon content with reduction in oil	Partly low-carbon and replacement essential	Centralized and very low-carbon	Centralized and low-carbon	All renewables & phasing-out of nuclear
	C10. Urban land policies	Project-based urban development and ineffective planning	Cooperative development: coordinated, negotiated, compensated urban development	Massive urban renewal	City over the city: effective planning and location-based taxation	Eco-planning and enw land appraisals
	C11. Transport technologies	Efficient and clean transport	Light and slow	“Liveable” cars	Revolution in alternative fuels	Revolution in alternative fossil fuels
	C12. Mobility policies	Travel optimization and sustainable mobility	Massive shift towards public transport	Economic regulation of local mobility	Mobility-shared public good	New infrastructure paradigms
	C13. Residential and commercial buildings (project management)	Basic renovation and energy efficiency	Technological challenge	Massive rehabilitation, demolition and reconstruction	Sharing and networking	Bio-logis (green homes) and bioclimatic housing
	C14. Housing policies	High level of home ownership	Package of housing-mobility services	State as builder	Public-private partnership	Co-renting
	C15. Social and energy poverty policies	Withdrawal from direct financing, privatization, contracting	Appropriations (fair and effective)	Priority to disadvantaged and vulnerable populations	New rights and reintegration through social policy	Local, community-based initiatives

Figure 1. Scenario Blueprint: Micro scenario for each variable items and names.

existing cities. Indeed, the main purpose was to go further by bringing these strategies up for discussion, to develop new ones and to assess the players' degree of flexibility considering opportunities and obstacles. Eventually, we obtained some trajectories from today to 2050 which seemed consistent across all key players involved. The backcasting tool allowed to devise transition pathways within a timeframe of 30 to 40 years, also called backcasting scenarios. Formally, the procedure consists in starting with the ultimate objective (i.e. the three components of a post-carbon society in 2050) and identifying the pathways to reach this objective. In the same time, a forecasting method was used to make projections about megatrends, that is to say variables tightly linked to the context.

major role in the design of strategies. The main and basic assumption adopted for the creation of scenarios was that the transition pathways will mainly depend on how stakeholders (in particular local authorities) perceive the uncertainties associated with the situation, as well as how they identify their opportunities and their degree of flexibility. Having this in mind, six differentiated scenarios were constructed, which can be represented in a 3*2 matrix, according to the level of flexibility perceived – on economic tools, urban infrastructures and planning, or on lifestyles and urban forms – and the type of context – trend vs. in favor of innovation (Figure 2). Thus, economical, technical, cultural and social aspects of the city can be – at least partly – considered across the various scenarios.

		Degree of flexibility for action		
		Through technology and price signal	Action on urban investment and urban planning	Action on urban forms and lifestyles
Context	Baseline	Scenario 1 Smart wait-and-see attitude	Scenario 3 New climate and energy infrastructures	Scenario 5 Self-contained city
	Disruption (fosters innovation)	Scenario 2 Carbon creativity	Scenario 4 Biopolis	Scenario 6 Urban frugality

Figure 2. Six scenarios towards a post-carbon city

In practice, a group of approximately 25 experts (researchers, academics, energy experts and practitioners from local authorities) with several disciplines (economists, engineers, town planners) have met on a regular basis (every other month) for two years in workshop sessions. At the end, we created a matrix, composed of micro-scenarios for each variable, to build up the final scenarios (Figure 1).

Considering the distant time horizon, uncertainty and the large variety of representations of the future naturally play a

The six scenarios: a qualitative description

From the Figure 2, it appears that: (1) picking up a line (i.e. context), the more we go to the right, the more the perceived degree of flexibility; (2) choosing a column (i.e. degree of flexibility for action), the second line offers more freedom for disruptive change while the first one sets up more constraints. In the following, we will present scenarios using columns as entries, that is to say by stabilizing the degree of flexibility for action. More detail is available in the reports from the workshops (Futuribles, 2010; MANA, 2012).

In an initial configuration (scenarios 1 and 2), little flexibility is given for transformational policies at the urban level. Instead, local authorities, businesses and residents adapt in a smart – but reactive – way to incentives, constraints and opportunities. Actually, these incentives are mainly imposed to local authorities, that is to say coming from national or international policies, and are especially related to energy and carbon prices, new technologies, technical standards, etc. In other words, price-signals are a decisive element in these two scenarios.

