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Winners and Losers in Energy Transition: Study Case of Wood Biomass Power-Plants Implementation in France

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Abstract: International policies promote renewable forms of energy to mitigate climate change. In Europe, the production of electricity using wood biomass represents one of the most popular energy alternatives. In 2012, France initiated a large-scale strategy to develop wood biomass energy. The biggest wood biomass power-plant project has been developed in the French Mediterranean area and its huge size raises several issues for the short- and long-term sustainability of local forests and associated economic sectors. The French Mediterranean forests provide four types of economic goods (private, club, common, and public goods) and multiple ecosystem services, which makes them complex to manage under an energy transition policy. In this paper, we applied three qualitative methods, namely interviews, participative workshops, and observant participation, and three conceptual models, namely (i) Ostrom's (2010) self-organization key conditions, (ii) the types of economic goods classified according to their excludability and rivalry properties, and (iii) the ecosystem service categorization system of the Millennium Ecosystem Assessment (2005). With our methods, we show that the renewable strategy chosen in France replicates the current centralized production model based on fossil and nuclear fuels. Thus, we demonstrate that European, national, and local authorities fail to consider the multiple ecosystem services that forest management strategies should include to face the energy transition, climate change, and the other ecological challenges of the 21st century.

Keywords: common-pool resource management; local vs. global; economic oligopoly; panacea paradigm; renewable energy; sectoral organization

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1. Introduction

In the face of climate change and the energy crisis, international policies seek to accelerate renewable and low-carbon energy development (e.g., the "Paris agreement" held in 2015). One such renewable resource is wood biomass, proposed as an alternative source of energy to reduce greenhouse gas emissions and create a new bioeconomy market in the energy sector [1–4]. However, the development of renewable and low-carbon energy raises crucial issues concerning the capacity of societies to implement this energy transition. We defined the energy transition as a political strategy, described by Griffiths (2019) [5] as the aim to change our energy and economic system throughout the remainder of this century by a shift from reliance almost entirely on fossil fuels to a much greater reliance on renewable energy [6,7], especially at a local scale.

The European Directive 2009/28/CE on the promotion of the use of energy from renewable sources (hereinafter named H2020) sets the common EU objective to reach at least 20% of renewable sources in terms of gross final consumption of energy by 2020 and to develop bioeconomy markets that rely on renewable biological resources [8,9]. Accordingly, policymakers are facing the difficult challenge of developing new renewable energy sectors and associated bioeconomy markets under high uncertainty while taking into account the

three sustainability pillars: the ecological, the social, and the economic. Yet, the literature shows that many political instances of energy transition planning fail to consider some issues, such as landscape and cultural values, human health, and either equity or justice issues [10], as well as fail to consider environmental issues in developing new bioeconomy sectors [2,11,12].

In France, reaching the H2020 goal requires that renewable energy sources must more than double their 2005 share (10.3%) in terms of gross final consumption of energy to reach a final goal of 23% at the national scale (each member state has a different goal, which allows a 20% share to be achieved at the European scale). In 2006, the wood biomass energy in France represented 83% of the thermal renewable energy consumed by households and industries (i.e., 9 million tons of oil equivalent (toe) of wood biomass per year). This represents 50% of the French renewable energy production [13,14]. Moreover, wood biomass energy is considered as an interesting strategy for France, taking account that the standing volume of wood in France has been increasing by 0.7% per year since 1992 [15]. Even if an increase of the wood standing volume does not necessarily increase its availability, in 2016, the French Forest Ministry edited a national report to promote forestry sectors with a strategy to develop wood biomass energy at large scale [16].

In the National Strategy for Ecological Transition towards Sustainable Development (2017) report, France defines bioeconomy as "the photosynthesis economy, and more generally, the living world economy. It encompasses all biomass production and processing activities, wether forestry, farming or aquaculture, directed at the production of food, feed, bio-based products and renewable energy" ([17], p. 39). In its bioeconomy strategy, France considers wood biomass as the main pillar [8,18]. As many authors highlighted, environmental or ecological issues remain vaguely addressed in bioeconomy sector development [12,19,20]. Moreover, Dietz et al. (2018) said that future research in bioeconomy and new renewable energy markets should contribute to documenting examples of implementation processes and outcomes of new sectors at local scales. The wood biomass energy sector fits in the bioeconomy strategy, and thus it is crucial to analyze the implementation of the process to identify failures and keys to success.

In July 2010, the Energy Regulatory Commission published its 4th Biomass call (hereinafter named CRE4) to develop renewable energy plants in France. In February 2011, 15 projects were accepted, such as the project of the German Company E-On/Uniper, which proposed to convert a coal-fired plant into a wood biomass power-plant. The project is located in the region Provence-Alpes-Côte-d'Azur (PACA), which corresponds to the French Mediterranean area. Despite the fact that several of the CRE4 specifications required in the call were not respected, the project was accepted by the public authorities because of its capacity to contribute to European and national renewable energy targets and to help the French government make progress in closing coal-fired power-plants. Moreover, the project has been supported by regional authorities for its capacity to improve regional energy security and to either create or protect regional jobs. The French government invested €66 million, and the E-On/Uniper company invested €250 million, for the new wood biomass plant installation.

It is important to note the huge size of the E-On/Uniper project, and thereby its massive potential ecologic, social, and economic impacts. The CRE4 call estimated that, in the coming years, 420 MW of additional energy capacity should be created to supply the ever-increasing energy demand in France. Several companies have won the CRE4 call, but the E-On/Uniper project covers 36% of the 420 MW. The other companies that won the CRE4 call have presented projects that will produce a much lower percentage. For example, the second biggest project that won the CRE4 call will have an energy capacity of only 26 MW. Considering the power capacity of the E-On/Uniper plant and the required supply, approximately 850,000 tons of wood per year, this project raises many issues for the short- and long-term sustainability of the PACA region in respect of the local economy [4,21–23], biodiversity and forest ecosystem services [24,25], and the capacity of local actors to organise the regional sector [26,27].

The capacity of actors to organise themselves at the regional scale (the PACA region) to fulfil biomass policies decided at a larger scale (EU) is crucial to diminishing the costs (economic, social, or ecologic) and the potential negative impacts ([27], p. 3). The arrival of the power-plant is putting pressure on wood resources and represents an ecological risk. Development of the forestry sector through reliance on E-On/Uniper, a multinational group with 12,000 employees worldwide (Uniper, 2018), is not conducive to employment. Very large-sized companies (more than 250 employees) are known to create fewer jobs than do small- and medium-sized companies (between 50 and 250 employees) ([28], p. 14).

In this paper, we analyse both emergent trends during the implementation of a new energy sector at the regional scale and the preliminary organization of regional stakeholders to respond to national strategy. Our analysis is based on the study case of the E-On/Uniper power-plant in the PACA region. Our approach considers the local environmental and historical conditions, the current stakeholder's network, the type of goods and services offered by forests and the political context. To grasp the complexity of the social–ecological system, we carried out document analyses, semi-structured interviews, participative workshops, and local immersions in the form of observant participation [29,30].

Thus, we answer three research questions: (A) What are the historical characteristics framing the capacity of local actors to self-organise to manage forests? (B) How are local actors trying to self-organise at the medium scale to respond to the top-down energy policy decided at the large scale? (C) Is the implementation of the energy transition policy by the E-On/Uniper power-plant, improving local forest management and sustainability?

2. Materials and Methods

2.1. Case Study: The French Mediterranean Region and Its Forestry Sector

The study was conducted in the PACA region, delimited by administrative limits (The authors choose to circumscribe the study case to the administrative limits. We are aware that it is questionable, but this decision was made because available data are inventoried at the administrative scale of the PACA region, and many reports are edited at this scale too), which covers 31,400 km^2 and is the most forested region in France. Forests cover 1,606,000 ha, which represents 48% of the regions surface area [15]. The forest cover in the region has been increasing by 1.35% per year since 1985 [15]. However, even though the forest cover is one of the largest in France, the productivity of Mediterranean forests remains low, at 86 m^3/ha against 175 m^3/ha, on average, for the rest of France. The wood productivity is limited by severe climatic conditions, frequent fires, and poverty of soils in some zones [31–33].

