Energy Transition of Local Territories: Lessons Learned from the Case of the Sud Paca Region in France

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Abstract

Regions represent an essential scale for achieving the carbon neutrality objectives that France has set for itself. The prospective analysis of the different options available for the SUD PACA region allows the discussion of the relevant energy transition trajectories available for it.

Introduction

The last report from the Intergovernmental Panel on Climate Change (IPCC) reminded us, if humanity wants to limit the rise of temperatures to 2 ^{0}C or even 1.5 ^{0}C, it is required to start immediately a rapid and massive deployment of solutions targeting the reduction of greenhouse gas emissions (Masson-Delmotte et al., 2021), especially, it is required to stop burning fossil fuels, and start using other type of energies whose use is more environmentally friendly, in other words it is needed an energy transition. In this sense, achieving such energy transition is one of the greatest challenges that humanity is facing nowadays because it does not depend just on the deployment of technological solutions, it demands a complete shift in how society interacts with the environment and how it governs energy systems. In fact, past energy transitions have mainly relied on technological innovation, such as the transition towards greater use of coal with the invention of the steam engine, or the transition to the use of oil products with the invention of the internal combustion engine. The current energy transition is above all driven by awareness of environmental issues and it is in this sense much more complex because it is not only a question of promoting new technologies or resources, but of putting in place a set of new ways of governing together with the promotion of technologies, the change in consumption behavior, which will be implemented through political and social actions (Millot & Maïzi, 2021). In this regard, the establishment of energy policy has to shift from a centralized manner to a more participative one, including different actors, in particular including the participation of the territories that can influence on a great deal of emissions, and through their actions they can massively contribute to the energy transition by the deployment of actions according to the reality of their local energy system and their responsibilities.

Territories, key actors of the energy transition

Territories can contribute to the decarbonization of energy systems by mobilizing their local decentralized energy resources, for example, the recovery of waste heat through heat networks, or the development of renewable resources. In addition, local authorities can deploy transversal actions through different sectors and further contribute to energy transition, for instance, through the implementation of actions for the transport sector and urbanization. In this way they can promote the use of decarbonized energies for private and public transport, and through a better organization of the territory they can favor the shift to the use of less consuming energy vehicles, such as electric bicycles. In this sense, they can also increase energy efficiency by fostering building's renovation, and by including citizens in the energy strategies of the territory. It can be fostered better energy consuming behaviors and the implementation of other strategies aiming to reduce the environmental impact of the territories' activities. This scale is all the more crucial if we consider the

development of the circular economy (CE), whose strategy resonates with territorial development. CE emphasizes to reduce the consumption of resources, and the production of pollution by shifting the idea of conceiving something as waste, to consider it as a resource that has to be integrated into the economy, and if it is not possible to do so, it should be reintegrated into the environment in a way that it can be absorbed naturally. Its application depends mostly in the proximity between producers and consumers, as the transport of the resources would increase their final cost, so the recovered resources should mainly be consumed locally. This is for example the case of municipal solid waste whose management is a responsibility of local authorities. In this sense, French territories have been receiving the competences that allow them to contribute to the energy transition, and the application of more sustainable solutions.

