Four scenarios for urban energy coordination: large companies, local authorities, state intervention and cooperative actors

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Introduction

Pressed by the urgent need to mitigate climate change, renewable energy sources are already replacing fossil fuels. Temporary drops in the spot price of electricity now occur in Europe when peak solar and wind output coincides with slack demand. There may nevertheless still be a need for conventional thermal power plants to cope with peak demand. Management of intermittent energy sources and energy storage are consequently crucial issues for the medium term. Two possible routes are of particular importance: on the one hand, funding of generating capacity[1] – via a market instrument yet to be devised – to cover only periods of peak demand and intermittent supply; on the other temporary demand-side management of end-users. These two routes have been studied in detail by energy actors and encouraged by public-sector sponsorship of research. But they have so far made no allowance for local

[1] In addition to material production capacity, this instrument would be designed to capitalize on the demand-reduction capacity of large consumers.

authorities, resident groups and intermediate bodies, despite the fact that they are playing an increasingly important part in deploying renewables and achieving greater energy efficiency. Being more complex than commercial transactions, the relations between the various actors have given rise to sharply divergent analysis by different disciplines.

Scripting future scenarios, which requires input from several disciplines, is standard practice as a decision-making tool informing democratic debate. With (or without) assistance from experts in energy and geo-physics, economists have scripted quantitative scenarios integrating energy prices linked to greenhouse-gas emissions and resources. For many years such scenarios have contributed to climate research as part of international negotiations and to framing national and European R&D policies (Alazard-Toux et al. 2014; Ademe 2013). Quantitative technical and economic scenarios have played an important part in French strategy on research and the national debate on energy transition, leading to legislation in 2015. The French law on energy transition aims to have as decisive an effect as the Energiewende in Germany.

Geographers and planners also use prospective scenarios covering the entire country, a city or an urban project, in order to clarify policy decisions or inform debate on planning decisions on the basis of qualitative rather than quantitative criteria. However they were little used in the debate on energy transition and in prospective scenarios; political scientists, who are not familiar with such methods, have not used them much either. Yet all these disciplines contribute to an understanding of the interplay of games and systems of action, and in so doing, to that of the technologies, regulatory systems and strategies being deployed.

The socio-technical approach – a current of thought in the social sciences – has largely demonstrated the links between technology and society: the effect of institutional regulation on energy governance (Poupeau, 2013) and the deployment of technical systems (Berkhout et al, 2004; Geels and Schot, 2007); the organization of large technical networks and its subsequent dependence paths (Coutard, 2002); the enmeshing of town planning and networks (Dupuy et al, 2008; Rutherford and Coutard, 2014).

Our purpose is not to discuss their findings, simply to illustrate the various forms of interdependency between the political, urban, organizational and technological dimensions of energy in a manner accessible to decision-makers and the general public. To achieve this, we propose four scenarios for coordinating energy in an urban environment between now and 2040. The scenarios are based on research carried out as part of the Ecoquartier Nexus

Energie project, funded by Ademe[2] and involving a dozen Grenoble researchers specializing in planning, economics, sociology, management and technology.

We present here the broad lines of the Ecoquartier Nexus Energie[3] research action and the method used to script and summarize the four scenarios, centring on four pivotal actors:

- Large companies, supplying urban energy systems;
- Local authorities, steering territorial planning;
- The State, acting as the central power framing rules and regulations; and
- Cooperative actors, collectives seeking to regain control over housing and energy.

Ecoquartier Nexus Energie project

The Ecoquartier Nexus Energie project had three objectives:

- To explore the field of possible outcomes in terms of society and organization for the local management and storage of energy;
- To develop a pluri and inter-disciplinary approach connecting energy systems, urban planning and public regulation;
- And, thus, to contribute to democratic debate on energy transition.

In order to grasp the organizational, political and planning dimensions of managing energy in a city, the Nexus research action observed innovative energy systems as they were deployed at the finest mesh of energy networks, at the level of neighbourhoods and buildings. This level is in the process of becoming the locus of production, consumption and storage.

We gave priority to a socio-technical approach, treating urban energy systems (including networks) as the result of assemblages. The basic unit is what we refer to as a socio-energy node, a group of physical components purveyed by a prime contractor (property developer, utility, local authority, etc.) interacting with stakeholders, and national and local regulatory bodies (Debizet and Blanchard, 2015).

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[2] The author and all of the NEXUS team are very grateful to Ademe (Agence De l'Environnement et de la Maitrise de l'Energie, France) for its financial support.

[3] Ecoquartier Nexus Energie research project, led by the Pacte UMR5194 laboratory (coordinator Gilles Debizet), the Federative Research Structure Innovacs, Edden, Ines (CEA) and Grenoble School of Management. http://www.nexus-energy.fr/ .