From the forestry sector and political stakeholder point of view, the PACA forest are considered as underexploited, because the "harvest forest biomass production" ratio is approximately 20% in PACA, whereas the national average is estimated to be between 56% and 65% [15]. Moreover, the soil characteristics, the slope, and road accessibility are not suitable for forest exploitation, which explains why 70% of the volumes of standing timber (80 million m^3) in PACA are considered difficult to exploit [34].

The power capacity of the E-On/Uniper woody biomass power-plant amounts to 150 MW per year and is aimed at supplying electricity to 440,000 households. The facility is designed as an incinerator (specific French legal status) and is therefore also capable of burning different types of wastes, such as green waste, recycled wood, and some household wastes. The project has received considerable criticism, particularly because of its overall low efficiency of 44% due to the lack of a heat recovery system (although the CRE4 call for proposals required an efficiency of 60% minimum). The amount of resources burnt in the plant will be very large and equivalent to 850,000 tons of biomass per year, including 600,000 tons of wood that are currently mainly imported from abroad (60%) but should come from within 400 km of the plant by 2025. This project adds up to two existing plants in PACA: a paper pulp mill, named Fibre Excellence, using 1,150,000 tons of wood per year and another woody biomass power-plant, named Inova, which has a power output of 22 MW and uses 150,000 tons of forests product per year from a supply radius of 150 km.

2.2. Interview Design and Key Actors' Selection

To develop our research hypothesis, we used an inductive methodology related to the grounded theory. Hence, our approaches are based on poststructuralist and constructionist methods of social sciences. The poststructuralist framework helps us to define the conditions of emergence and the current properties of the PACA social–ecological system. The constructionist framework helps us to determine the individual motivations and perceptions of actors [35]. These two methods allow to understand the social–ecological system (e.g., actor's network) and its current processes (e.g., energy transition process).

To collect information on local conditions and understand all the underlying dynamics of the PACA forest sector, we used four methods (Table 1): (1) document analyses (media, archives, maps, official reports, statistics, etc.), (2) four local immersions in the form of observant participation [29,30] during a total of 18 weeks over the period 2014–2018, (3) semi-structured interviews of 1–2 h each carried out with a total of 40 stakeholders between April 2017 and June 2017, (4) and three participative workshops of 3–4 h each with a total of 12 local stakeholders carried out in April 2018. The interviews and participative workshops have been transcribed and interpreted by the authors in accordance with the traditional interpretive method used in social science research [36], respecting the point of view of the interviewees.

Table 1. A categorisation of information types and methods used to analyse them. Note: tacit information is known only by individuals, whereas explicit information is shared, with some level of agreement. The 3 shaded cells correspond to information types that we did not use for this study. (Adapted from Fabricius et al., 2006 [37]).

	Tacit Information	Explicit Information	Methods Used
Formal information	Private images or photographs	Ecosystem assessments	Document analyses (archives) and local immersions
	Unpublished models and databases	Peer-reviewed papers, chapters, or books in the scientific literature	Document analyses (official reports, medias)
	Diaries	Peer-reviewed databases	Document analyses (models, statistics)
Informal information	Opinions	Oral traditional knowledge	Semi-structured interviews and participative workshops
	Experience	Indigenous knowledge, rules, and practices	Local immersions and semi-structure interviews
	Intuition	Communal beliefs and values	Semi-structured interviews and participative workshops
	Private beliefs and values	Untested scientific databases	Local immersions, semi-structured interviews and participative workshops

We interviewed three types of actors: industries/companies (economic actors), institutions/associations (political actors), and private forest owners (private/citizen actors). We designed distinct sets of questions for each type of actor. Based on our expertise of the forest sector and the PACA region, we chose the first key stakeholders to be interviewed, and additional key stakeholders to be interviewed were either recommended by the first ones or simply mentioned by other stakeholders in informal conversations during observant participation.

Participative workshops have been organized with several stakeholder types as interviews (the same listed in previous paragraphs). Note that E-ON/Uniper and FibreExcellence participated in these workshops, contrarily to INOVA that did not respond to our invitation. The goal of workshops was to identify and design narrative scenarios for the forest and forestry sector of the PACA region, based on experiences, skills, perceptions and expertises of stakeholders. The main question addressed to actors at the beginning of the workshop was "What is the future for the forest/forestry sector in PACA region?" The workshop took place in three successive steps as described below.

Step 1: Identifying main issues for the PACA region. Each actor expresses his main concerns about forest and/or forestry sector, and categorizes them as risks, opportunities,

or priorities. All issues are presented to the group. Then, each actor is invited to identify the most critical or worrying issues by sticking a red sticker. At the end of Step 1, we eliminated issues with the lowest number of stickers which allowed us to identify three main issues for the PACA region in each category in order to have: a risk, an opportunity, and a key priority issue.

Step 2: Highlighting components or dynamics which influence these issues. Each actor defines one driver for each issue and specifies what type of influence it is, negative or positive. Then, similarly to the previous step, actors identify the drivers with the strongest influence sticking a red sticker. At the end of Step 2, we have two drivers for each issue, one negative and one positive.

Step 3: Determining the capacity of each actor and the uncertainty. Each actor identifies drivers for which he/she could have a capacity for action, and they propose several action plans. Then, with a scale from 1 (low uncertainty) to 5 (high uncertainty), each actor sticks a number on the previous action capacity to assess the perceived uncertainty.

Step 4 is the last one of the participative workshops and it consists of drafting a scenario for the PACA region according to work carried out by actors in Steps 1–3. We drafted one business-as-usual, one probable, and one desirable scenario.

2.3. Conceptual Framework: Key Conditions for Self-Organisation in Managing Common-Pool Resources Considering the Complexity of Good Categories in Forests

Common-pool resources are goods, manmade or natural, that are large enough that their exclusion from the resource system is costly (and sometimes impossible) and consumption of a resource unit is rivalrous (i.e., there is rivalry with other consumers, the resource is no longer available to others after consumption by someone) [38–40]. These two characteristics make common-pool resources susceptible to overharvesting and destruction. In a property system, common-pool resources are not free to access, contrary to public goods, and property rights could exclude certain categories of actors. However total exclusion is rare in our case. For example, although rules might exclude access to forests for trekking, if there are no fences, which is often the case in huge forest areas, such exclusion is not fully operational. Some common-pool resources such as forests are simultaneously rivalrous and non-rivalrous, depending on the resource unit considered, i.e., the ecosystem service [39]. This shows that some ecosystem services supplied by forests could be classed as belonging to the category of public goods, which might change the way they are managed.

For a good to be properly managed in a way to satisfy supply capacity and demand, it is necessary that the property rights of the good are well-defined. However, the forest is a peculiar good in the sense that it provides multifunctional services and associated resources for which property rights are not well-defined or well-known. In such a case, four types of goods co-exist, i.e., private, public, common, and club goods, without clear legal regulation considering them, which does not ease their management [38,40,41]. The ecosystem services offered by forests could be sorted in the four categories (Table 2). From this statement, we consider forest as a boundary object, which makes management practices complex to implement, and by extension, challenges the development of new bioeconomy sectors [42].

Table 2. The different types and levels of public and private goods related to forest resources and services. These types have important economic and social implications.

	High Excludability	Low Excludability
High rivalry	**Private goods** *(Provisioning ecosystem services)* Resources sold on a market such as wood, meat, fungi, genetic, and biochemical resources.	**Common goods** *(Provisioning and recreational ecosystem services)* Stocks of woods, resins, fruits, games. Recreational activities such as walking, biking, jogging, camping.
Low rivalry	**Club goods** *(Recreational, regulating and provisioning ecosystem services)* Services provided by hunting associations, forest cooperatives, forest associations.	**Public goods** *(Regulating, supporting and recreational ecosystem services)* Cultural services such as landscape esthetical value. Regulating services such as fire, flood, climate, and pollution regulation services. Supporting services such as biodiversity support.

Forest overharvesting or mismanagement, like many other environmental problems conceptualized as "global problems", are the cumulative result of actions taken at diverse levels, i.e., at the local level, by regional and national authorities, and by international institutions [27]. Solving this problem requires collective action, and many actors at diverse levels need to change their behaviour. Ostrom (2010) identified at least six key conditions required for self-organisation to succeed in solving collective action problems (see Box 1). In the following sections, we use the conceptual framework from Box 1 to present and analyze our results. In this paper, we have considered the local scale for cities, villages, unions, associations, private firms, and communities; the regional scale for regional authorities; and the large scale for national and European authorities and institutions.

