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Review Article

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Ecological and Environmental Science is Needed in The Energetic Transition: Example of The Macro-Photovoltaic Parks Projects in The Corbières Massif, Aude, South France

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Summary

The aim of this article is to analyze how a project for a ground-mounted photovoltaic park came about, how the process unfolded, the role of the authorities and local residents during the public inquiry, and the need for scientific studies. The responses to the public inquiry are analyzed, as are the main arguments for and against the project. Finally, we analyze what the Corbières and its garrigue habitat represent in terms of the environment, biodiversity, soils, climate change and the biosphere, as well as the services the garrigue provides and the well-being it affords to local residents. We also analyze the effects that this voltaic park, and the ring of other solar parks planned around it, would have on living things. This information will be followed by a discussion on the energy transition, the merits of this photovoltaic park, and social contradictions in the face of private companies with huge financial interests who are aggressively canvassing villages, with no energy returns and limited economic benefits for residents and the commune. We'll also look at the role of science in this process, since faced with all this the villagers had to organize themselves and felt the need for scientific support. In conclusion, we'll show the importance of associations. Indeed, it's worth pointing out that associations with a long-standing presence in the Corbières were very important in guiding the process, and strongly supported the arguments against the voltaic park. Among these associations, the arguments of the LPO were very effective in informing local residents and organizing responses to the public inquiry, especially with regard to avifauna and biodiversity.

But understanding the impact on soils and their vegetation cover, and the CO₂ retention capacity of the garrigues, was often difficult to explore and impossible to measure. The role of these habitats on the quality of the biosphere is also little-known, despite their extreme importance for living organisms. This habitat is essential for combating climate change and ensuring the survival of human and non-human species. Here again, the participation of scientists would have been welcome. Social and economic issues, from the point of view of local residents and municipalities, focused more on cash income than on structural issues, which are at the heart of the two current crises in the region: the crisis in municipal finances and the crisis in agriculture, especially winegrowing. Science still lacks answers to these questions.

Science needs to have a much more visible presence in the field and in these local conflicts, and to listen to local residents. Themes must not remain compartmentalized, and research must enable us to truly grasp problems from all their perspectives: social, human, economic, legal, environmental and ecological, the relationships between territorial and administrative scales, and the challenges of rural areas, which are all too often poorly understood.

¹ League for the Protection of Birds

Introduction

A ground-mounted photovoltaic park project requires a number of steps before a permit can be obtained and construction work can begin:

- a) The company behind the project first presents it to the town hall² concerned, which discusses it and may give a favorable lease opinion in return for a series of obligations on the part of the company. In the case of Fontjoncouse, at the Municipal Council meeting of August 25, 2017, there were deliberations authorizing the mayor to sign a promise to lease for the Photovoltaic park.
- b) A building permit application is then submitted to the Departmental Prefecture (Aude, 11)³ and to the DDTM11⁴, which forwards it to the DREAL Occitanie, the decentralized administration of the French Ministry of the Environment and Ecological Transition. The file must include an environmental impact study and a detailed presentation of the project.
- c) The dossier is being monitored by the Mission Régionale d'Autorité environnementale (MRAe)⁵ (Occitanie Region), which is due to issue an opinion with technical support from the DREAL, on this ground-mounted photovoltaic park project.

It is important to note that the opinion does not concern the opportunity of the project, but the quality of the impact study and the consideration given to the environment in the project. It is therefore neither favorable nor unfavorable. Its aim is to improve the design of the project and enable public participation in the preparation of decisions that affect it. The photovoltaic park project is promoted by the company Hexagone Énergie and located in the commune of Fontjoncouse in the Aude department, and in the Occitanie region map. The project site is located in the Corbières, on the Devès plateau, overlooking Fontjoncouse to the northeast of the area. The total fenced-in area of the project site is around 62 ha. The

project comprises 108,234 polycrystalline silicon photovoltaic modules, each with a power output of around 390 Wp⁶. The modules will be secured either by anchoring (piles or screws), or by external foundations requiring no excavation (concrete studs or stringers⁷).

At its highest point, the height of each table will be around 2

m, and the height of the lower edge of the table from the ground will be around 1 m. The installed capacity of the solar park will be around 58,000 Megawatt hours/year. The photovoltaic park will be equipped with 12 transformer substations, each with a surface area of 20.5 m², and a 16 m² delivery substation. The dossier states that “the nearest substation likely to be able to receive the electricity generated by the solar photovoltaic plant is the Palayrac substation”. This substation is currently being planned and is located around 21 km from the project. For this type of installation, a public inquiry is mandatory. The complete file is made available to all citizens. The opinion of the MRAe must also be included in the public inquiry. At the end of the public inquiry, the Aude prefecture authorizes the project or not.

Public inquiry

By order of the Prefect of Aude, the public inquiry was held over 33 consecutive days, from October 2, 2023 to November 3, 2023, in the small municipality of Fontjoncouse (131 inhabitants). The purpose of the public inquiry was to gather public opinion on the proposed macro photovoltaic park⁸. Residents are informed of this survey by signs on site, a notice in the town hall and 2 publications in the local press. It's worth noting that a certain number of residents, especially many newcomers, became aware of this photovoltaic park project while out and about, seeing the signs posted for information. A spontaneous movement was immediately organized to inform Fontjoncouse's inhabitants, to understand the stakes of this project on a garrigue environment, and to build arguments to respond to the public inquiry. The role of the LPO (Ligue de Protection des Oiseaux) was essential in this participatory process.