So, in the case of the heating energy vector, the developer commissions, designs and produces (directly or indirectly) the distribution equipment and network inside the building; a utility develops a heating plant and a neighbourhood network serving buildings (see Figure 1). These nodes are connected to larger electricity, gas or heating networks, capture heat from the sun or ground, may be supplied by lorries conveying biomass. A node consists of at least one apparatus for converting energy (power transformer, biomass boiler, central heating and power system, substation, etc.). The node's perimeter is defined by the actor tasked with funding and building it or, in the case of existing nodes, operating it.

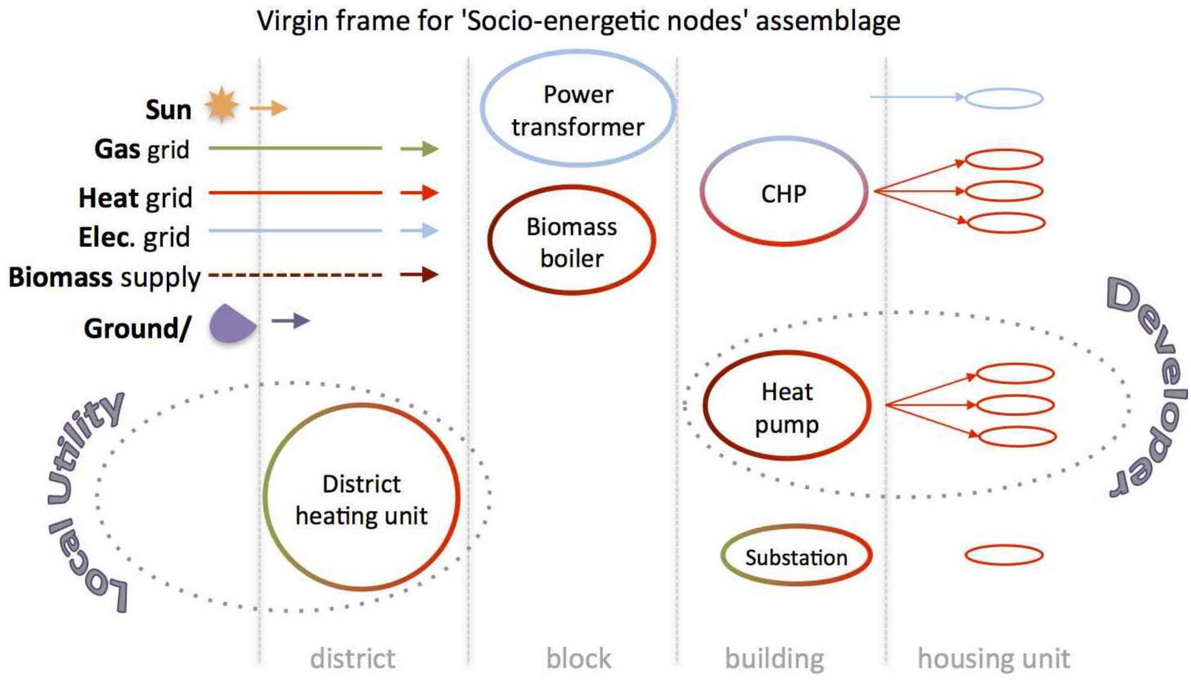

Figure 1. Examples of socio-energy nodes and other components (Debizet)

Drawing on actor-network theory (Akrich et al, 2006; Latour, 2007), applied in particular to the city (Farias and Bender 2010), we can use this definition, having adapted it to suit energy systems and focused it on the prime actor. We can name and delimit research objects common to the various members of the research team, regardless of discipline. For example a socio-energy node may be treated as the basis of a business model, as the heating packet of an urban development project, or as part of an energy network.

Prior assumptions rooted in specific disciplines may thus be set aside, but not given up, researchers being at liberty to go on using them for their own analysis. Simply, on a provisional basis, they are not shared with other members of the team. The socio-energy node concept thus enables researchers from different disciplines to discuss the same objects in concrete situations without imposing a single point of view or explanatory categories (Debizet et al, 2014).

The project comprises phases of individual analysis, from the perspective of a single discipline, within a shared corpus: firstly a bibliography on about 15 eco-neighbourhoods in Europe, then a set of interviews carried out in four French eco-neighbourhoods. These individual phases fit into phases of joint production:

- compiling a bibliographic corpus of European eco-neighbourhoods (Figure 1): selection of eco-neighbourhoods and the fields for a bibliographical database; selection of technologies and eponymous field headings (Debizet and Blanchard, 2015).