The first scenario is named **Smart Wait-and-see Attitude**. The priority is given to no-regret strategies and to other measures that do not require massive investments. Decisions are taken in a very cautious manner due to the lengthening of the economic and financial crisis on the one hand, and to the relatively mid-low oil prices – between today and 2025 – on the other hand. Although this acts in favor of public awareness and of the mobilization of targeted actors, such a scenario leads to a crisis in 2030-2040 which is as brutal as global.

The variant of scenario 1 is **Carbon Creativity** (scenario 2). Here, the context is more in favor of radical change; this is translated by a strong price-signal on carbon sent to economic agents who tend to change their habits to greener activities. Even though economic instruments are used at a national and community level, local authorities play a role for driving local innovation as well as setting up pricing policies (e.g. urban tolls).

Even though scenario 1 is clearly the weakest, we shall not underestimate the effects these two scenarios may have on GHG emission reductions. Yet, both of them are confronted to two main problems. First, as they are dependent on the decision-making at national and international level, they are vulnerable to uncertainties of many kinds: physical and technological ones, but also economical and fiscal ones. Second, they lead to higher inequalities and social issues; the brunt is very likely to be borne by poorer households, who do not have the capacities to adapt and to have access to costly innovations.

A second configuration envisions a massive transformation of urban and energy infrastructures, in a more or less decentralized setting (respectively scenarios 3 and 4). Massive investments are realized in the retrofitting of buildings to ensure their very low consumption of energy; in energy systems so that they can be based on a larger share of renewables; and finally in all types of general infrastructures, such as public and collective transportation, infrastructures to fight against climate change impacts, etc. Still, we shall note that this second configuration does not properly consider any change in lifestyles nor in the ways of using space.

Scenario 3 – **New Climate and Energy Infrastructures** – is the closest scenario to a "business as usual" in France, with the implementation of measures suggested by the Grenelle laws. The State is leader in giving public incentives to urban areas, major energy players and households, doing so thanks to its ability to design toolboxes to foster the above-mentioned investments. The creation of some institution such as a Public Energy Bank (see Podesta and Kornbluh, 2009 for a similar proposition) could be one eloquent example.

Scenario 4, also known as **Biopolis**, pursues the post-carbon objective through the same means but prefers to tackle it in a more decentralized way. Local authorities are reorganized at a regional level and gain some competencies, for instance in energy production. The distinction between rural and urban areas becomes every day blurrier, like the distinction between nature and the built environment.

The transformation of territories is thus at the heart of these two scenarios. The former offers a great potential for the modernization of cities, and more specifically for the biggest ones. In addition, it allows structural changes whose consequences can influence widely current behaviors. As a consequence, scenario 3 looks like an obvious pathway to a post-carbon city. The latter depicts a real "ecological city" and takes seriously into account urban inertia. Its pragmatism is underlined by its willingness to adapt to climate change – helped by ecosystem services – and the large integration of renewable energy in its energy mix. However, New Climate and Energy Infrastructures and Biopolis suffer from the same limits. Their major drawback is that they lead to an uncontrolled urban sprawl. A cascade of negative consequences falls from this, as the rise of energy poverty and mobility vulnerability. In addition, they are difficult to implement. Indeed, massive investments are by definition extremely costly and solutions (e.g. public-private partnerships, third-party financing, etc.) may not necessarily be effective from a climate change standpoint. More specifically, Biopolis requires profound institutional changes in order to be able to transfer competencies –and fiscal authority – to regions, or to cope with land use conflicts. This is another obstacle to overcome.