Box 1. Key conditions required for local stakeholders to self-organise to solve collective action problems in managing common-pool resources [27].

1. Reliable **information** is available about the immediate and long-term costs and benefits of actions.
2. The individuals involved see the **common resource as important** for their own achievements and have a **long-term** time horizon.
3. Gaining a **reputation** for being a trustworthy reciprocator is important to those involved.
4. Individuals **can communicate** with at least some of the others involved.
5. Informal **monitoring and sanctioning** (award and punishments) is feasible and considered appropriate.
6. **Social capital and leadership** exist, related to previous successes in solving joint problems.

3. Results and Discussion

3.1. The Weight of History: Absence of Long Term Vision and Leadership

Despite there being a very large forested surface area, the inhabitants of the PACA region do not have a forestry culture (more details in Sansilvestri et al., 2020) ("There is no culture for good forest species and noble wood in Mediterranean area" (Forest expert from private office, personal interview, May 2017)), which does not help forest actors involved in the wood supply chain to see forest resources as a common-pool resource for their own achievements over a long-term time horizon. In other works, key condition No 2 (Box 1) is not fulfilled. This lack of common view can be explained by several historical and environmental conditions.

As with many Mediterranean climate regions, PACA is exposed to a high fire risk, which creates fear among the community of forest owners and pushes them to focus forest management on reduction of the fire risk (Box 2). Thus, the forest practices considered as good and subsidised by public authorities focus chiefly on fire defense ("Here, when

you want to sign a management plan with a private forest owner, you just have to talk about fire. They are so scared that they accept any management plan" (forest expert CRPF PACA, personal interview, April 2017); "I think that forest management should focus on fire risk decrease" (private forest owner, personal interview, April 2017)), discarding any other kind of longer-term objectives (Table 3, "fire-defense" strategy). Actually, the fire risk and fear are exacerbated by the pressure of climate change due to increases in the intensity and duration of droughts in the PACA region [31–33]. The fear of fire and the real risk enhanced by climate change, combined with the low value of wood, are three factors explaining why fire-defense is seen as the most important practice by private forest owners. The fire-defense strategy was presented as a business-as-usual scenario during the participative workshop identifying the impacts on the different forest ecosystem services (Table 3).

Table 3. Description of the different scenarios and the associated impacts on the four ecosystem service categories, and on the accessibility to forest goods and services. The different scenarios have been developed with stakeholders during participative workshop, and then specified by our analysis based on interviews and document analysis. The fire-defense and the conservation strategies have been described as business-as-usual scenarios, the biomass policy (at large and local scale) as the probable scenario, and the fire-management strategy as the desirable scenario by the majority of actors during participative workshops. Legend: the arrows indicate the increasing, decreasing or no change evolution of the characteristics listed in the first column (large arrow indicates a strong increase or decrease). The color of the cells indicates the desirable level according to the assessment of stakeholders during workshops (Dark green cells = extremely desirable for future, light green cells = desirable, yellow cells = no assessment or neutral, light red cells = no desirable, dark orange cells = extremely desirable).

Ecosystem Goods and Services, and Economic Competition Characteristics	Fire Defense Strategy	Conservation Policy	Biomass Policy (Large Scale)	Biomass Strategy (Local Scale)	Fire Management Strategy
Provision goods (for wood only)	↘	→	↗ [1]	↗ [2]	→ [3]
Supporting services	↘	↗	↘	→	↗
Regulating services	↘	↗	↘	→	↗
Cultural services	→	↗	↘	↘	→ [4]
Rivalry	↗	↗	↗	→	→
Excludability	↗	↗	↗	→	↘
Unfair economic competition	↗	↗	↗	→	↘

[1] Biomass policies (at large scale) increases the provision of wood on the short term but it is likely to generate a decrease on the long term; [2] Biomass strategies (at local scale) have to remain limited on the long term to maintain the service of wood provision; [3] The provision of wood could increase on the long term under fire management strategies if public knowledge about forestry and forest experts' education are developed. [4] Cultural services could increase on the long term under fire management strategies if the policy-decision process includes landscapes management at the scale of the territory and all of the actors (foresters, shepherds, inhabitants, associations etc).

Box 2. Details about fire defense vs. fire management strategy.

Fire-defense: The increase of human pressure in the Mediterranean basin across century drives policy-process to develop strong fire-policy to protect human populations. But, Mediterranean forests have natural cycle which include fires, e.g., some species need fire for reproduction or expansion. Today's management practices focus on firefighting, to avoid or to constraint fires. Such practices are named hereinafter *"fire-defense management"*. The traditional practices in *fire-defense management* aim to create corridors in forest by cutting trees, hard undergrowth clearing and permanent fire monitoring units.
Fire-management: Also called "prescribed burning", it consists in voluntarily burning some forest areas to improve socio-ecological system management. For now, prescribed burning is underused in the Mediterranean basin, it is applied on only 3% of forest lands [43]. Fire-management practices plan the use of fires in the SES to achieve clear objectives such as biodiversity preservation, fire risk reduction or traditional landscape protection [44,45].

Though actors at the regional scale all agree on the fire-defense service as being the forest public good to be managed, this is not the case at upper levels. Considering that the Mediterranean basin is one of the biggest biodiversity hot-spots in the world, most regulations decided by decision-makers at European and national scales have been implemented on a regional scale to protect biodiversity. Yet, the development of biodiversity conservation regulations in the PACA region since the 1990s has preserved its high natural capital (natural capital is defined as a stock that yields a flow of services over time [46] and as the biological components and intrinsic functioning capacities of the ecosystem [47,48]), constrained its economic and social capital (social capital is defined as the social networks, cognitive elements, values and perceptions, and culture of the human system [49–51]) that rely on the forest ecosystem). Among the various biodiversity regulations in PACA, there is the Natura 2000 ecological network (Birds (79/409/CE) and Habitat (92/43/CEE) EU Directives), a man and biosphere reserve, and eight regional protected parks (Figure 1). Each protected zone strongly limits human activities, forest operations included. Hence, a large part of the PACA surface is protected. Preserving forest biodiversity allows generation of many ecosystem services, but they are hardly economically valuable for foresters ("From societal point of view, forests have to be conserved. No possibility to talk about harvest operations or money here" (Forest cooperative member, April 2017)). Therefore, under such regulatory pressure for biodiversity set at upper scales, local foresters could never develop their activities properly in a well-structured forestry sector. This has generated a lack of forest practice knowledge and has impeded the emergence of successful regional forestry activities (see the "Conservation policy" strategy in the Table 3, which provides a high level of supporting services but a low level of provision services). The strategies "Fire-defense" and "Conservation policy" represent the historical trends of the PACA region and can be defined both as business-as-usual scenarios for the region.

It was only in the 1950s that a big company, named Fibre Excellence, settled in the PACA region to produce paper pulp (Figure 1). Fibre Excellence is still in operation. Indeed, this company generated a boom in the forestry sector that coincided with the large-scale abandonment of agricultural land and forest area expansion. However, economic profits in the forestry sector continued and remain underdeveloped because of the lack of diversity in wood processes and markets (Figure 2). The current lack of management plans and secondary processing sectors keep the wood price per ton in the PACA region at a very low level, forcing forest owners and foresters to produce wood in terms of quantity, rather than quality ("Here, and in France in general, we know how to produce wood, but we don't have wood processing industries. This does not encourage to develop management plans for future" (Forest community association member, personal interview, May 2017)).

Until 2011, Fibre Excellence developed the industrial forestry sector of PACA based mainly on production of paper pulp (a low added value product). However, recent national energy transition goals involving the implementation of two wood biomass power-plants in the PACA region, E-On/Uniper and Inova, changed the deal. The Inova company built

a new wood biomass electric power-plant in 2014 and opened it in 2016. Meanwhile, the E-On/Uniper company proceeded to convert an old coal-fired power-plant in 2014, which did not open yet (Figure 3). Fibre Excellence is continuing its activity in the PACA region, but it now has to "play" with two new economic competitors for wood resources ("The INOVA project could have been a good opportunity for our region, but with E-ON/Uniper and INOVA, it will be complicated" (Forest expert from CRPF, personal interview, April 2017)). Today, these three companies create an oligopolistic wood market in the PACA region.