- survey of four eco-neighbourhoods (Figure 1): selection of terrain and 38 people to be surveyed; preparation of a survey plan; interviews carried out by two-person teams; transcription; preparation of a common coding system, using N'Vivo software; and coding.

- morphological analysis and scenario scripting (Figure 1): identification of variables on the basis of an inventory of what already exists and weak signals; choice of inputs to the four scenarios and the prime witnesses for the prospective workshop; revision and adjustment of scenario scripts (Figure 1).

The scenarios and the three chapters focusing on interaction between technology and the economy, and policy-making and town-planning, respectively, and on business models will be published in late-2015 in a French-language book. Alongside this collective work, research-team members have been encouraged to publish in their respective communities in order to pursue the individual analysis discussed above in greater depth.

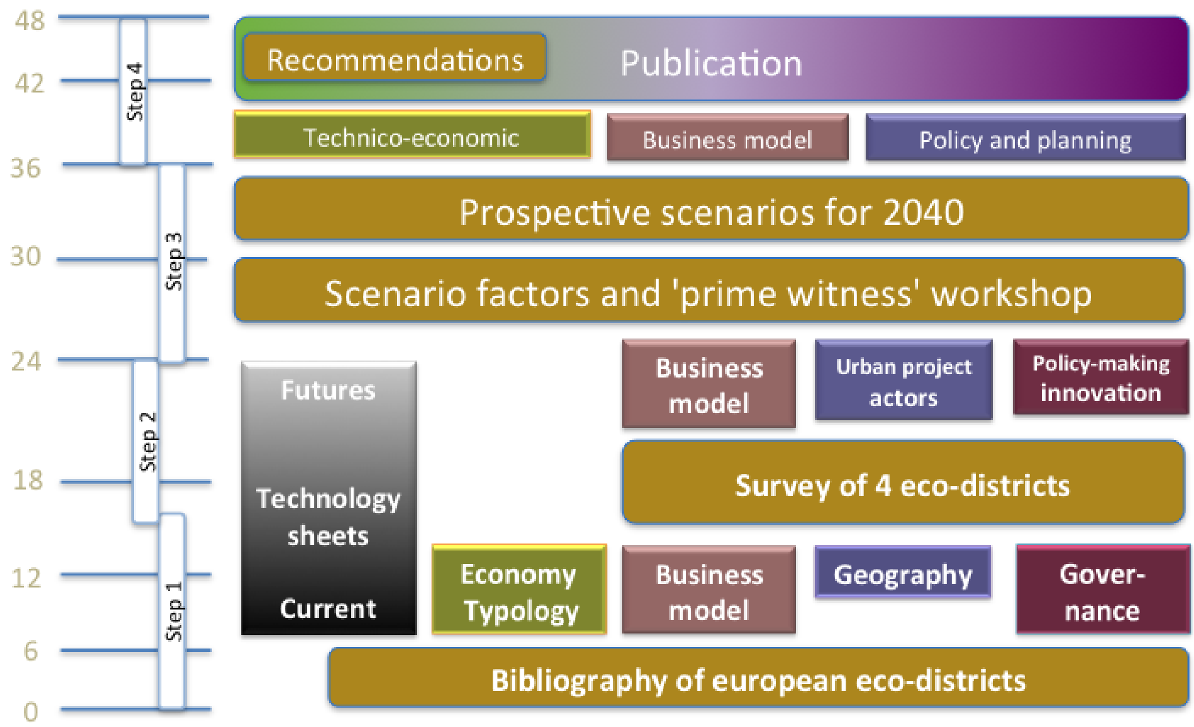

Figure 2. Sequence of Ecoquartier Nexus Energie research

Scripting scenarios

In the following we shall focus on the final phase of the Nexus research project: it involves proposing coherent systems for organizing the energy function (particularly electricity and heat) in a city between now and 2040. This prospective work takes the form of scenarios which are plausible but lead to contrasting trends, in particular in socio-technical terms.

Drawing on the work carried out during the previous phases of the Nexus project[4], we have established that the core actors in the process exert considerable influence over the future direction of a city (regarding energy or other fields). Technology obviously influences the available options, but this is conditional on it being advocated by actors who see in it as an opportunity, coordinate their action and overcome obstacles. At the same time the type of technology which is developed depends on the motive configurations of the actors, with regard to both the energy vector and associated facilities. In this respect we have posited that

[4] The methodology is described in detail in the chapter: Debizet, G., Doré, A., La Branche, S., 2013, *Méthodologie de construction et d'exploitation du corpus d'entretiens*, in Debizet G. (ed.) Rapport intermédiaire n°2 Projet de recherche Ecoquartier NEXUS Energie, submitted to Ademe on 30 September 2013, unpublished, 195p.

the future for energy depends on the categories of actors in a position of force in the relevant territories. We refer to them as ‘pivotal actors’.