The territorialization of energy policy in France

In France, through many different laws, energy policy was progressively declined to their territories, with an important milestone with the Grenelle I and II laws of 2009 and 2010, which reinforce the energy transition objectives of the territories by demanding them the development of a "Regional climate air energy scheme" (Schéma régional climat air énergie (SRCAE)) where they have to set long-term ambitions to decarbonize their energy system in line with national and European energy-climate objectives. In 2015, the law related to Energy transition and green growth (Loi relative à la transition énergétique et la croissance verte (LTECV)) profoundly renovates the tools of national and territorial governance to allow a more shared definition of policies and objectives. The means of action of local authorities are clarified and strengthened. This law introduces for the first time the CE concept into the French legislation, which is enounced as an economic model that looks to reduce the environmental footprint of human activities, but ensuring economic growth or green growth. In addition, the "National low carbon strategy" (Stratégie nationale bas carbone (SNBC)) was also set up and defines for all sectors of activity the various strategic orientations that will guide France towards a sustainable and low-carbon economy. The law on the "New territorial organization of the Republic" (loi portant sur la nouvelle organisation territoriale de la République (NOTRe)) law was also adopted in 2015. It aims to modify territorial competences by giving French regions responsibility for energy, air, the environment, and adaptation to climate change, and asks local authorities to adopt the "Regional scheme for territorial planning, sustainable development and territorial equity" (Schéma régional d'aménagement, de développement durable et d'égalité des territoires (SRADDET). This SRADDET makes it possible to rationalize the number of existing documents by merging several sectoral plans, including the SRCAE. In addition, in April 2020, the latest revised version of the (SNBC) was published setting the goal of achieving carbon neutrality by 2050, which means a reduction in carbon emissions by a factor of 6 compared to 1990. All these directives must be considered into the SRADDET. Hence, in response to these guidelines, the regions in France started to adopt their own objectives targeting the decarbonization of their territory. In the case of the SUD PACA region at the south east of France, it has updated its targets for the decarbonization of its energy system by aiming a carbon neutrality by 2050. This region presents particular characteristics concerning its energy system, mainly a concentration of the energy consumption in littoral areas that represents around 80% of the final energy demand of the region, and an important potential of renewable energies, especially in the rest of the territory where energy consumption is lower. In this regard, different questions arise when envisioning the future regional energy system, in particular how to develop the regional energy resources and how? What are the best options to reconcile high and low

consumption areas? Or how the application of CE perspective can help the development of the energy system and the achievement of the carbon neutrality.

Envisioning the future energy system of the SUD PACA region

For all these issues, different strategies can be followed leading to different trajectories of evolution for the regional energy system. In this context, prospective modeling appears to be a valuable (not to say indispensable) tool for decision support, so does the model constructed for studying these different possible options. More precisely, using the TIMES framework which was developed under the IEA's Energy Technology System Analysis Program (ETSAP) (Gargiulo, 2009), $TIMES_{PACA}$ is a bottom-up model using a partial equilibrium under a linear optimization paradigm, with the objective to satisfy the final exogenous demand of energy services at the lowest possible discounted cost for the development of the energy system in a time period and under constraints defined by the user (Loulou & Goldstein, 2016a, 2016b). For a better representation of the regional energy system, and to better capture its energy consumption characteristics, the energy system has been divided into ten different zones which represent the six departments of the region, Alpes-de-Haute-Provence, Hautes-Alpes, Alpes-Maritimes (AM), Bouches-du-Rhône (BDR), Var, and Vaucluse. However, three of these departments, AM, BDR, and VAR present their energy consumption concentrated in littoral areas, so to better capture their energy characteristics, they were divided into high consuming and low consuming zones. The tenth region, called PACA, represents the regional energy consumption on which the energy policy established by the region has no impact, such as for vehicles coming from outside the rest of France and from Europe, or airplanes. The model includes different technologies that can be developed and that can help the decarbonization of the regional energy system including: electrolysis, gasification, methanation, carbon capture and storage, among other. The analysis is developed under six different scenarios that try to explore the evolution of the region's energy system through different perspectives. These scenarios are:

- *Reference*: analyses the evolution of the energy system based on trends observed in past years, including recent energy policies already in place.
- *SRADDET*: expresses the objectives that the SOUTH PACA region sets itself within the framework of its SRADDET and seeks to analyze how they can contribute to achieving carbon neutrality.
- *Circular economy*: to explore how a circular economy perspective could facilitate the implementation of a low carbon energy system.
- *Carbon neutrality*: to assess the public policy guidelines established in the SNBC, in particular considering the carbon budget and an increase in the electrification of the industrial sector
- *Hydrogen*: Promoting the production and consumption of hydrogen, to look at the role that power-to-gas technologies can have in the territory transformation.
- *Autonomy*: explores a possible autonomy of the regional energy system