Along with power-plants implementation by national authorities, several local actors have tried for many years to develop consistency in the forestry sector through the development of a collective heating network with community boilers at local scale (described as the "Biomass strategy (local scale)" in Table 3). This can be observed through the growing number of regional small community wood-fired boilers, which increased from approximatively 30 in 2003 to 284 in 2016 [34]. However, the lack of leadership in forest sector and the unstructured network limit the organization of actors as reflected by actor's assertions during interviews ("Communication is very difficult, there are too many interlocutors" (Forest operator, personal interview, May 2017); "The interprofessional structure is too young to create cohesion between actors" (Foresters union member, personal interview, April 2017)). All the historical traits mentioned above result in low social capital and no common vision of the regional resource and long-term achievements. Consequently, Ostrom's key conditions No 2 and 6 are not fulfilled (Box 1).

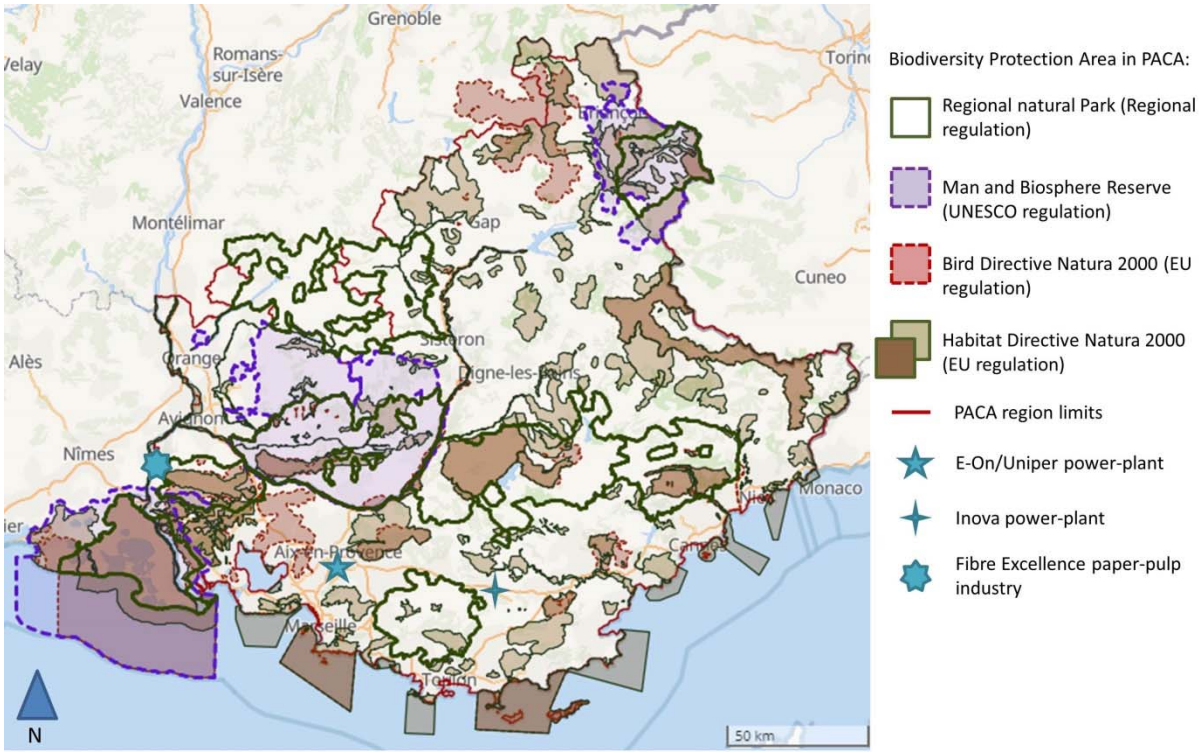

Figure 1. Map of PACA environmental regulations decided at upper scales (global scale: man and biosphere reserve labelled by UNESCO; European scale: Natura 2000 area; National and regional scales: Regional Natural Parks) and location of the three main industrial actors (E-On/Uniper, Inova and Fibre Excellence). Map edited from the online Regional Natural Park database for geographical information system (SIT PACA Database).

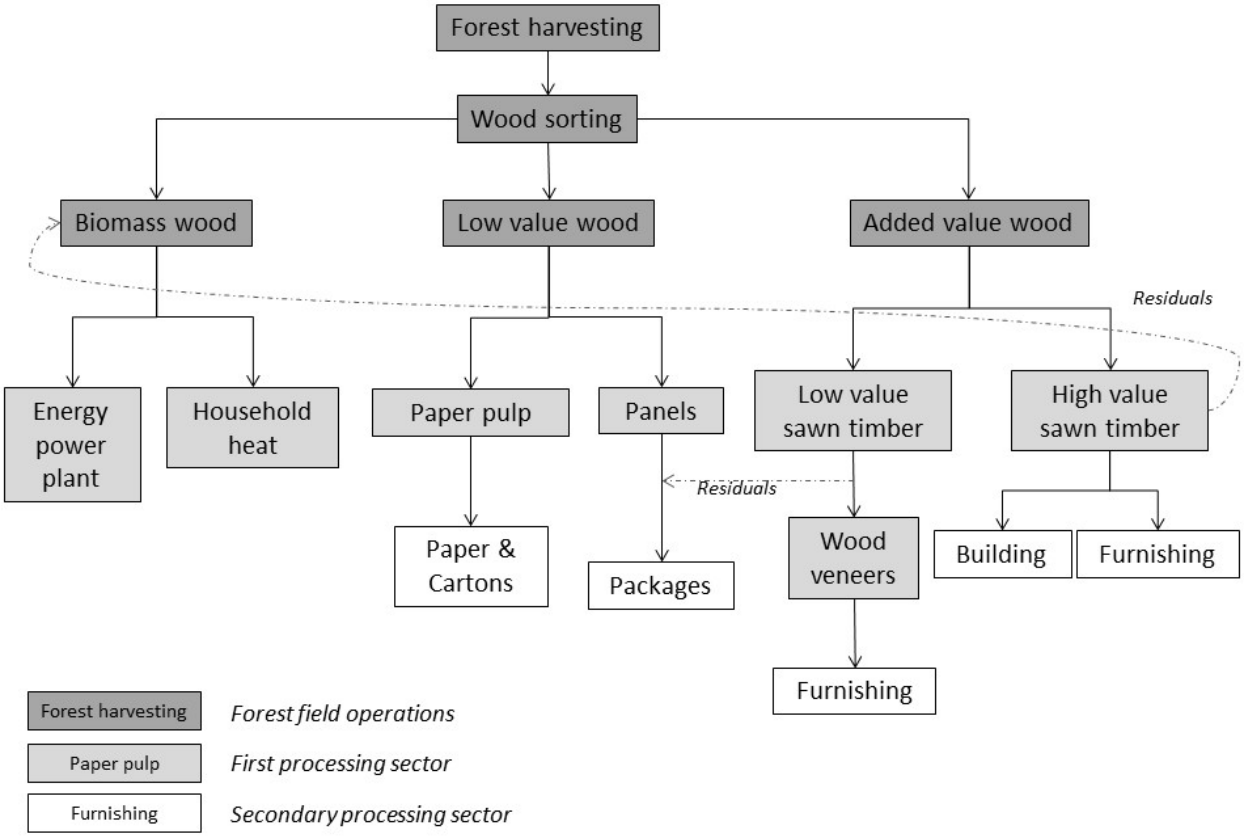

Figure 2. Simplified description of a structured and diversified forestry sector. As it was stated by most of PACA forest actors "*A more profitable and structured forestry sector should involve a regional wood supply chain with both first and secondary processing sector of transformation*". Yet, the development of a secondary processing sector requires wood with higher added value, necessitating management plans for selection of young trees with high potential value, wood sorting once trees are cut to select high value lumber, and technical structures.