In defining a pivotal actor, we have taken our cue from Brullot (2009), who followed Mitchell et al. (1997). An actor is pivotal if it can mobilize other actors as a function of its interest in stakes, its legitimacy and power of coercion. For the purposes of our discussion, we shall distinguish between two aspects of power: legitimacy and coercion. The second aspect relates to an actor’s capacity to incite and/or constrain other actors to obey a rule. This applies to the State, of course, but also a local authority, depending on its prerogatives, and even a company, providing it is in a position of dominant power (such as its capacity to fund, or not, a project, or through its oligopolistic position). Power of coercion is not enough; the influence exerted by an actor (through lobbying, for instance) is also the result of its interest and legitimacy. Finally, the latter relates to the capacity of an actor to convince other actors that its actions, ideas and aims are valid, or at least deserve respect.

In keeping with prospective scenario-scripting practice (Ademe, 2013), morphological analysis was broken down into variables containing specific qualifiers for each scenario. It drew on the results of thematic analysis by the various disciplines, discussion within the interdisciplinary team and a workshop attended by about 15 prime witnesses from the energy, construction and planning sectors. Coordinated using the PAT-Miroir method (FAcT-mirror method, Le Cardinal, 2001) the workshop enabled these witnesses to express fears, preferences and temptations and to assess their importance for different actor categories. This input from urban development and energy actors enabled us to validate – or adjust – the hierarchy of interrelations brought into play by the scenarios.

The ‘exogenous’ assumptions are common to all four scenarios. Most of them are compliant with French and European climate forecasts and the long-term forecasts issued by the International Energy Agency: energy demand for heating is set to fall, but will increase for cooling; the price of fossil fuels will rise; intermittent energy sources will account for a substantially larger share of the electricity mix; the potential for self-production of electricity and heat will also substantially increase. The last two factors amplify fluctuations in wholesale electricity prices and impact negatively on generating operators. At an institutional level we have assumed that the State and local authorities will still be in place and in a position to levy taxes on the operation of transmission and distribution networks. It is also assumed that the market will remain an essential – albeit not the only – mode of economic transaction; on the other hand the regulatory framework (applied, for instance, to gas and electricity) may differ from its current form.

Prospective scenarios

Large companies scenario

The return on major investments in renewable-energy production and real-time management correspond to complex, multiple-energy systems controlled at the level of a whole city or large parts of a city. An integrator company – or consortium of companies – sells integrated services subject to performance-based contracts (reliability, standard tariffs, and even environmental performance) negotiated by the local authority, and proposes a range of energy services (dynamic pricing, remote energy management, load-shedding, etc.) to end-users. The companies use renewable energy produced on the spot or purchase from the market via the European electricity grid, depending on circumstance and in such a way as to optimize profits. In the urban space these companies deploy equipment to convert and exchange flows between the electricity, heating and perhaps gas networks, in order to store surplus electricity at times of peak output by local wind or solar sources, as well as electricity purchased on the market at an advantageous price, when production in Europe as a whole peaks; they then feed this electricity back into the network at times of peak demand. Their preference is for complex, technologically advanced solutions which enable them to contain competition from newcomers.