From the analysis of these different scenarios, it is possible to get some insights about how the region can reach a carbon neutrality. First, it has been shown that the application of a CE for the development of the regional energy system is a significant strategy that can massively help the transition towards the decarbonization of the regional energy system by the application of its

principles of reduce, reuse and recycle. In this sense, for the residential and tertiary sector, it should first be prioritized the renovation of buildings as it helps to reduce final energy demand, and second it should be aimed to develop the recovery of ambient and geothermal heat through heat pumps, which can help to cover heating, cooling, and water heating demand. The use of heat pumps is more attractive in the region as the weather is milder that the rest of France. Following the same perspective, it should also be prioritized the recovery of waste industrial heat through heat networks in order to cover heat demand, increasing at the same time the efficiency of the whole system. For the transport sector, it should be favored the shift to the use of individual mobility vehicles, such as electric bicycles which will help the reduction of final energy demand. This strategy should be followed by the electrification of private vehicles, and the recovery of end of live electric vehicles batteries that can be reused to back up solar roof production. For heavy transport vehicles and for buses it should be aimed the use of hydrogen. In the case of the decarbonization of the regional industrials activities, carbon capture and storage has to be developed for the steel and cement producing industries. The CO_2 captured should be mixed with hydrogen through methanation in order to produce synthetic methane, whose combustion produces less emissions than natural gas (14% less) (Meylan et al., 2017), which can help to reduce the use of other fossil fuels. But this synthetic methane should be only used for industrial activities as the other sectors can use other energies for its decarbonation.

For the energy supply side, electricity production can be completely decarbonized by the use of local renewable energy resources. First, onshore wind technologies should receive more attention from regional policy makers, and they have to overcome the current barriers that are affecting its deployment in the region as its production can really help in the regional energy transition (International Energy Agency, 2017). Hydro resources will still represent an important part of the electrical electricity production of the SUD PACA region in the future, but its development should be cautious, as climate change might have an important impact over the availability of the resources. In fact, with 1% more installed capacity in 2017 with respect to 2007, the region has produced 1% less electricity using this resource (Région SUD, 2018). The use of biogas and biomass for electricity production appears to be also an important leverage for the energy transition of the region as it helps to cover some of the peak, and night electricity demand, the same applies for ocean electricity production. Finally, solar energy turns out to be one of the most important assets in this transition. Solar roof photovoltaic production, are mostly developed in high energy consuming areas. Its production can cover residential and tertiary electricity demand, and the excess energy produced during high irradiation periods can be stocked in batteries and it can be also used to produce hydrogen through water electrolysis. Hydrogen is an important energy vector for the decarbonation of the regional energy system, as first it can contribute to the decarbonation of the transport sector, especially of freight transport vehicles, and it allows the reutilization of CO_2 in order to produce synthetic methane which helps decarbonizing the industrial sector. One important asset that facilitates the production of hydrogen is the saline cavity present in the Alpes-de-Haute-Provence department as it allows to store the hydrogen produced during high irradiation periods. In this sense, the region through the development of its renewable energy potentials, and the application of a CE perspective can reach a carbon neutrality and can contribute to the decarbonation of the French energy system.

Territories have to further commit with the energy transition

The analysis of the energy transition of the SUD PACA region is an example of how a territory can develop its local available energy resources in order to decarbonate its energy system and how it can contribute to reaching national climate-energy objectives. But as stated at the beginning, decarbonization options have to be deployed right now, and as fast as possible. In this sense, local territories have to understand their undisputed role in achieving this energy transition, so they have to embrace their competences showing real commitments, and learn to overcome the different challenges affecting the deployment of climate-related actions in its territories, finding the paths to deploy coordinated actions including all the different actors of the territory. This applies in particular to the SUD PACA region as the ambitious objectives established in the SRADDET have been declared following a display logic, but without real concrete commitments, mainly because political and economic actors do not yet appear sufficiently invested and committed about the subject of energy transition (Haut Conseil Pour le Climat, 2020). This explains also the lack of commitment from industrial actors who appear not sufficiently involved in the decarbonization of their activities in the region, and without their actions reaching the carbon neutrality seems unlikely. In addition, there is a lack of joint work between the region and its local authorities as the leadership role of the region is not strong enough, then some of the departments are not interested in working side by side with it (Ibid). Consequently, France has to seek as well to reinforce the means that the territories to act over the deployment of the energy transition, as the quality of their response will largely depend on the means at their disposal.

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