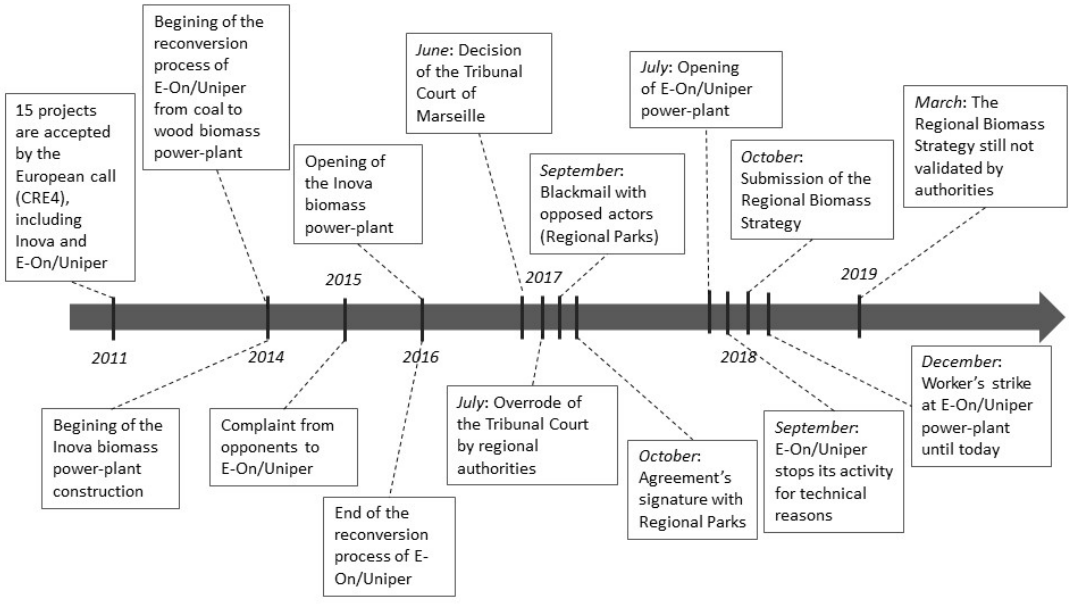

Figure 3. Chronology of the arrival of woody biomass mega power plants in the PACA region.

3.2. The Local Response to Top-Down Policy: Consequences of Lack of Information and Trust

The E-On/Uniper and Inova power-plants offer economic and political opportunities for the region. However, at the same time, the top-down implementation of the national woody biomass policy has sparked considerable disruption in the regional governance and for local foresters and citizens ("It is a big project suddenly launched in a very fragile context" (Forest community association member, May 2017)).

As explained in the previous section, regional forest actors have developed a collective heating network of small boilers with short wood supply chains. Hence, the implementation of the large E-On/Uniper power-plant in the region has been perceived as treason by foresters and regional decision-makers who work hard for the forest sector. Local actors perceive the wood energy approach as being probably more in line with the decentralised energy system imagined by Rifkin (2011) [52], an approach deeply rooted in the local territories breaking with the conventional centralised energy production based on huge energy power-plants. The giant E-On/Uniper company requires a much higher amount of wood resources, and has far greater harvesting capacities, than do local foresters. This situation drove several actors to prosecute E-On/Uniper in 2015 because of a weak environmental report with no consideration for regional actors, the context, and the forestry network that was already in place.

The political stakes of the E-On/Uniper project skewed the actor map and contributed to imbalances in the power involved. In June 2017, the Administrative Court of Marseille announced its decision to cancel the authorisation to operate that the French State had granted to E-On/Uniper in 2012. This decision was based on the lack of sufficient environmental impact studies, mainly on overharvesting risks for the forest, for the economic sectors present in the region before E-On/Uniper installation, and on transport pollution and noise disturbances. Thus, the Administrative Court of Marseille required E-On/Uniper to produce new environmental impact study that took into account its 400 km harvest's operation radius and not only the 3-km legal radius. However, a few weeks after the decision of the Administrative Court of Marseille, the political representative of the national government at the regional scale (named Préfet in French) overrode the decision and gave to the E-On/Uniper power-plant temporary authorisation to operate for nine months. Finally, in September 2017, two regional natural parks (the park of Luberon and the park of Verdon), who were the main actors to sue E-On/Uniper in court, were "blackmailed" (wording used in the press article) by the Préfet [53]. They were forced to sign an agreement with E-On/Uniper, otherwise they would not receive public subsidies from the regional authorities, the main source of their income. This last action highlighted the key motivations of this industrial project, motivations that are essentially political, questioning the real considerations for the interests of the PACA region, its forests, and its forestry sector. As demonstrated by Upreti and Van Der Horst (2004) [54], the non-negotiated and inflexible top-down implementation of the strategy, namely imposing social, economic, and environmental costs not previously discussed locally, has been interpreted by local people as a case of national targets having supplanted local issues ("I don't think that all of this project has been thought inside the PACA region. The reactions started at the arrival of E-ON/Uniper" (Forest operator, personal interview, Avril 2017)). This hard top-down implementation blocks the development of a trustworthy relation with a bad reputation for E-On/Uniper, implying that key condition No 3 is not fulfilled (Box 1).

Due to this preliminary reluctance and the weak network organisation of forest actors, the delays observed in operational planning gave decision-making power to big industries and created insecurity for small local forest companies. To respond to the industrial demands for wood resources, the PACA region had to create a committee, named the Regional Biomass Committee, in charge of implementing a supply strategy. The committee is constituted from regional institution members, a private forest owner union, a local forester company union, the forest cooperative, and all wood industrial actors, including E-On/Uniper, Inova, and Fibre Excellence. However, the committee was established after the national decision allowing E-On/Uniper and Inova to set up in the region, and the final

strategy report, named Regional Biomass Strategy (RBS), was published only in October 2018, whereas the development of the wood biomass sector for electric energy purposes began in PACA in 2014 (see the chronology in Figure 3). In the short-term, the delay in the RBS has created economic insecurity for forest operators and reluctance from private owners. In the long-term, it could threaten forestry sector development in PACA, the local biodiversity, and the carbon storage potential, so by extension the sustainability of PACA's forests. Such a lack of reliable information illustrates that the key condition No 1 is not fulfilled (Box 1).

The first impact of the RBS delay is an economic one with high disturbances in the forestry sector ("We created competition between wood biomass and the other wood sectors" (Forest operator, personal interview, June 2017); "The arrival of E-ON/Uniper increased wood prices very fast and created a bargain effect for foresters. Today, it is another story . . . " Forestry union member, participative workshop April 2017)). Even if the wood biomass development had a deadweight effect for regional economic actors, today profits for foresters remain modest. This can be explained by several factors. First, in the absence of a coordinated strategy, most regional forest entrepreneurs have invested independently in hard mechanization (We define "hard mechanization" as large and heavy equipment such as felling machines, chippers, or skidders. All of these machines are very expensive and bulky. This equipment is recent, until now most of foresters used light harvesters or chainsaws, and trailers), anticipating the future wood demands ("Today, each forest operator, even the smallest one, has its own mechanic harvester, skidder or truck" (Forest operator, personal interview, June 2017)). One mechanical harvester costs approximately €600,000, which explains why many forest entrepreneurs are now indebted. Second, E-On/Uniper has a constant need for biomass. At the beginning of the contract, E-On/Uniper establishes prices and biomass supplies with forest entrepreneurs for five years, and they vary according to E-On/Uniper's annual financial capacity (approximately €65 million per year, E-On/Uniper assertion, June 2017), the energy global market, and economic arrangements between E-On/Uniper and the French Electricity Company EDF (The French Electricity Company (EDF) is the first producer and supplier of electricity in France and Europe). Fibre Excellence does not establish five-year contracts. It buys wood logs to forest entrepreneurs when it needs it following the current market price and not the fixed price of the contract. Thus, wood biomass resale prices to the power-plant do not increase, even if the standing wood prices increase (see "Biomass-Policy (large scale)" in Table 3, which generates high provision services but also high rivalry). This situation obliges forest entrepreneurs to harvest large quantities to generate adequate salary and profits (e.g., to reimburse their debts) while the traditional wood market (e.g., sawmills cutting wood for construction and equipment purposes) would valorize wood quality ("Forest entrepreneurs seeking to maintain the stability of their activity will prioritize the supply contracts they signed with wood biomass power-plants. This is ruining the efforts developed to value woods for construction and equipment purposes, while the sawmill sector is in so much need of revival" (Richard Fay, regional forest association, Pers. Comm., 2017); "They take our valuable wood to burn it. There is no competition, we are just disappearing" (Sawmill owner, personal interview, May 2017)). Moreover, this need to produce wood in quantity threatens the local biodiversity and PACA's landscapes.