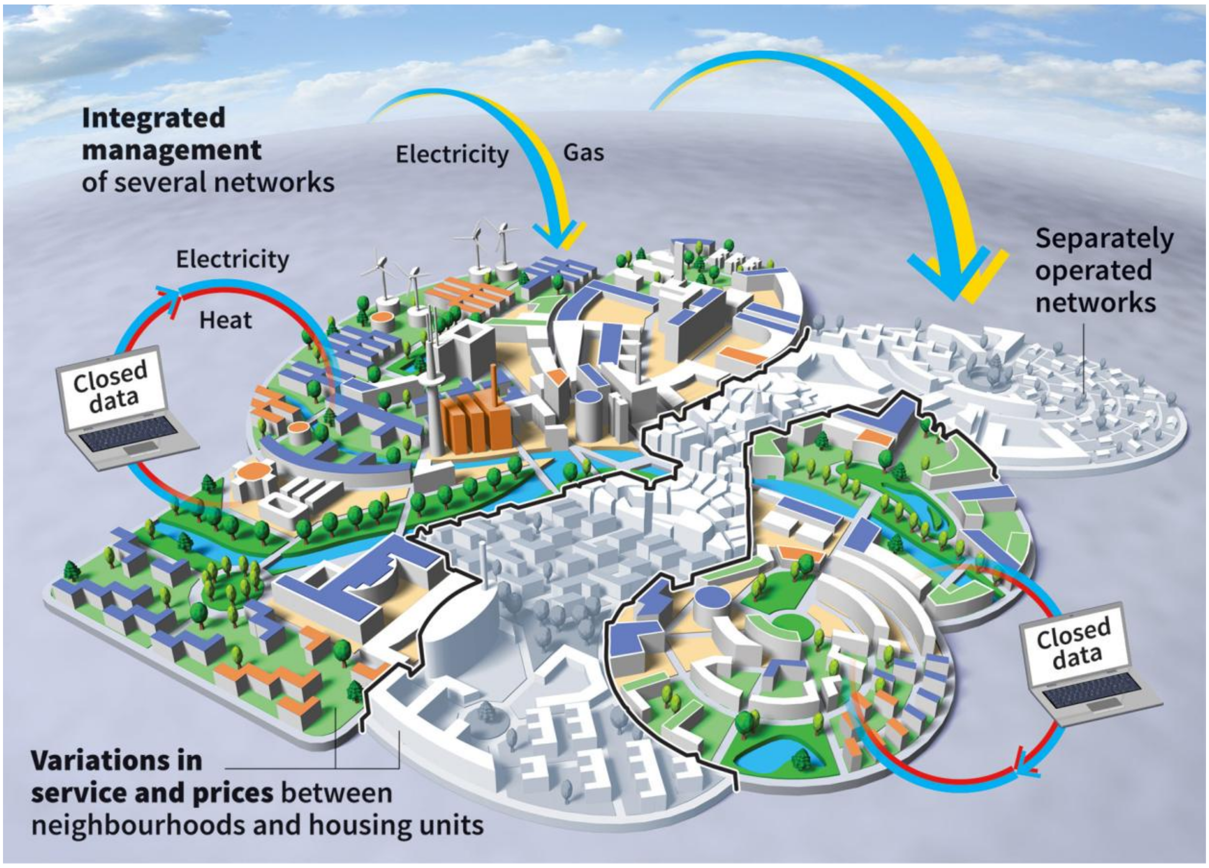

Figure 3 Large companies scenario (illustration, P. Mouche)

Keen to sustain competition and keep a margin of influence, the local authorities only grant concessions to multiple-energy companies for part of the urban space, particularly in large metropolitan areas. Areas of the metropolitan territory with high network costs or low energy demand – due to self-production (peri-urban or suburban districts) or low income – are unlikely to be concerned. This business model may result in unequal access to energy between neighbourhoods or population groups, due to differentiated commercial offerings.

Local authorities scenario

Keen to reduce the energy bill for the territory it governs, while securing equal access to service, the local authority plans energy distribution, production and storage, and supervises the working of separately operated energy networks. It encourages energy-efficiency and the use of proximity energy sources (solar, wind, hydropower, biomass, etc.), as well as local storage resources (methane heat and hydro-electric reservoirs). The local authority – its territory generally covering the entire metropolitan basin – seeks a high degree of energy-sufficiency, drawing on its hinterland and supplemented by energy exchanges with other territories via national or European (gas and electricity) networks, as part of cooperation contracts.