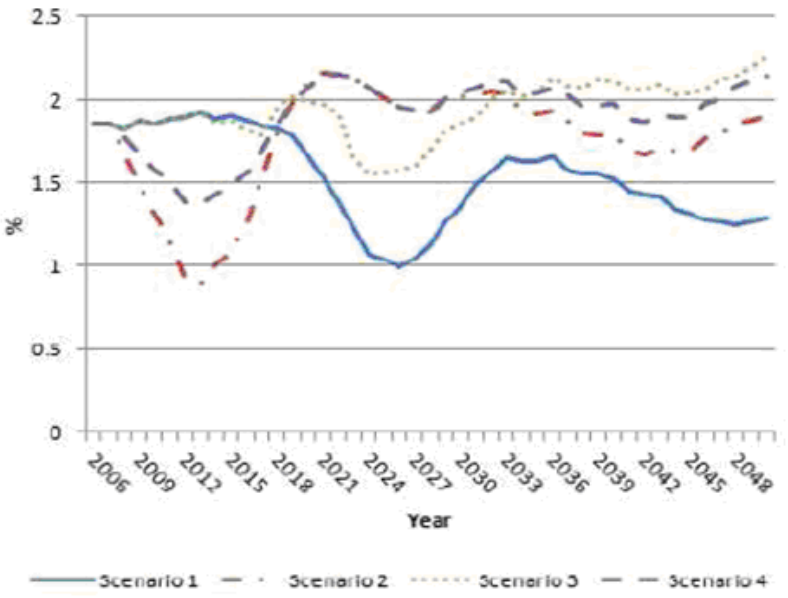

Figure 3.
Evolution of GDP growth rate over the period 2006-2050 for the first four scenarios (Source: CIRED, 2012).

A third and final configuration (scenarios 5 and 6) explores the conditions and the expected impacts of large-scale changes in lifestyles and the ways of using space.

In the **Self-contained City** (scenario 5), local authorities and town planner are leaders in the transition towards post-carbon cities. They use urban planning tools in an integrated manner to be able to have a systemic view on policies, and thus integrating energy, climate, inequalities and quality of life standpoints at the same time. As illustrations, urban development projects are determined by the existence of public transportation, and land trust competencies are transferred to intercommunalities in order to make consistent choices at the territorial level.

Finally, in **Frugal Urbanity** (scenario 6), inhabitants themselves are at the heart of deep and disruptive changes. They are the main driver of city transformations through the modification of their lifestyles. In practice, this is achieved by the emergence of ecological and frugal values, altering the pure economic rationality of consumers. New forms of economy are thus gaining momentum, such as the sharing economy. At one point, these trends are confirmed by widely accepted new constraints (e.g. personal carbon trading). By 2050, a new society has emerged.

Here, the two last scenarios allow the minimization of vulnerability to climate change and fossil fuel dependence. They also offer unique opportunities to design and rethink,