A second consequence of the RBS delay is the mistrust felt by private forest owners towards the forestry sector, and especially the wood biomass energy one. In fact, 65% of forests in PACA are private properties that are fragmented into small plots, with 217,850 owners [34]. Moreover, only 20% of the private forest plots have an official forest management plan. In France, only forest plots larger than 25 ha require an official forest management plan certified by the regional institution representing the National Forest Ministry. To mobilise biomass quantities, forest operators must deal with the fragmentation of private forest lands. Hence, the most accessible and smallest plots suffer under pressure from forest operators because operation costs are low on easily accessible plots, and environmental regulations are weak on plots smaller than 25 ha. Thus, we are already

observing a dichotomy in the PACA forest landscapes, with some plots being overharvested and others left unharmed. Without a forest management plan, there is no selection of standing trees. Thus, high value trees are not preserved to keep them growing and sold them later to second transformation industries in the future (Figure 4). Given the high speed of development of the wood biomass energy sector, private forest owners feel that their forest resources are "looted" (information collected during participative workshops), which creates resistance from forest private owners and reduces trust, making it difficult to achieve the key condition No 3 in Box 1.

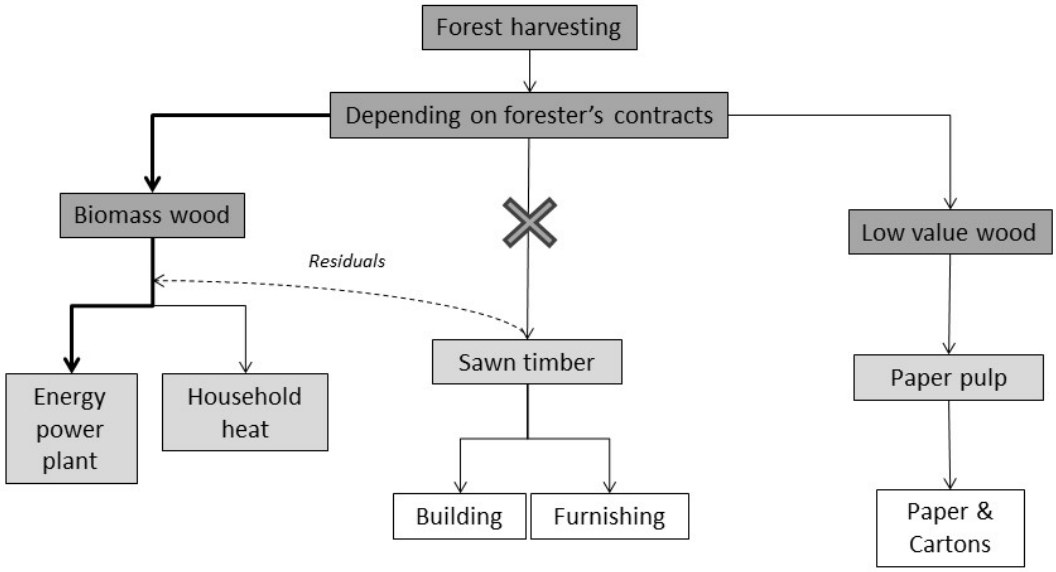

Figure 4. Description of an altered forestry sector with a domination for the biomass wood production. In this case, woods are not still sorting according to their value but according to the forester's contracts with industries.

3.3. Recent Social Capital and Leadership Development: Helping to Solve Joint Problems in Managing the Forest Common-Pool Resource?

Even though local actors questioned the legitimacy of the arrival of the E-On/Uniper power-plant, most of them admitted that a new wood market could create regional wealth and opportunities for the forestry sector ("Now, E-ON/Uniper is here, we have to deal with it" (Forest expert from CRPF, April 2017)). Some local actors understood that this political project was unavoidable and that it could be an opportunity for the development of a regional secondary processing forest sector. In this way, E-On/Uniper and Inova have been a trigger for the PACA region, generating hope for new potential opportunities.

It is a matter of fact that E-On/Uniper has emerged as a potential driver for the regional forest development. The absence of a forestry leader in the PACA region for many years presented an opportunity for E-On/Uniper to endorse the vacant role of leader for the regional forest sector to facilitate the integration of the project inside the territory, which seems to fulfil the key condition No 6 (Box 1). First, in response to the fear of overharvesting, E-On/Uniper engaged in creating a sound forest chart that aims to ensure sustainable forest practices (personal comments collected during participative workshop). Second, for industrial transparency, E-On/Uniper participated in all regional forest meetings and built a close relationship with regional actors. Then, the company went further by planning the installation of a sawmill and wood storage next to its wood-fired power plant to value high quality trees ("We are open to the installation of a sawmill in our structure. Moreover, it will be possible to use "the overflow heat" to dry logs" (E-On/Uniper member, participative workshop, April 2018)). This quelled the controversy raised by several actors (environmental associations, some Forest Entrepreneur Union members, and some Forest Private Owner Union members), who feared that these trees

would end up being burnt for energy purposes whereas their height, their shape, and their diameter would have allowed them to be sold to high value-added sectors (Figure 4).

The previous paragraph suggests that wood-biomass power-plants in PACA might have positive impacts on forestry sector for structuration and economic development. However, during the participative workshops, some stakeholders asserted that the E-On/Uniper sawmill will not attract the secondary processing sector in the region: "Today, it is not a problem of resource quantity but of quality. If private owners do not develop a forest management plan in their forest, we cannot increase the value of PACA forests" (Forest Private Owner Union and Forest Entrepreneur Union, participative workshop, April 2018). According to those stakeholders, because of lack of forest management plans on private lands, high value woods are rare, and E-On/Uniper will only be able to value a few high-quality logs that arrive at the plant by coincidence from time to time.

The resulting structuration that UNIPER proposes with its sawmill will be based only on the E-On/Uniper perspective and activity, which is based on biomass exclusively rather than on holistic planning. This monopolistic market could be dangerous for the PACA forestry sector in terms of impacts on prices, resource's supply, salaries, forestry sector development, and employments. In addition, it could be dangerous for the sustainability of local forests because only one stakeholder vision of the forest ecosystem and services is taken into consideration: forest biomass for energy purpose, so the key condition No2 is not encountered. Such a biomass policy at large scale is likely to generate low supporting, regulating and cultural services, as it is described in the scenario in Table 3 developed by local stakeholders during participative workshops. All stakeholders, except E-ON/Uniper, have attested that this scenario is dangerous for the PACA forest if harvest operations continued as they are currently.

3.4. Competition Generated: Loss of Trust and Lack of Monitoring

According to Jenkins et al. (2018) [55], environmental challenges, such as energy transition, could represent an opportunity for the "bottom of the social pyramid" because they involve new stakeholders to create new offers and satisfy currently unmet needs. However, this suggests that all actors, old and new, share at least one common target in the transition process. The European Union sets the H2020 environmental targets and the French government sets renewable energy policies to meet the targets. In terms of climate change mitigation and renewable energy development at both European and national scales, the meaning of this strategy is quite understandable. However, it is questionable if among all the goods and services provided by the forest common-pool resource, we should only consider the public good of climate regulation service or also the other ecosystem services and goods provided by forests at both medium and small scales (Table 2) ("Today, our forest is more vulnerable to wood biomass sector than to climate change" (Private forest owner, personal interview, May 2017)).

To create opportunity for "the bottom of the social pyramid", all actors should be left with the same chances. However, in the PACA region, we observe disparities between large- and small-size forest companies. Large-size companies have much higher technical and financial capacities, in addition to both greater and easier access to forest plots than do small-size companies. As a result, large-size forest companies succeed in selling huge amounts of standing wood to power-plants at lower prices, whereas small local companies do not succeed in harvesting such amounts of wood and cannot afford to sell at low prices. In particular, two companies benefit from the implementation of Inova and E-On/Uniper power-plants in PACA: the Forest National Office (Office National des Forêts (ONF) in French) (The National Forestry Office is a French public institution of an industrial and commercial nature responsible for the management of public forests under the supervision of the Ministry of Agriculture, Food, and Forestry and the Ministry of Ecology, Sustainable Development, and Energy) and the Forest Cooperative (Coopérative Provence Forêt in French) (The forest cooperative was founded in 1997 by 18 forest owners of PACA with the aim of optimizing forest management and making better use of timber cuts by sharing

their costs and the skills of their forest technicians. In 2016, the forest cooperative counted 2842 members, representing 120,698 ha in the PACA region).