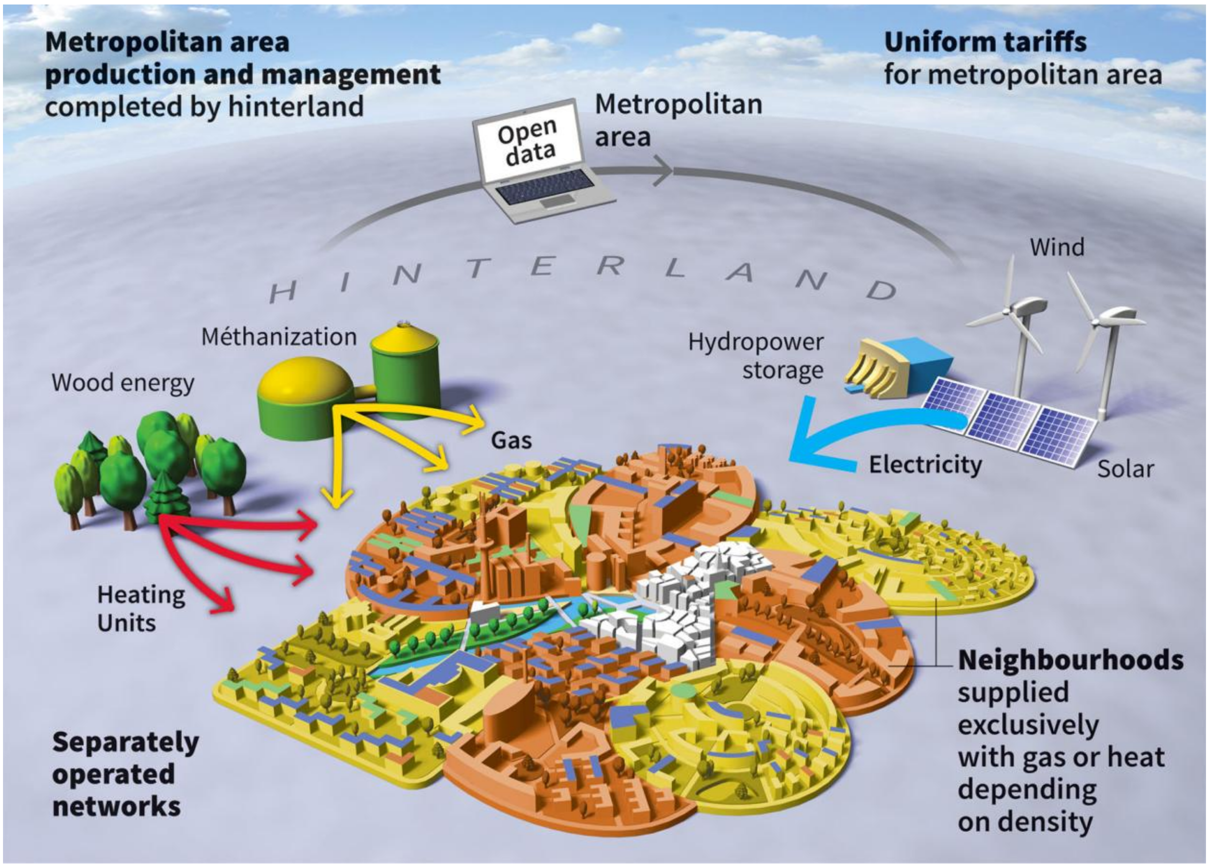

Figure 4: Local authority scenario (illustration, P. Mouche)

The authority promotes a high level of social and functional diversity in its neighbourhoods in order to minimize network costs. Economic (tariff schemes, taxation, etc.) and quality-of-service (reliability of distribution) conditions vary more markedly depending on territories. Taxes on energy consumption are nevertheless organized in such a way as to balance out over the territory as a whole. On the other hand, taxes related to the national (electricity and gas) transport networks are gradually lowered in line with reductions in the capacity of these networks, because local production and storage reduce both the volume of energy and peak demand for energy from the networks.

Interventionist State scenario

The State sets strict targets in terms of solutions and levels of performance, using available instruments, such as planning rules, regulations, tax system, subsidies and tariff schemes. The State and publicly owned national companies take charge of the design of the networks and infrastructure necessary to achieve efficiency and reliability. Optimizing renewable resources at a national level they give priority to large projects (on and off-shore wind and solar farms) coupled with massive storage facilities. They also exert strict supervision over smart grids in order to limit the load on the national grid at peak hours, this infrastructure already being under considerable pressure due to the distance between centres of production and consumption.

The State guarantees access to energy at a standard (and affordable) price nationwide. This price is barely sufficient to cover network costs and the production capacity needed to meet peak demand. Under these circumstances fluctuations in European electricity prices compromise the viability of national operators. To reduce peak demand, storage facilities are made compulsory in new buildings and older structures receiving state subsidies, but this measure leads to greater pressure on the part of new energy operators to unlock the smart-grid business model.

In this scenario, the economic fragility of national operators – which are essential to the State – could prompt the latter to disregard European Union rules. Local authorities take no measures to develop and manage renewables, for lack of adequate margin for manoeuvre and a politico-economic interest, and may be tempted to oppose projects which jeopardize their environment.