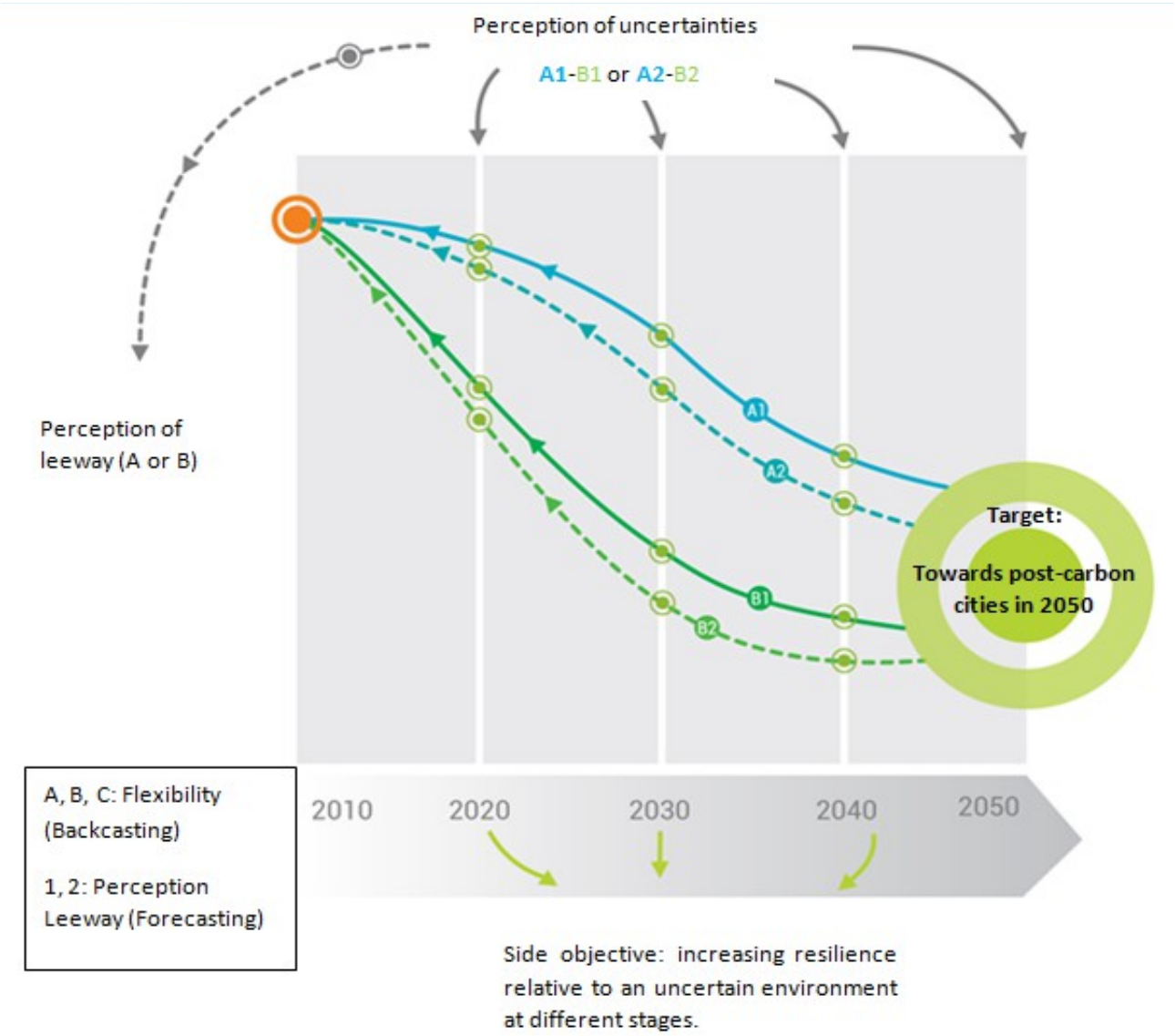

Figure 4. Method used for the scenario building: a strategic approach to decision making in situations of uncertainty

This figure aims at describing the way scenarios were constructed. The first stage consisted in defining the whole system (parameters, variables, etc.), and how it was evolving over time, thanks to a forecasting approach. Eventually, it led to the description of the post-carbon city in 2050 (i.e. the target). The second stage used backcasting methods to build up the scenarios. The color of the lines (blue or green) represent two different configurations. Picking up a color, the full line and the dashed one would constitute two variants of a same configuration.

with the participation of inhabitants, urban areas so that they can be more attractive, resilient and sustainable. Their main difficulty lies in their assumption, since they consider economical transitions that are hardly conceivable today.

Quantitative analysis: role and limits of modeling

Building six scenarios describing six pathways, from today to 2050, leading to post-carbon societies was a first achievement (see Figure 4). Their qualitative analysis, overviewed in the previous section, was another one. Eventually, a further step consisted in combining qualitative and quantitative assessment. This section first aims at reviewing how these evaluation methods were used in the foresight research program, and how they can contribute to the design of a policy-relevant framework.

Modeling activities is a way to ensure credibility and robustness of the scenarios. This is why a hybrid macroeconomic model, namely the IMACLIM model (CIRED, 2012), was used to assess the extent to which local measures can impact national objectives on CO_2 reductions and fossil fuel independence[9]. The above-described scenarios have therefore been translated in the hybrid macroeconomic model according to a global set of hypothesis on the twelve most important cities in terms of employment and population in France (CIRED, 2012). In order to study the relationships between the spatial patterns – at the urban and regional scale – and the oil market, a spatial model that can be incorporated in a Computable General Equilibrium (CGE) framework for climate policy analysis has been developed (Sassi *et al.*, 2010).

From this exercise, we are able to obtain interesting dynamics about the various scenarios. Beyond the final digits thrown out by the model, it is interesting to analyze the order of magnitude of these results.

The first configuration of scenarios (i.e. scenarios 1 and 2) is particularly relevant for such an analysis. A “Smart wait-and-see Attitude” (scenario 1) leads, around 2025, to a strong decrease in GDP, due to the incapacity of the economy to cope with a high oil price. Spatial organization is tightly linked to this, and impacts GDP growth as well as oil consumption. However, after 2030, big cities shrink and the “agglomeration effect” (i.e. need in urban investments, transport capacities/infrastructures, work productivity) decreases. As a direct consequence, GDP follows the same trend. Scenario 2 (Carbon Creativity) is quite different since high prices of energy are already imposed in short term through the settlement of significant price-signal on carbon. As a result, the model shows a considerable loss of GDP in the short term, but recovers quickly and reach higher levels in a second period (2020–2050), compared to scenario 1. In addition, the development of alternative car engines limits the impact of oil price on growth.