By the end of the survey, 210 comments had been received (200 on the website⁹ and 10 at the town hall). The investigating commissioner worked on these opinions, identifying the main arguments raised by residents about the project. A few weeks later, he published the report of the Public Inquiry¹⁰ into the creation of a ground-mounted photovoltaic power plant at Fontjoncouse. In this report, he takes up the main arguments and organizes them by theme. We will only give the number of opinions expressing concerns on each of these themes. An opinion may include concerns relating to several themes.

² Local Administration

³ Direction Départementale des Territoires et de la Mer for Aude

⁴ Administration representing the French state in the department or region

⁵ The regional environmental authority missions (MRAe) were created in 2016, alongside the Agency, in order to be able to express independent opinions on all “plans/programs” and to contribute to a better democratic functioning for the preparation of environmental decisions (consulted on March 15, 2024)

⁶ The watt-peak (Wp) is the unit used to measure the maximum power, or “peak power”, delivered by a photovoltaic solar panel under given conditions of sunshine, temperature and air quality (known as STC conditions). One kilowatt-peak (kWp) corresponds to 1,000 Wp.

⁷ Dedicated to encircling the floor, longrines are rectangular beams made of prestressed or reinforced concrete. These beams are equipped with steel and transverse reinforcement.

⁸ Reviews can be found at <https://www.democratie-active.fr/parc-solaire-fontjoncouse>

⁹ <https://www.aude.gouv.fr/Actions-de-l-etat/Environnement/Plan-et-planning-projects-susceptible-of-impacting-the-environment/Les-enquetes-publiques-et-consultations-du-public-dossiers-complets-hors-ICPC/Le-photovoltaïque>

¹⁰ <https://www.aude.gouv.fr/contenu/telechargement/26855/185428/file/rapport%20centrale%20photovolta%C3%AFque%20de%20FONTJONCOUSE%2030122023.pdf>, 2023.

List of themes in the public inquiry report:

Theme 1: Questioning the size of the project, often described as “gigantic” and perceived as oversized: 27 observations

Theme 2: Criticism of the choice of site in a rural area in a quality environment, when other alternatives are possible, particularly in anthropised, industrial, commercial or derelict areas: 54 observations.

Theme 3: Damage to the environment and biodiversity, particularly with regard to certain protected species. A request for derogation is often mentioned: 41 observations

Theme 4: Damage to the quality of rural life, the landscape and tourism (visual and noise pollution, etc.): 24 observations.

Theme 5: Fire risks due to the nature of the facility: 6 observations

Theme 6: Doubts about the project’s economic benefits and their use at local level, and questions about the cost of leasing communal land: 23 observations.

Theme 7: Cumulative projects within a 20 km radius: 9 observations

Theme 8: Call to respect the majority unfavorable opinions of the institutions and organizations consulted and the inadequacies of the impact study: 19 observations

Theme 9: Insufficient ERC¹¹ measures and questions about their durability, failure to apply for exemptions for protected species: 4 observations

A request for a derogation for protected species was submitted at the end of the survey. This is currently being examined by the DREAL Occitanie.

Theme 10: There are observations in favour of the photovoltaic park that are not supported by arguments: 31 observations

Theme 11: Comments in favor, with arguments, citing the need to produce renewable energy, reduction of carbon footprint, financial interest, non-agricultural nature of the areas chosen, fire protection: 45 comments

Theme 12: Observations highlighting a lack of information and communication: 3 observations

In conclusion, it is noted in the report that there were many opponents to the project, whereas there were only a few opinions in favor, for the most part without providing any arguments¹². In the review of opinions made by the author of this article, the themes proposed by the investigating commissioner overlap with his own. It should be added that several unfavorable opinions noted that the recent strong deployment of photovoltaic power plants in Corbières¹³ was the consequence of the new law to accelerate renewable energies for the energy transition. Several voices were raised to demand that renewable energies and the energy transition should respect biodiversity and not take place in natural or agricultural environments. An obvious paradox that several people have noted is that in Fontjoncouse, residents are forbidden to put photovoltaic panels on their roofs or garage spaces, as all the houses are located within a 200-meter perimeter around listed monuments:

The church, the remains of the castle, the wall and the Visigothic portal dating from the end of the 8th century. Several opinions highlighted the serious crisis in local finances, especially in small municipalities, and the crisis facing winegrowers. They also denounced the excessive liberalism that allows these private companies to take obvious advantage of these situations (Figure 1) map.