The ONF has a huge advantage over other forest companies; it manages most of the public forests, which are the property of the State or cities (the ONF plays a key role in organizing the "Biomass policy (large scale)" under a situation of high excludability with harmful consequences on several ecosystem service categories; see Table 3) ("The ONF has a stranglehold on the offer and plays with the availability of wood volumes, and they increase prices when we need it" (Forest operator, personal interview, June 2017)). This means that the ONF has prior access to a vast number of forest plots not only in the region, but also all over the country. The competition is as follows: the ONF keeps the most valuable wood, in terms of high-value woods or low harvest costs, to sell it directly to the processing sector (Figure 2), and it sells the lower value standing wood to the local forestry companies, which will have to cut the wood and then sell it to first processing sector. We observe in this context an extreme and unfair economic competition between actors (Table 3; bold arrow in the cell on the 4th column and 8th row). This situation creates many conflicts within the region and increases tensions between local forest entrepreneurs, drastically reducing the level of trust and impeding achievement of the key condition No 3 (Box 1).

The second actor who benefits from the energy transition in PACA is the Forest Cooperative named as "Provence Forêt". It has economic resources, such as financial means, already amortized machinery and equipment, and human capacities. Their human capacities (12 employees and 10 privileged operator partnerships) allow them to prospect forest private owner, which is time consuming. To do so, they use their members' network and their status which gives them trustworthiness. Moreover, these prospections allow mutualisation of harvest operations with several private forest owner plots that are not members of the cooperative, thus decreasing the cost of harvest operations ("The big ones, as Provence Forêt or Fibre Excellence, they have the possibility to hire people who are only dedicated to prospecting. But us, we are already struggling to pay our lumberjacks" (Forest entrepreneur, personal interview, May 2017)). This gives a crucial advantage to Provence Forêt rather than to small forest entrepreneurs usually working with just two or three employees, and hence lacking human resources to prospect private forest owners. The larger mechanical capacities of Provence Forêt make it a good operator for ONF's complex forest plots. Smaller forest entrepreneurs cannot compete.

As we have said above, the ONF company benefits from priority access to all national public forests. Hence, the ONF company could supply the E-On/Uniper power-plant with wood biomass from another French region; especially from North-East France [56] where tree productivity and plot accessibility are better. Unfortunately for small PACA forest entrepreneurs, they have to deal with local wood resources and hard environmental conditions. This generates great levels of jealousy, which decreases solidarity and increases local entrepreneur isolation in PACA ("The ONF does not play fair. They sell plots at expensive prices which are difficult to access and to harvest, which generates high harvest costs. Besides, they keep the most accessible plots for their own harvest activity, which allows them to sell wood to industries with a larger profit margin" (Forest union member, personal interview, April 2017)). Such a situation is destroying the social capital among local forest entrepreneurs (key condition No 6 in Box 1) and the trust (key condition No 3 in Box 1) between small local entrepreneurs on the one side, and large-size companies, as well as the French government (ONF included), on the other side. Today, only 40% of the wood supply purchased by the E-On/Uniper power-plant comes from the PACA region, while the rest comes from other French regions, Spain, and Brazil (assertion during interview with E-On/Uniper).

This situation has strongly degraded the trust that had prevailed for more than half a century between foresters and industrial sectors (mainly with Fibre Excellence). This explains why the key condition No 3 is not encountered (Box 1). Based on the knowledge we gathered through interviews, participative workshops, observant participation, and

archive analysis, we designed an integrative causal-loop diagram describing local dynamics of the PACA forest system (Figure 5). The three feedback loops maintain the system in a deadlock process combining the historical barriers (R1 in blue in Figure 5), the top-down implementation of the wood biomass policy (R2 in orange in Figure 5), and the consequences of the created unfair competition (R3 in red in Figure 5).

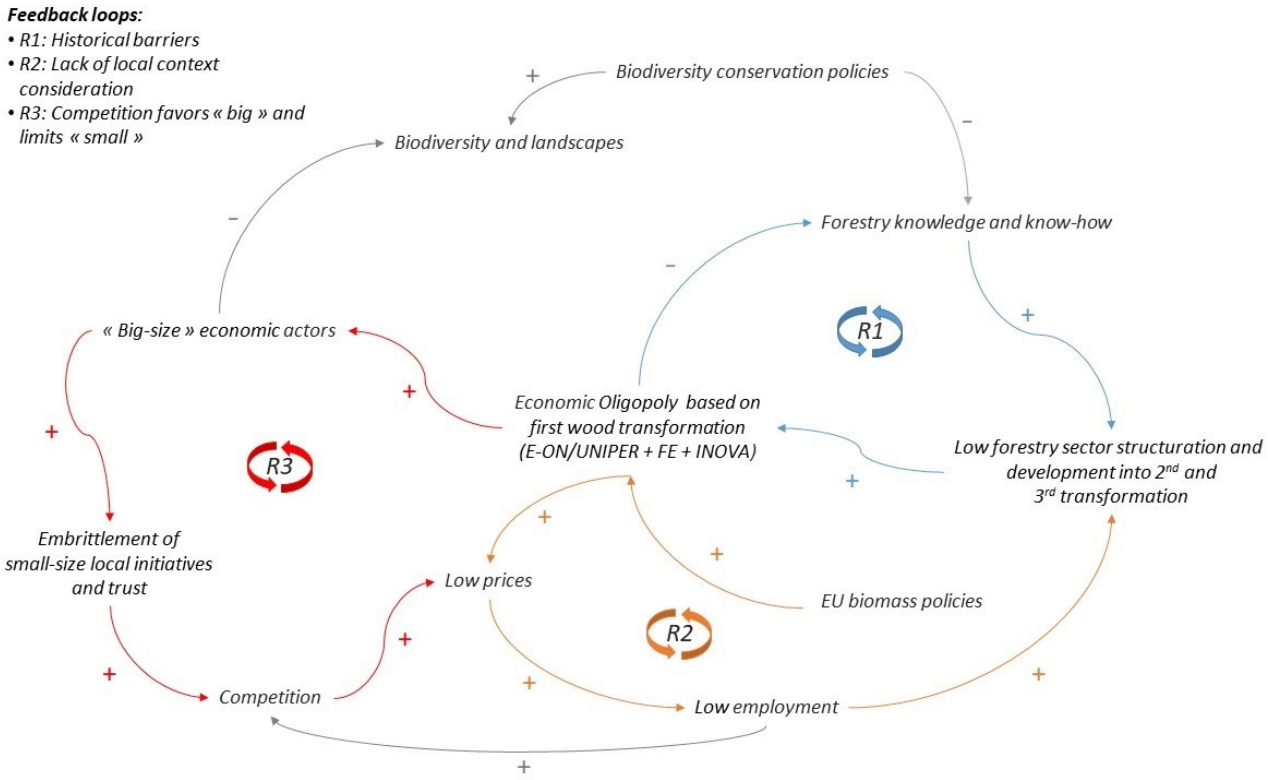

Figure 5. Causal-loop diagram summarizing the local dynamics of the PACA forest system. The sign + describes an enhancing effect and the sign − describes a limiting effect. The blue arrows are associated to the feedback process R1, the orange arrows are associated to the feedback process of R2 and the red arrows are associated to the feedback process R3. The grey arrows represent simple cause-effect dynamics in the system.