Scenario 4 (Biopolis) faces the same evolution than Scenario 2 until 2020, but then the GDP increases compared to scenario 1 and 2, as urban areas become bigger and the economy benefits from the “agglomeration effects”. Finally, we found out greatest values of GDP in scenario 3 (New Climate and Energy Infrastructures). Indeed, cities develop significantly and the economy is not constrained by oil price at the beginning of the period.

More generally, the quantitative analysis performed by the model helps to show that the spatial dimension of the economy matters in energy security and oil

9 Climate change adaptation is more difficult to assess through such an economic model. It is more subjective, and would require more complex data set and equations to simulate climate change impacts on economies. As a consequence, this third component of post-carbon society was not part of the quantitative assessment.

scarcity. It differs from earlier work, which focused on a global aggregated approach, by introducing production, consumption, trade and urban-related external costs for multiple cities within regions. But if the scenarios 1 to 4 could be analyzed in the model without too many difficulties (with all necessary precautions), the two last scenarios can hardly be processed. Indeed, their constitutive hypotheses imply new rationalities and new types of relations between stakeholders (i.e. a new economic model). Beyond technical and economical evolution, changes in cultural aspects have to be considered as well.

In short, it appears that modeling does not just give orders of magnitude on the expected GHG emission reductions between the scenarios but also ensures an overall consistency. In addition, it allows to observe some convergence between actions and measures, and to discover sometimes counterintuitive results. On the other side, qualitative method analysis for scenarios opens creative fields and allows not only potential disruptive changes, but also to improve the conceptual, necessarily rigid and conservative, modeling framework. In other words, they seem highly complementary since while modeling scenarios may seem frustrating, even simplistic, the qualitative description may seem unrealistic. In a more optimistic way, it comes out that great synergies exist between qualitative and quantitative evaluations, and a proper "dialogue" must be established between theses two types of assessment.

4.Towards a policy-relevant framework

The foresight research showed the diversity of pathways that could be followed towards a post-carbon city, highlighting for each of them their advantages and weaknesses. However, one of its main conclusions is that none of the six scenarios achieve all of the objectives of the post-carbon society. In other words, an efficient solution would have to be found in the combination of some scenarios. For instance, Self-contained City (scenario 5) could be highly compatible with Carbon Creativity, New Climate and Energy Infrastructures or frugal urbanity (respectively scenarios 2, 3 and 6)[10].

Going further than these first conclusions, the research program "Rethinking cities in a post-carbon society" had a goal to offer to decision makers some practical help to design coherent and efficient strategies over time. This is why a seventh scenario was developed, whose aim is to highlight the main obstacles a city could encounter and the possible ways to overcome them (at a local scale but also at a global one, with a coordinated framework).

The seventh scenario: the conceptual frame

Its philosophy is summarized here in seven main guidelines, for policymakers:

- Taking into account all of the objectives of a post-carbon city in an integrated manner, without separating constraints from opportunities;
- Affirming at national level the central role cities have in the transition to a post-carbon society. The overall governance must seek to articulate institutional layers between each other;
- Being able to identify distinct timings for action, to ensure their articulation (there is a need to coordinate the three time frames despite the current crisis: short-term emergencies, medium-term Climate Plans and long-term strategies);
- More clearly differentiate urban

10 Conversely, Biopolis and Self-contained City on the one side, and Carbon Creativity and Frugal Urbanity on the other, are designed according to hypotheses that are quite contradictory.

intervention scales;

- Segmenting actions by "target groups";
- Combining technical innovation and social innovation, expertise and involvement of the society;
- Articulating strategies for sustainability, strategies for long-term transitions, and resilience.

A brief description of a successful transition to a post-carbon society, from today to 2050, would consist in a three-step journey.