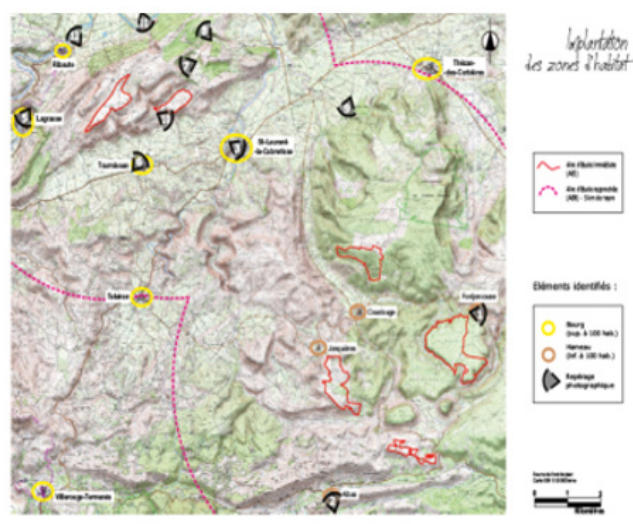


Figure 1: The network of 7 municipalities affected by Société Hexagone's photovoltaic park projects

¹¹ Avoid, Reduce and Compensate impacts

¹² <https://www.aude.gouv.fr/contenu/telechargement/26855/185428/file/rapport%20centrale%20photovolta%C3%AFque%20de%20FONTJONCOUSE%2030122023.pdf>, 2023.

¹³ Apart from the 7 parks promoted by Hexagone, other companies have applied for building permits throughout the Corbières.

The Corbières and the garrigue

The term garrigue or matorral is of Provençal origin. It designates an environment characteristic of regions with a Mediterranean climate. Sheep, goats, people and fires have all played a part in the development of this low, open vegetation since the post-glacial warming of the climate 10,000 years ago. The garrigue is not a deserted, uninteresting place, quite the contrary: it's a landscape that has been built up over thousands of years, a real landscape heritage that is little known or recognized. In France, garrigue covers some 400,000 hectares of limestone soil in Provence and Languedoc. The garrigue is made up of drought-resistant thorny shrubs: boxwood, gorse, juniper and cade, woody jasmine, rosemary, lavender, kermes oaks and herbaceous plants: honeysuckle, sarsaparilla and thyme. These open spaces are particularly important for bird nesting. Semi-open, rocky areas of garrigue are also highly protected. There are also holm oaks and olive trees. Forests of white oak and holm oak covered the slopes of the Corbières between the eighth and twelfth centuries¹⁴.

Specific adaptations in the flora enable plants to retain water, resist heat and protect themselves from predators. Corbières plants are resistant to drought and extreme temperatures. They can adapt better than other species to the new conditions of global warming. This flora creates a unique habitat, capable of maintaining a fragile balance despite environmental constraints: shallow soils, strong sunlight, drought and strong winds. These plants are essential to the survival of many animal species, which depend on them for hiding, shelter, safe reproduction and food. Without these plants, animals could not survive. Dry garrigue grasslands are home to numerous invertebrate species, including locusts, bees and a wide variety of butterflies. Also found here are the scolopendre and the languedocian scorpion. Among reptiles, the ocellated lizard and the Montpellier snake are protected species. The garrigue is home to a number of bird species that are declining in the rest of France, including the Bonelli's Eagle and the Short-toed Eagle. The Grey Harrier nests in the area affected by the photovoltaic park. To calculate the benefits of the garrigue and its importance for living organisms and humans, scientists use what are known as ecosystem services, which represent the benefits offered to human societies by ecosystems. Without the support of scientists, it has been difficult for us to make precise assessments.

There are four service categories:

- a. Supply services, direct extraction
- b. Temperature and climate control services

- c. Cultural services, nature walks, nature schools
- d. Support services. Preserving air and water quality

a) Supply services are all tangible products extracted from ecosystems, such as food, fuel, materials or medicines. These include hunting and game, pastures with their flocks of sheep from which meat, skins, wool, milk and cheese are extracted, timber and firewood, charcoal, blackberries and other wild fruits; flowers such as lavender, thyme and rosemary, whose nectar is used by bees to make honey; plants and mushrooms that are gathered to make essential oils or pharmaceutical products. Ten of the 25 best-selling drugs in the world are extracted from living organisms. The pharmaceutical industry draws most of its resources from biodiversity: in 1997, its turnover was between 75 and 150 billion dollars in the United States alone. Since the 1940s, natural compounds or compounds derived from natural sources have accounted for 55% of the products marketed in oncology. According to Newman and Cragg¹⁵, this percentage rises to almost 80% of drugs for the period 1981-2010, and 65% since the first anti-cancer drug was marketed in the 1940s. Cancer treatments include 42% wild plants in their composition¹⁶.

b) Regulating services are the long-term benefits provided by well-functioning ecosystems, which create biodiversity. Biodiversity is essential for regulating temperature and climate, and for pollination. The importance of fungi in plant-to-plant communication and soil creation, along with microbes and worms, is an essential process that is still largely ignored by the general public and our politicians¹⁷.

- c) Socio-cultural services

These services refer to the aesthetic, spiritual, recreational and educational aspects of wild habitats, as well as the source of inspiration they represent for human societies. Today, the garrigue is increasingly becoming a "wilderness" where people come to stroll or, as the buzzword has become fashionable, "to go wild". A survey carried out in the spring of 2010 among various users of the northern Montpellier garrigues, shows some of the different ways in which this area is viewed (Claval, 2012¹⁸). When asked to define what the garrigue is, a large proportion of responses were characterized by the predominance of terms evoking a sensitive approach to space, such as freedom, solitude, space, relaxation, walking and health, contemplation, resourcing, communion with nature, art, meditation, knowledge, values, etc.