4. Policy Implications and Concluding Remarks

We demonstrated that the implementation of the wood biomass energy policy remains difficult considering that the six key conditions (Box 1) designed by Ostrom are not encountered in the PACA's forest social–ecological system. As stated by Jenkins et al. (2018) [55], transition processes without good governance and social considerations create strong inequities, favoring few winners and disadvantaging many losers, as did the historical fossil-fuel transition. The choice of the French government to impose E-On/Uniper and Inova structures in the PACA region clearly generates exacerbated unfair competition, rather than collaboration. This unfair economic competition is generated by two market failures resulting from the centralized wood energy production system chosen in PACA. First, prices of standing wood biomass purchased by E-On/Uniper to ONF and small local forest companies are maintained at low levels due to the oligopolistic market. E-On/Uniper can impose low purchasing prices since there are not many other purchasers in the region under such a centralized energy production system. Second, ONF abuses of its dominant position and does not contribute to market equilibrium, as would occur in pure and perfect competition, since it is unable to reduce its prices of standing wood biomass sold to E-On/Uniper, whereas the 2800 small local forest companies cannot. Thus, E-On/Uniper, Inova, the Provence Forêt cooperative (2842 forest owner members) and ONF are the "big" winners of this energy transition, whereas Fibre Excellence, 226,000 private forest owners,

and 2800 small local forest companies suffer from the global wood market and international political agendas.

The transition process needs leadership to create movement inside the social–ecological system [57] and the emerging bioeconomy requires innovative policies to regulate markets [1]. In such a new context, forest actors would be more likely to behave collaboratively to manage their forest goods and services. Here, we propose an energy transition policy based on three steps which would help to solve collective action problems in PACA's forest management. The three steps are developed below and can be summarized as follows: (i) the development of communication and transparency, (ii) the clarification of shared values and common vision, and (iii) the increase of involvement and solidarity. These three steps lead to the emergence of social capital and local leadership (key condition No 6), crucial factors to the success of local energy transition initiatives.

First, forest properties should be visible to all forest stakeholders to create transparency and connection between actors. Transparency would enable the design of an information and communication system in which forest owners would interact and receive information about forest management practices related to their own property as well as information regarding the other forest community members, such as their location, the management plan and practices they choose, etc. (key conditions No 1 and No 4, Table 4). Such a transparent information system open to the members of the forest community would allow comparisons to be made between neighbours. Comparison is important in a collaborative system. It helps community members to learn how to improve their forest management behavior and to develop consideration for other forest owners who have designed a well forest management plan. The learning process operates as follows. Owners without management plan could be informally sanctioned by the community and encouraged to implement a management plan with the help of other members (key condition No 5, Table 4). Owners with proper management plan would receive the expression of informal moral rewards from other members (simply being seen by others as a good person, and the internal satisfaction of doing good). The moral reward is obtained by respecting the norms and the values of the social group that people need to follow to be considered as being a good person who deserves to be liked, respected, or esteemed [58]. Such a collaborative system relies on observations incorporating aspects of behavioral psychology and experimental economics suggesting that the desire to be seen favorably by peers and the belong to a social group is deeply rooted in human psychology [58].

Table 4. Proposition of policy measures for the emergence of Ostrom's key conditions required for local stakeholders to self-organise to solve collective action problems in managing common-pool resources.

Ostrom's Key Conditions	Policy Measures
1. Reliable information on impacts of the collective action	• Modify the regulation to make the cadaster * accessible that would provide concise information on how foresters manage their forests (required by actors during participative workshops). • Make information accessible to forestry institutions concerning the private community, in order to develop collective projects and to design precise cartography (required by actors during participative workshops).
2. A same common resource is seen as important by everyone	• Switch from the concept of common resource (e.g., wood supply) to the common service (e.g., fire management) (identified during participative workshop). Also proposed as "Build upon the entire spectrum of ecosystem services" in the National Strategy for Ecological Transition towards Sustainable Development (2017) [17]. • Identify in a participatory workshop, ecosystem services or goods provided by forest for which all actors commonly agree [59–61].

Table 4. *Cont.*

Ostrom's Key Conditions	Policy Measures
3. It is important to be a trustworthy reciprocator	• This condition is likely to emerge spontaneously once policy measures succeed to build a social group (key condition 2), aware of the costs and benefits of collective actions (key condition 1), communicating and working together (key conditions 4), and sharing the same values (key condition 5).
4. Each one can communicate with the others	• Modify the regulation to make the cadaster * accessible to an association that would be allowed to use the cadastre to create an online platform (proposed by actors during workshops).
5. Informal monitoring and sanctioning	• The information sent to forest owners (key condition 1) will provide a signal on the norms and values shared by the members of the forest community. • Develop labels and certifications of sustainable forest management, as REDD+ [1,11], for all forest plots, not only protected one, to avoid drifts as it is already observed in the region.
6. Social capital and leadership	• Design an environmental tax or a system of payment for forest ecosystem services and transfer the amount collected as an incentive to forest owners who design forest management plans or tax exemption to encourage reinvestments [62]. • This condition is likely to emerge spontaneously once policy measures have succeeded to build a social group (key condition 2), that communicate and learn how to work together (key conditions 1 and 4), and share the same values (key condition 5).

* The cadastre of forest properties is secret in France. Nobody has access except ministry of Agriculture and Forest, regional representative of the ministry, and the Prefet (State's representative in the region).

Second, participative workshops with local actors should be organized to identify shared values and vision of the territory with the aim to favor the emergence of the key condition No2 (Table 4) [59–61], i.e., developing more sustainable management based on a common vision of the social–ecological system (it corresponds to the policymaking key point named "Become sustainable in all dimensions" in the European Commission report on Bioeconomy (2018) [1]. For the purpose of our case study, during the workshops we organized, we identified that many actors (regional parks, residents, hunters, foresters, shepherds, etc.) wanted to preserve the numerous ecosystem goods and services provided by forests (wood logs for multiple purposes; fresh and clean water supply; landscapes; recreational activities; biodiversity; climate regulation; etc.). Accordingly, the fire-management strategy (last column in Table 3) proposed by actors during workshops could be the common vision of the PACA's forest management, considering that this practice could improve also cultural landscapes, biodiversity, social cohesion, traditional knowledge, agro-forestry, pastoralism and security (it corresponds to the policymaking key points "Build upon the spectrum of ecosystem services" and "Enhance cross-sectoral cooperation" in the European Commission report on Bioeconomy(2018).

Third, because some forest goods and services are non-excludable (e.g., common-pool resources in Table 2) and even non-rivalrous (e.g., public goods in Table 2), they benefit to everyone even to community members who do not contribute to forest management costs. Therefore, public authorities should design specific taxes or a system for ecosystem services

payment (PES) borne by those using public goods and common-pool resources provided by forests. These taxes or PES would be paid to forest owners in order to encourage them to implement forest management plan respecting shared values and practices (key condition No 3 and No 6) (Statements from participative workshops). In the same way, Elyakime and Cabanettes (2009) [62] propose to decrease taxes for bioeconomy sectors and the creation of investment funds to encourage stakeholders to invest in these mutual funds to reinvest for large scale and collective sylvicultural projects.

The wood biomass energy strategy implemented in the PACA region is based on the panacea paradigm, which assumes that the installation of one sole huge wood biomass power-plant would be able to mitigate climate change (international issue), solve energy demands (European and national issue), and develop the economic forestry sector (local issue). However, many authors highlight that environmental issues and sustainable development require a portfolio of diverse solutions and means, in addition to the creation of new partnerships between companies, civil organizations, and public actors [1,63]. As described by Kleinschmidt et al. (2017) [12] and Pülzl et al. (2017) [18], new bioeconomy sectors such as wood biomass remain mainly a combination of technological progress, markets, and growth, and often forget environmental and social issues. Here, we observe a similar phenomenon, with a strategy that rests mostly on one main, subsidized, and multinational company (E-On/Uniper) and on one forest ecosystem service (biomass provision). This strategy tightens the spectrum of forest ecosystem services and goods which jeopardizes the sustainability of the social–ecological system. More specifically, the creation of such an oligopolistic wood market is risky in terms of the impact on prices, resource supplies, salaries, and employment. Thus, we can observe that France based its energy transition on high tech sector development and emerging industry stimulations with a new power-plant, E-ON/Uniper, as part of the current centralized nuclear energy network [52]. However, a lack of diversity in the social–ecological system reduces resilience in both the mid- and the long-term and makes the system more vulnerable to all types of disturbances.

The case of the PACA region energy transition represents a relevant example concerning the dangerous evolution of forest resource uses during the 21st century at the global scale, namely the hard industrialization of forest management and energy demands. Such a situation raises an important question. What type of forests do we want in the future, i.e., which forest ecosystem services or goods would we like to either preserve or develop?

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