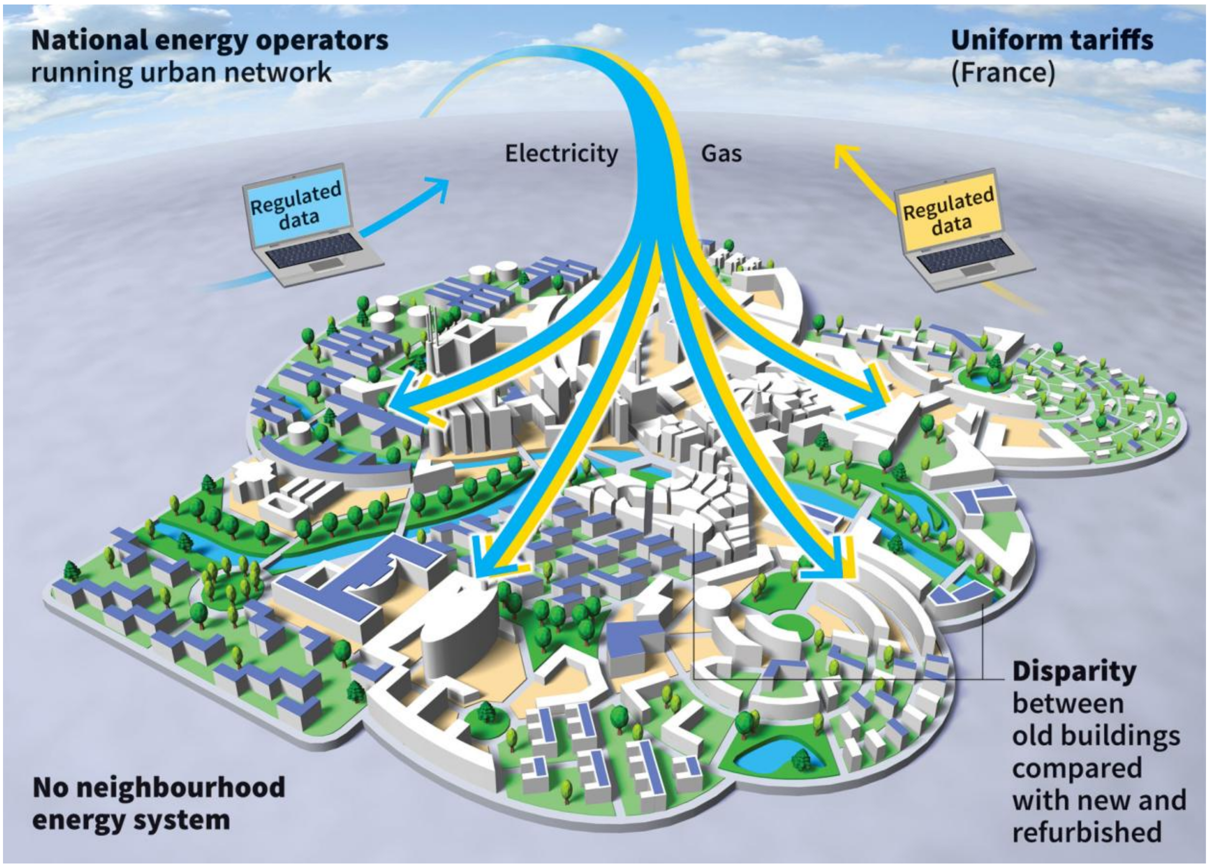

Figure 5: Interventionist State scenario (illustration, P. Mouche)

Cooperative actors scenario

Private, resident initiatives are driving a steady increase in the number of cooperative buildings, managed collectively to achieve environmental targets and promote social cohesion. The aim is energy independence for individual buildings but this is difficult and expensive to achieve. So cooperatives have connected several buildings in order to pool equipment (heat storage, wood boiler, etc.) and exchange flows, in some cases even jointly investing in renewable-energy production (collection of heating wood, wind, rural methane generating units) and storage facilities on the edge of the city (small hydro-electric reservoir). The prevailing culture of self-management gives priority to robust, low-risk technology with regulatory systems which are simple enough for the rules to be debated collectively.

The cooperative makes allowance for solidarity concerns when defining the price of access to energy; but disparities develop between coops in the same city. The economic and 'democratic' success of these coops favours their deployment, with cooperative networks taking on-board existing collectively owned housing units (condominium) and small firms. The local authorities support such initiatives but also seek to exert control over them: to guarantee resource reversibility and network stability; to prevent isolationist withdrawal, and; boost the security of infrastructure funding. In this way co-commitment networks are forming within the metropolitan space in connection with resources located in the hinterland, without creating continuous (joined up) spaces; the cooperative model co-exists in the territory with one or more of the other scenarios.