¹⁴ Louis Lapeyre (1970): Histoire de Fontjoncouse, mimeo, 35 pages

¹⁵ Newman and Cragg. Natural products as sources of new drugs over the 30 years from 1981 to 2010. *J Nat Prod* 2012; 75: 311-335. [Google Scholar]

¹⁶ Newman and Cragg, idem

¹⁷ See the work of scientist Marc André Selosse of the Museum National d'Histoire Naturelle, Paris

¹⁸ Paul Claval 2012, Une nouvelle approche des sociétés et des milieux, Collection U, Armand Colin

d) Support services

Support services are those that are necessary for the production of all other services. Their effects affect human beings directly and indirectly, and are perceptible and essential to life in the long term. These services include, for example, the major biogeochemical cycles of water, CO₂, methane and oxygen. They enable the natural depollution/self-purification of water and air. They help mitigate the effects of climate change. They ensure the quality of the biosphere (Figure 2). Like all plant formations, scrubland plants, through photosynthesis, breathe. They absorb oxygen and capture CO₂ through their leaves and send them to their roots and to the soil. The garrigue therefore has an essential function in purifying the air, preserving and forming soils and their microorganisms. It also allows, through

the roots of plants, the infiltration of water and the supply of aquifers. It allows the presence and growth of deciduous and coniferous trees, and also offers protection to crops and humans against violent winds and heatwaves. These natural functions are essential for the well-being of the inhabitants of these valleys. The large surface area of garrigue on the slopes of our valleys and plateaus is precisely an essential condition for all these vital functions to be as effective as possible. Plants, roots and soils are carbon sinks. We talk about it a lot, but we talk little about the oxygen released by plants. Plant leaves and needles produce more oxygen than they absorb under conditions where leaf area is large and forests are growing and have not yet reached their climax. As it is the case in our research field, the garrigue thus contributes to the quality of the biosphere (Figure 3).

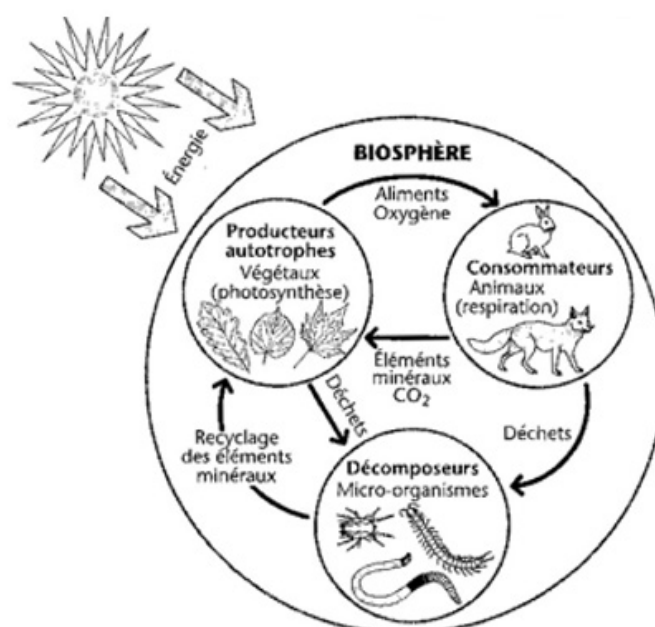


Figure 2:

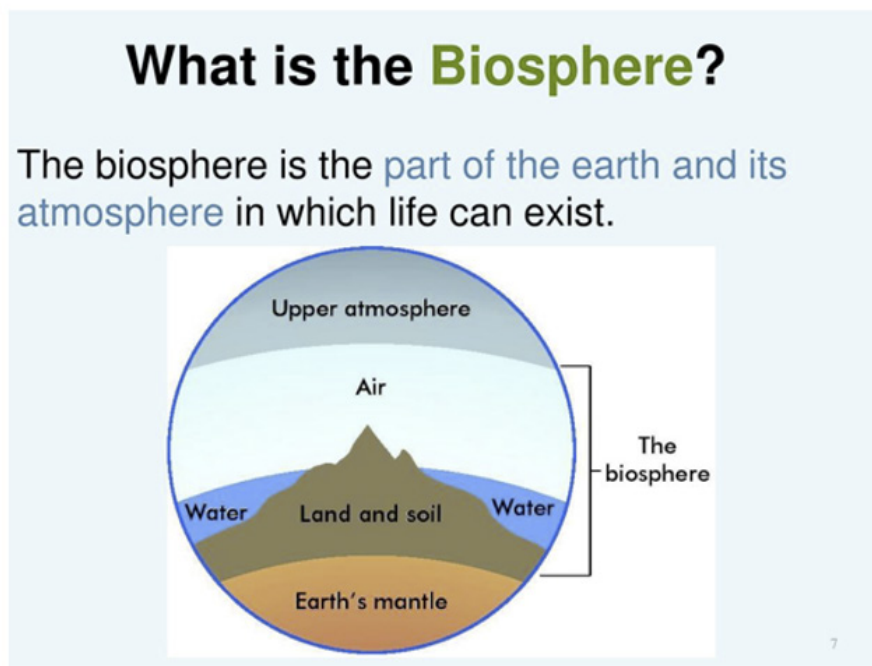


Figure 3:

Discussion

The energy transition and therefore the development of renewable energies represents a fundamental issue in the fight against global warming. In fact, the exploitation of clean and renewable solar energy allows significant electricity production and becomes an interesting alternative to fossil fuels. Compared to other renewable energies, solar energy benefits from the most stable and largest free resource available now. In Europe, the share of renewable energies reached 20.7% of gross final energy consumption in 2022. In 2021, France was in 14th position in the European Union. For its part, the photovoltaic solar sector has developed significantly since 2009. In 2022, production amounted to 21 Ton Watt h, an increase of 31% compared to 2021. The state and the prefecture consider Occitanie as an ideal place for its exceptional sunshine. In this regard, the Occitanie region and the Aude department are privileged solar sources¹⁹. Within these two territorial entities, the Corbières are at the center of this interest. Landlocked territories, in the grip of a serious crisis in local finances and a wine crisis which caused tractor demonstrations and road blockages in February and March 2024, the Corbières massif hosts in its valleys small villages remote from all large urbanization areas, many of which are around 100/150 inhabitants. In such a situation, the commercial aggressiveness of some project developers obviously benefits these kinds of facilities (ECCLA), because they can get low prices to rent the land they need. The economic structure guided today by industrial capitalism and excessive liberalism allows private companies to take advantage of the social and economic crises to enrich themselves quickly. This recent "boom" of photovoltaic solar projects in Corbières, and in

scrubland areas with high environmental value, is analyzed as an effect of the new Renewable Energy Acceleration Law (ECCLA)²⁰. As for LPO Occitanie DT Aude, it calls for an energy transition that respects biodiversity. It is therefore unfavorable to the development of renewable energy projects in natural environments or replacing agricultural environments. The MRAe recalls that the implementation of national and regional guidelines for the installation of ground-mounted solar power plants implies an approach at a supra-communal level, generally on the scale of a living basin area and that the sole modification of the development methods cannot be considered as a development alternative on a sufficient scale. Consequently and given the scale of the installation, it considers that the justification for the location of the site is not sufficient in view of the environmental issues. The MRAe²² also insists on the fact that there is no common reflection on the part of developers on a territory to be managed, nor on a common and sustainable management method. (C. Riols, LPO Occitanie)²³. Governance in a declining rural south is a key question here. Are the Corbières in the process of being colonized by uses (mass tourism) and infrastructures that the city does not want or does not have the place to put them in (eg. renewable energies, large landfill sites and waste recycling)?

In the criteria for the choice of the site one of them is the following: "The site is selected because it is located on a plateau area made up of unexploited scrubland"²⁴. It is precisely its open and unexploited spaces which allow the wildness and the very high ecological values of the floristic species present (grass with branched brachypode, lawns with therophytes, rare orchids, etc.). These are also areas protected by regional designations (Parc

Naturel Régional des Corbières-Fenouillèdes), and European (Natura 2000, and special areas for birds (ZPS, ZICO, ZNIEFF).

The Devès plateau is a very important nesting and reproduction site for the Grey Harrier – *Circus pygargus* (four young fledglings in 2022 and 2023), with a population of at least 5 pairs identified in 2023. This species is declining on the rest of French territory. The Devès plateau is a remarkable place for the Aude department with a colony of this importance. The regular presence of several Jean le Blanc Circaetes – *Circaetus gallicus*. This site also constitutes an environment particularly conducive to the good development of several species of Mediterranean warblers, including the Pitchou Warbler-*Sylvia undata*, which is present on the site in high density while its populations on a regional and national scale are in free fall (-85 % in the Occitanie region, -69% in France²⁵. The Ortolan bunting- *Emberiza hortulana* and the Red-headed Shrike-*Lanius senator*, not observed on the site by the design offices, are nevertheless present in the immediate surroundings of the plateau and more in-depth research would have merited to be accomplished (L. Feuillas, LPO).

Coming back to governance, we must also look at the promoters: the company Hexagone Energie²⁶. Since 2017, the “salespeople” of Hexagone energies (or its subsidiaries) have been prospecting for land and negotiating leases with small town halls in Corbières. Hexagone energies is a company organized as a S.A.S (Simplified Stock Company) since 2021. The SAS is characterized by its great flexibility insofar as its partners are free to determine, in the statutes, the terms of its operation (decision-making, management bodies, etc.) and to regulate the transfer of its titles (approval clause, inalienability clause, etc.). The amount of share capital is freely determined at 10,000 euros in the case of Hexagone. It should be known that in an SAS, the partners are only financially responsible up to the amount of their contribution. Thus, the creditors of the SAS cannot pursue the partners on their personal

assets. The shareholder and indirect beneficiary of Hexagone Énergie is also CEO of Néoen Solaire, which manages 23 other companies. This is the principle of a holding company. Among the leaders of Hexagone energie, the firm Bolloré Energie²⁷ is in first place on the list, which develops its activities in transport, logistics, energy distribution, plastic films, super capacity batteries, electric vehicles, communication and the media.