A first step would be a “boot time”. Building on the national debate on energy transition[11] outcomes, the goal would be to mainstream the topic of post-carbon cities and society in the national and local public debate, linking it to innovation expectations and responses to the socio-economic crisis. In a second step, based on the experience gained in the first phase, it would be possible to consider deeper reforms regarding current institutions, which would give cities the means to pursue ambitious climate and energy policies. To do so, they need to be more independent in the decision making process and to be able to cope with these issues in an integrated manner. Working on transitions at the local scale is a great opportunity to modernize the local institutional system, taxation or access to housing conditions. It can also participate to the clarification of the very long term vision for the French energy system (at least 2060), and thus to think beyond the lifespan of current nuclear power plants. Last but not least would be the period of mutations of the society. Indeed, steps 1 and 2 set up the bases for a potential trajectory towards some “low carbon” cities. Nevertheless, reaching the "post-carbon" status requires much deeper transformations regarding lifestyles, the organization of labor or even regarding the ownership of the city. More generally, the whole model of economic development will have to change significantly. A major part of scenario 6 – Frugal urbanity – is devoted to this. In other words, the mutations which must be sought are not only related to specific policies, but also related to cultural, economic and sociological change in our day-to-day life. The principles to which we yearn for are therefore the following: a sober society, structured by the new means of consumption and production, communication and solidarity.

As a conclusion, the "seventh scenario" provides a framework for action which allows every single community to define its path to a “post-carbon city” consistent with a global system of governance. Here, many guidelines are suggested, and the overall framework may seem at first sight to be very difficult – and therefore unlikely – to be implemented given the current context. However, it must be stressed that many of these proposals have already been widely raised up in the public debate and, in some cases, partly implemented. Above all, it is a long-term agenda. Yet, it is important to reinforce the general movement that has already begun. Regarding this objective, the measures proposed in this foresight research can be useful.

In the current context of economic and social crisis, taking into account the risks growing cities will face in climate and energy policies does not appear as a non-sense goal. Most of the 2050 post-carbon issues are already here for some cities and their inhabitants: energy bill is becoming too high for many, commuting is often too long, real estate and housing sometimes inaccessible, etc. The proposed framework is also, as the scenarios shown it, a potential considerable trigger for innovation in technological but also social, cultural or institutional areas. As a result, French cities could increase their attractiveness and quality of life. Therefore, we are not adding up new constraints but opening new opportunities.

11 Occurred in France between 2012 and 2014.

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Office of the Commissioner General for Sustainable Development
Sustainable Development Department
Tour Sequoïa
92055 La Défense cedex
France
Tel: +33 (0)1.40.81.34.89

Abstract

Through the Europe 2020 strategy, the EU identifies climate change and energy sustainability as top priorities of its political agenda. In this context, the idea of a transition towards a **"post-carbon society"** is gaining momentum. This concept can be defined as the achievement of three main objectives by 2050: dividing GHG emissions by four compared to 1990 levels, being almost self-sufficient regarding fossil fuel use (more specifically oil) and having the capacity to adapt to climate change. Of course, this has to be realized in line with a sustainable development.

Futures studies often lack territorial approaches when dealing with climate and energy challenges. This article is a contribution to fill this gap by answering two main questions: **what is the role of cities in this transition? How could they lead to a post-carbon society?**

The first question raises the point that cities are both guilty and victims of climatic changes and fossil fuel dependence, and shows in the same time that local level offers unique triggers to engage a territory in towards this transition. The second question was treated through the quest of current and future opportunities cities could mobilize to transcend urban inertia. To do so, an **interdisciplinary foresight and research program** involving academics, experts and local authorities, has conducted some research, focusing on the French case. Six various scenarios, i.e. six contrasted transition paths, from today to 2050, were designed using a combination of both forecasting (for global trends) and backcasting methods (for levers and policies). The outcome is twofold. Not only the way the scenarios have been built intend to reflect the complexity of urban metabolism, but their qualitative and quantitative assessments also detail the role urban stakeholders could play in various trajectories.

As a result, three issues clearly appear to be crucial in the transition towards a post-carbon society. The first one is that combination of **technical and social innovation** will be required to address the challenge of sustainability. The role of **changing behaviors and lifestyles** is also important, particularly in short term as an insurance to face uncertainties and a way to develop resilience. Third, more **consistency shall be given in transition processes** between time horizons (short, medium, long terms) on the one hand, and spatial scales (from the individual to global level) on the other hand.

Above all, this research is built on the myriad of initiatives that already exist in exemplary cities across the world. Unfortunately, these isolated actions will not be enough for moving to a post-carbon society, and a more massive shift is required. In this perspective 'Rethinking cities in a post-carbon society' aims at **gathering local experiences in order to foster their diffusion at a wider scale.**

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