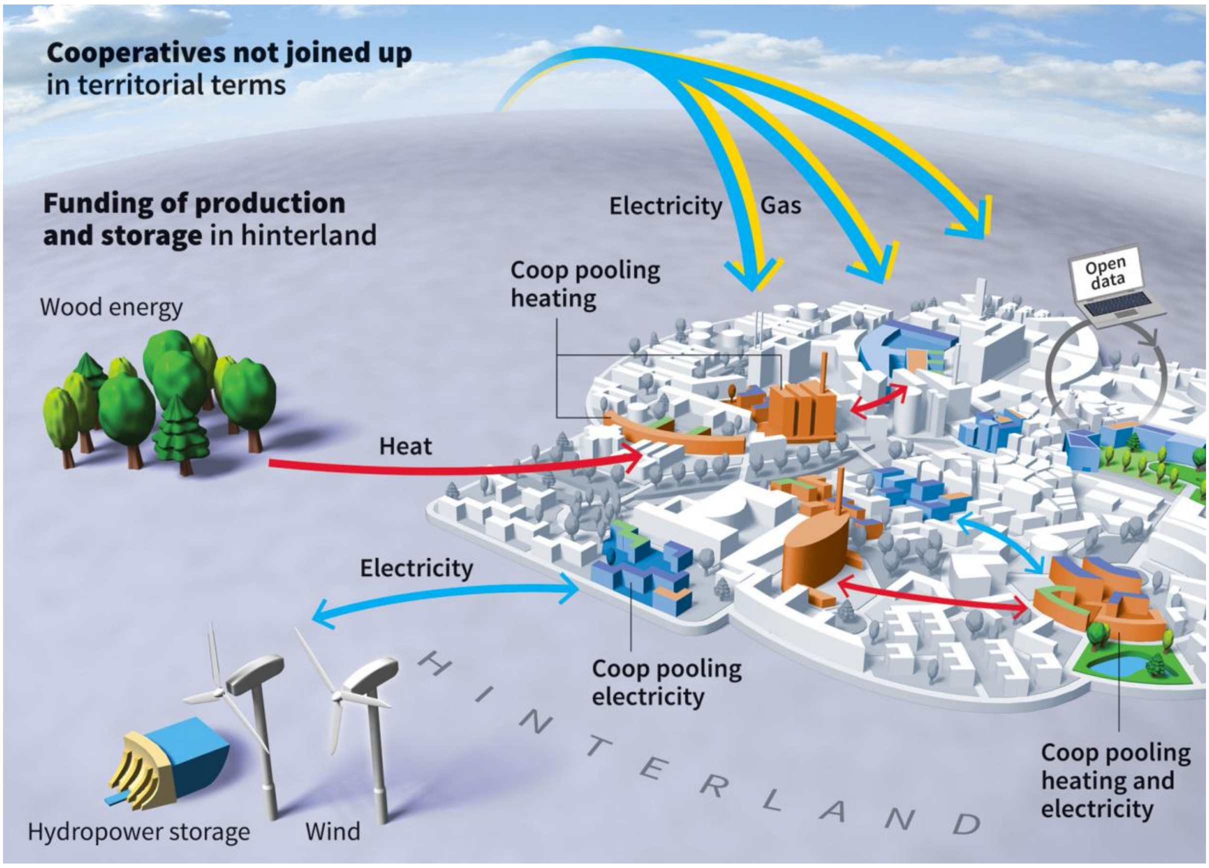

Figure 6: Cooperative actors scenario (illustration, P. Mouche)

Conclusion: of the usefulness of the scenarios

Contrary to the view that technology and macro-economic stimuli necessarily drive the deployment of technical solutions, the scenarios proposed here illustrate the social, economic and political factors weighing on the deployment of technology, factors which socio-technical approaches have amply demonstrated, but as yet too discreetly. Such analysis highlights the territorial implications of developing renewable energy sources, and hence its impact on democracy. In so doing it serves as an aid to decision-making by public and private actors, in doubt about the possible futures they might have to face.

The prime witnesses (see above), who have read the full version of these scenarios, expressed almost ideological preferences for such and such a scenario: notions of economic competitiveness, solidarity, democratic control (of trade-offs and data) and territorial scale were uppermost in their responses. They thought the scenarios plausible given the reality of the emerging mechanisms described and the internal coherence of each scenario.

The work done within the team and the presentation of the scenarios to technology R&D actors suggests that these scenarios make sense in that they make allowance for societal questions underpinning energy transition and show the value of socio-technical approaches for grasping the complexity of the connections between energy systems and territory.

For the researchers involved in the project, the interdisciplinary construction of the scenarios revealed links which could not have been observed from the point of view of their specific disciplines. There was nevertheless no need for them to master the vocabulary or the concepts of other social sciences to make themselves understood: breaking down urban energy systems into units (socio-energy node) which can be grasped by all the members of the research team made it possible to draw, in parallel, on several disciplinary readings of the case studies when collectively scripting the various scenarios.

For the benefit of R&D and energy-planning actors, we shall be presenting posters at the SDEWES2015 conference, summarizing the main factors in the energy assemblage in residential areas: we have modelled the conditions for inserting new socio-energy nodes into the urban fabric. Taking into account the diversity of the project sponsors and stakeholders involved in an energy facility or system, this mode reveals the energy and environmental variables which need to be integrated in energy planning as shown in an other SDEWES2015 communication: '**Reconciling energy planning with urban decision-making. Socio-geographic configurations and the socio-energy node concept'.**

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