Hexagone's promises regarding the lease for the municipal land of Fontjouce are not very clear. The town hall claims that it will obtain 1,500 euros/Ha per year, or around 90,000 euros per year. But on these grounds, Hexagone and its subsidiaries will earn millions. The rental price seems rather low. Even if rents are paid on time, and some residents have doubts about, there will be no return of free or lower-cost electricity for residents. The population already feels like a loser. Scientific research on the legal aspects of photovoltaic parks would be welcome.

Another question to bring into the discussion is that of the carbon neutrality of a photovoltaic park. With the growing development of the sector, the carbon footprint of photovoltaics is being called into question. A life cycle analysis (LCA) shows that photovoltaics for parks of the scale of those planned in Corbières are far from being without carbon impacts. Several scientific articles have analyzed these impacts in India (Mukesh Kumar Na et al., 2020²⁸). The principle is to count the resources used and the emissions caused at all stages of the life of a product from the extraction and refining of ores, the manufacturing of solar panels, their distribution, installation and use. panels, electricity production, site dismantling and waste recycling.

Without going into all the details of these calculations, it is obvious that they are complicated and require independent scientific knowledge and methods.

¹⁹ <https://www.aude.gouv.fr/contenu/telechargement/26855/185428/file/rapport%20centrale%20photovolta%C3%AFque%20de%20FONTJONCOUSE%2030122023.pdf>, 2023.

²⁰ <https://www.aude.gouv.fr/Actions-de-l-etat/Environnement/Plan-and-planning-projects-susceptible-of-impacting-the-environment/Les-enquetes-publiques-et-consultations-du-public-dossiers-complets-hors-ICPC/Le-photovoltaïque>

²¹ Idem that note 20

²² <https://www.mrae.developpement-durable.gouv.fr/occitanie-r21.html>. Avis n°2022APD31

²³ See note 20

²⁴ <https://www.aude.gouv.fr/contenu/telechargement/26855/185428/file/rapport%20centrale%20photovolta%C3%AFque%20de%20FONTJONCOUSE%2030122023.pdf>, 2023.

²⁵ Stoc 2001-2021

²⁶ <https://www.infogreffe.fr/recherche-entreprise-dirigeant/resultats-de-recherche?recherche=Entreprises&denomination=Hexagone%20Energie&dirigeantPage=0&dirigeantPageSize=>

²⁷ <https://www.usinenouvelle.com/article/dans-l-aude-hexagone-energie-prevoit-d-investir-80-millions-d-euros-pour-batir-une-ferme-solaire>
<https://www.bolloré-energy.com/>

²⁸ Mukesh Kumar Nag, Parmanand Kumar, and Mani Kant Paswan, 2020, Environmental Impacts from the System of Solar Energy, Lecture Notes in Electrical Engineering

We will only point out that China is today the leading producer of photovoltaic panels, representing 90% of offers. The construction of photovoltaic panels requires a significant amount of water and energy, particularly to melt the glass and crystallize the silicon²⁹. However, when a panel is produced in China, the energy used is not often green, even fossil fuels can be used to produce photovoltaic panels.

Furthermore, complaints about harsh working conditions and pollution caused by silicon refining operations have been denounced and documented over the past ten years³⁰. The impact of the production of photovoltaic cells is therefore both an environmental problem, but also a public health problem and an ethical question.

Indeed, the more the silicon is purified, the more optimal the absorption capacity of sunlight by the cell will be. However, it is the acid baths which allow this purification. Hence the pollution of the air and soil and therefore the negative impact on the environment. This does not reduce the carbon footprint of photovoltaic production. When the panels come from China, the carbon footprint of the transport used to transport the panels must be added.

The green and inclusive economy department of the Ministry of Ecological Transition has studied the issue on low-carbon panels in France, it is recognized that the production of electricity by solar panels is much less harmful to the climate than electricity from gas or coal power plants. Manufacturing solar panels, however, generates a certain consumption of electricity. Depending on the manufacturing countries and their electricity mix, this corresponds to more or less high greenhouse gas emissions³¹. According to this report, in France, all emissions from a solar panel (including the production of electricity and the manufacturing of the panel) are on average 55 grams of CO₂ per Kilowatt hour of electricity produced. It is also specified that this can vary between 39 and 89 grams of CO₂ depending on the sunshine, the country and the technology used to manufacture the panel. Several sources say the panels are 90% recyclable.

A photovoltaic park is therefore far from being carbon neutral. In addition, these panels raise a question of sovereignty, since France depends on another country for the production of this energy.

Hence the questions about the carbon footprint of photovoltaics.

And what will happen to the cleaning and recovery of the sites at the end of the lease? Normally the operating company must dismantle everything and restore it to its original condition. But unfortunately, many examples show us that this is rarely done, the sites being rather abandoned (Example of the Salsigne mine, where 20 years after its closure, all the companies which exploited the mine for decades refuse to clean the site). The concerns are justified. Scientific monitoring and independent measurements would be necessary throughout the entire process. To return to the garrigue, it is obvious that in the dominant perception these spaces are considered as "vast deserts", by many city dwellers, certain government authorities and the developers themselves who also benefit from this lack of knowledge of rural environments.

On the other hand, the scrubland as it is today offers great advantages for the inhabitants as the ecological services have shown above (Figure 4). The carbon retention capacity in the first 30 cm of soil by scrubland On the other hand, the scrubland as it is today offers great advantages for the inhabitants as the ecological services have shown above (Figure 4). The carbon retention capacity in the first 30 cm of soil by scrubland is around 70 to 80 tons of carbon/ha. Furthermore, plant photosynthesis is capable of producing oxygen to renovate the biosphere. Vegetation lowers the temperature on a local scale. If we do not touch the garrigue, this allows the progressive dynamic to prevail. The scrubland then goes beyond the stages of self-sustained blocking by fires and we often observe a wooded scrubland which seems to be moving towards the "resistance model", the installation of holm oaks under the cover of Aleppo pines, even a "stabilization model" with the installation of downy oaks. However, the regeneration of the oak grove, when carried out successfully, can "require a century, as in the Montpellier region" (Biro, 1965³²). The progressive evolution can also start from the lawn (or shrubby heath). So, without affecting anything, by only providing anti-forest fire measures, the scrubland can transform in 70 or 100 years into a forest of downy oaks and holm oaks, returning to the landscape conditions described between the 8th and 12th centuries.

³⁰ Most manufacturing and construction industries are likely to expose employees to inhalation of crystalline silica dust. The health effects of this mineral can be particularly serious and disabling (notably silicosis and lung cancer). Occupational exposure to crystalline silica should therefore be reduced to the lowest possible level.

³¹ <https://www.hellocarbo.com/blog/calculer/quel-bilan-carbone-pour-le-photovoltaique>

³² https://www.var.gouv.fr/content/telechargement/16127/125096/file/etude_d_impact_sur_l_environnement_05-chapitre_5.pdf.

³³ <https://Books.openedition.org/irdeditions/9794?lang=fr>

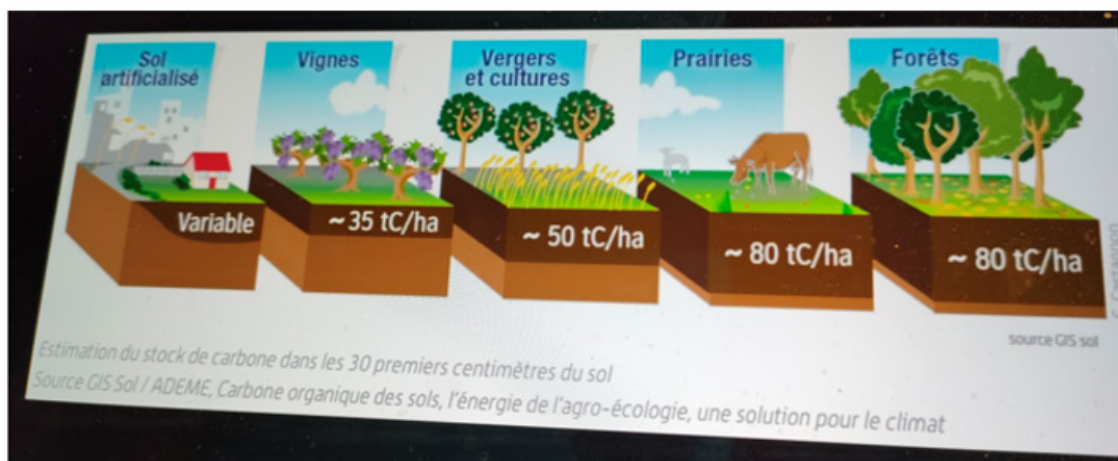


Figure 4:

Remember that a tree can lower the temperature by 3 to 4 degrees locally. Forests are a place of exchange between the atmosphere, soil, hydrosphere and biosphere. These exchanges of water, energy and matter affect the climate, both on a local scale (microclimates) and on a global scale. At the local level, forests play a buffer role, as much for extreme temperatures as for humidity and wind strength. In fact, they accumulate heat during the day before reemitting it at night. On the other hand, the phenomenon of evapotranspiration linked to photosynthesis and plant respiration humidifies and refreshes the air. Finally, forests form windbreaks that reduce the force of the winds.

Rewilding scrubland and converting garrigue into forest would make it possible to better fight climate change locally. It is obviously necessary to manage the open scrubland which is a very important issue for biodiversity in order to allow birds to continue to nest and hunt there. Here we need the support of science to better understand all these different issues. The last important point to discuss is that of energy justice. In the investigating commissioner's report, it is noted that everyone must try for renewables. They cannot only be located in cities. If we ask the question of the main consumers (of goods and landscapes) the inhabitants of the city are still well placed.

To achieve a just transition, we must understand, from cities and politicians, that large urban networks and small rural villages are not in the same situations. In Corbières there is a lack of doctors, cultural services, places to meet, and even the internet. So, because of sun, these territories should be occupied? Rural areas need to maintain a certain level of population to well manage the landscapes. Farmers and residents of these small villages are on the front lines of climate change and the lack of water affects them daily. Many are turning to self-consumption, growing their own vegetables, or participating heavily in small producer cooperatives as well as local markets. It is not fair to impose on these residents to support all the energy needs of city dwellers. Moreover, in Corbières,

many hazardous material discharges and treatment sites have also been installed. Burial and recycling of waste also devour large areas of garrigue and create risk areas. It is necessary and urgent to work with a more empathetic, better informed and participatory vision to bring social, territorial and environmental coherence.

The creation of solar power plants is important and must be done with plans of basins living areas and maps which also indicate all the other uses, often at risk, which occupy garrigue areas. These living area plans must be associated with fairer and more inclusive policies, which aim, with the participation of residents, to better insulate houses which are often real thermal sieves. Housing is in second position in the ranking of energy losses. It is also an important social issue in the small villages of Corbières where there are people who live with very little means, and cannot heat themselves with electricity which has become a luxury. We must also put in place policies to consume less. Everyone, rural and urban, is pushed to overconsume everything (invasive advertising, harassment of phone calls). Residents cannot afford an electric car which is not carbon neutral either. They often keep an old car that runs on diesel to go shopping or to the doctor. In the villages, people organize themselves to carpool and help each other. In this mountain area biking is not easy. The next big town is 25 km away. The closest public hospitals are in Narbonne (25 km) or Carcassonne (50 km). For heavy treatments and infrastructure for certain serious illnesses, you have to travel to Perpignan (100 km) or Montpellier (150 km).

Conclusion

Faced with the energy transition and the photovoltaic park project at home, and in the surrounding villages, residents must understand all the issues and make complex choices. In the case presented in this article, the villagers had to organize themselves to understand the situation and felt the need for scientific support. The rise of alternative energies and photovoltaic parks should **not** be

a new way for private companies to enrich themselves on the backs of residents, who are only entitled to a few crumbs of the profits, and are deprived of installing photovoltaic panels on their roofs because of the monuments of France. Legal sciences would be of great use in contributing to fairer returns for local populations. The energy transition must urgently address the territorial planning of solar parks and their governance. This constitutes a real challenge for the human and social sciences (Debizet and La Branche, 2019³³)

Scientists could also, carry out scientific monitoring and independent measurements in relation to CO₂ emissions, during installation and electricity production in photovoltaic parks. Scientists could calculate the correct life cycle values for photovoltaic panels and the network of solar parks built in surrounding villages. They could also contribute to measuring the evolution of soils covered with panels, the effects on biodiversity, in particular predictable animal mortality, on several parks and over a long time. The energy transition cannot go hand in hand with the destruction of many hectares of garrigue, rich in biodiversity and life, an ecosystem in the process of recovery towards the "Selva" even if it took a generation is a real treasure for life. Any introduction of new activities in an area of Garrigue, crossed extensively by herds of sheep and traversed by hunters, hikers and villagers, necessarily leads to the question of the mode of occupation of the space and landscapes. Agro-forestry techniques are a guarantee of the future to transform agriculture. But a photovoltaic panel is not part of the domain of life. It stays on statistics and indicators of technical and energy efficiency. It is difficult and not rational to impose it in the social context of small villages and rural areas, when the wild of Garrigue can give them better life conditions. Science could propose participatory methods by involving residents around these complex issues. There is a very strong demand for social justice in the small villages of the south. What will happen in a few years when rural areas are replaced by solar fields? What urban people will eat then?

How will we breathe then?

The protection of the biosphere will soon be a priority, because it means everything: The continuity of life on earth, and the possibilities of existing for all living things, humans and non-humans. In the Corbières it is still possible to opt for wildness. This new philosophy would allow farmers, winegrowers, shepherds, and residents, hotels, restaurants and self-catering sector; walkers, volunteers in associations working to improve local daily life, to find real meaning in their activities, all integrated into a policy with a noble meaning. It is urgent to think and put in place alternative economic models, which would make it possible to build exchange values and social bonds, foreign to the sole value of money. What are the ways and strategies to escape, at least locally, from this industrial and ultra-liberal capitalist, who only creates gaps between the very rich and the very poor, a gap that the system exploits to further subjugate populations and alienate them with false consumption values everywhere?

A photovoltaic park in this system can only serve private interests. Not the inhabitants, not the ecosystems. And this system plays with the desperation of mayors to be able to repair a street, a leaking water pipe, help fellow citizens in difficulty and face their responsibilities with dignity. Science is more than necessary to better understand the complexity of what is happening in garrigue habitats and in human society, it should be alongside people to improve their knowledge. A participatory science that breaks down the boundaries between disciplines. Science, which is also part of the system, is also in crisis since it depends on subsidies to carry out research, and must submit to "political correctness", which interests politicians and the large groups that dominate the global space. Science is more necessary than ever, but it must extricate itself from these corsets and be exercised in the consciousness of being. To finish let me cite François Rabelais (1483-1553): "Science without conscience is only ruin of the soul".

³³ Gilles Debizet, Stéphane La Branche. Approche critique des scénarios technico-économiques de la transition énergétique. Baglioni Vincent; Burger Cécile; Cacciari Joseph; Mangold Marie. Repenser la transition énergétique Un défi pour les sciences humaines et sociales, Presse Universitaire de Rennes,