Climate and biodiversity. Reconciling renewable energy and biodiversity

Michel Trommetter

Orée
Entreprises, territoires et environnement

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Climate and Biodiversity

Reconciling renewable energy and biodiversity

Under the scientific direction of Michel Trommetter
Director of research at INRA

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Camille SAINT JEAN - Intern project coordinator CSR Reporting and Local Grounding – Circular Economy / Recycling
Gabriel PARATIAN – Intern project manager

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Association ORÉE
42, rue du faubourg poissonnière
75010 Paris
Tél : (+33) 01 48 24 04 00
E-mail : oree@oree.org
Site Internet : www.oree.org

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Editorial by Nathalie Boyer, General Director

For a perspective on the links between biodiversity and climate

“ Since the COP 21 talks in Paris 2015, ORÉE has been pursuing its reflections on solutions for the climate and their biodiversity implications. This document deals with the links between the stakes of energy transition and fighting the erosion of biodiversity. Faced with the question of the coherence between these major issues, this document intends to provide lines of approach and actions which should make it possible to meet the different environmental issues by decompartmentalizing the thought processes.

Focused on the mitigation of global warming through a change in practices and their links with biodiversity, this book challenges the territories and their actors regarding energy management. It notes in this respect the significant role of Industrial and Territorial Ecology that ORÉE has been promoting for more than 10 years.

Here, ORÉE is proposing to integrate biodiversity in reflexions on energy and energy transition, by using reflexions by the Biodiversity-Economy prospective Working Group, the points of view of experts and economic actors. Thus the concept of sustainable energy is developed, in the meaning of the Bruntland report, including renewable and recoverable energy, under certain conditions: R&RE. This document will be followed by work from the WG Biodiversity-Economy to support in the best possible way the energy choices of actors in meeting our societies' and territories' sustainable development challenges.

Good reading ! ”

Nathalie Boyer
General Director of ORÉE

Editorial by Patricia Savin, Chairwoman

Renewable energy and biodiversity: when transversality goes hand in hand with multidisciplinarity and humanity with solidarity

“ The Paris Agreement urges the acceleration of the public and private commitments to limit impact on the climate and prompts us to rethink the relationship of energy, via energy sobriety, energy efficiency and sustainable energy. Announced as the great priority of the century, the fight against global warming is thus in the limelight, pushing the fight against the erosion of biodiversity into the background.

The links of climate and biodiversity are thus rarely made, due to reasoning and logic in silos. The legal silo with two distinct laws; the law of August 2015 on energy transition and the law of August 2016 on biodiversity. The political silo with the road book of 9th August 2017 addressed by the Prime Minister to the Minister for the Environment which focuses on energy transition and incidentally mentions biodiversity. The legal silo with lawsuits opposing the partisans of renewable energy and the defenders of biodiversity.

Actually, Humanity is faced with two major challenges to be tackled together in order to harmoniously blend «energy transition» and «Biodiversity». Knowledge helps to understand the issues. Awareness will help to accelerate the implementation of the solutions required to build the indispensable bridges between energy transition and biodiversity. A large number of voices are making themselves heard on this subject and among them the voices of all those who have contributed to this publication and our heartfelt thanks go to them. Experts, economic actors, politicians, citizens, etc., each of us, individually and collectively, is the solution to the challenges to rise to. Challenges which suppose that transversality goes hand in hand with multidisciplinarity and humanity with solidarity. ”

Patricia Savin
Chairwoman of ORÉE

Intersection between issues of biodiversity, climate and energy

Biodiversity «is the living fabric of the planet, the natural capital of our territories [...] and we are part of it»[1]. This term covers all the species, populations, ecosystems and interactions between organisms in changing environments. As a complex and systemic notion, biodiversity constitutes the living base of the actors of our societies.

The relationships between atmosphere and biosphere have formed over a thousand years of history. If we can understand our planet and its future by speaking of the climate or biodiversity, it is fundamental not to forget that they cannot be taken separately due to the multiple interactions and interdependencies between them. There are numerous exchanges of matter and energy between the biosphere and the atmosphere. The erosion of biodiversity exacerbates climate change and its effects, which in turn amplify the crises of living systems (particularly by desertification).

In the light of climate stakes, when the energy issue is added to the reflexion as a solution for reducing greenhouses gases (GHG) and therefore mitigating climate change, all these interactions must not be forgotten. If GHG seem to be easily measurable and reducible to some indicators, their management nevertheless remains linked to multiple biodiversity stakes which impose an approach to the complexity of climate-energy-biodiversity issues for sustainable solutions.

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Preface

“ We're there ! Never before have climate issues and zooms on biodiversity, whether on the subject of rhinoceroses, animal intelligence or invasive plants, been talked about to such an extent.

And never before have we looked so closely at the oceans, the land, the atmosphere, the climate and the fires caused by droughts which are ruining our beloved summers.

Politicians are now also taking over these dimensions, and we thank them for the impetus of the recent symposium on the project of a Global Compact for the Environment held in Paris.

All of this goes with a developing culture of fear, which of course responds to issues of safety, culture and society, and which is gradually spreading.

This may means that we actually have more knowledge than ever; instantaneous sensors which «say» things. To summarize, Diamonds' «*Collapse: How Societies Choose to Fail or Survive*» translates Humanity's knowledge and posture on its Earth island: what needs to be changed to avoid a collapse that previous civilisations went through, and which were avoided by others.

It is also absolutely remarkable to note how the media have been breaching the paradigmatic field. They are now daring to talk about these subjects and are developing a skill and an appetite for reporting the advances of our scientists, our politicians' brave attempts and the experiments carried out by our firms and local authorities.

How do we at ORÉE see all this? Is the game getting under way?

Anyway several crucial points have become clear to us.

Deep cultural change, which is the only change capable of modifying our life skills and consumption, is not yet deep enough or shared enough for citizens to change their idea of well-being and living together. Our fellow citizens living in towns (unfortunately this also affects country areas) do not have enough pleasant experiences to encourage them to invent collective lifestyles which are more respectful of the Earth.

Furthermore, we find it very difficult to rely on the enlightening tools and practices we need for decision-making when we need to make choices, carry out work or invest.

Following in Jacques Weber's footsteps, ORÉE's Working Groups confirm day after day that actually one of the major causes of our blocks (epistemological ones it would seem) stems from our great difficulty to tackle things by grasping complexity without fear, a complexity which is a reality of life. The popular and efficient path of simplification is now obsolete if we want to contemplate and operate on a terrestrial dimension.

This is how ORÉE's new guide pursues the combined approach of climate issues, diversity of life, economy, sociology and engineering. Congratulations. ”

Claude Fromageot
Yves Rocher (Co-Chairman of the WG Biodiversity-Economy, Development Director,
Leader of Groupe Rocher
et Director of Fondation Yves Rocher)

Michel Trommetter
INRA (Co-Chairman of the WG Biodiversity-Economy,
Head of Research at the Laboratory of Applied
Economics of INRA at UGA)

Introduction

Faced with the stakes of sustainable development, the challenges imposed by climate change and the erosion of biodiversity must be taken into consideration coherently.

To limit our impact on the climate, we must drastically rethink our relationship with energy and first and foremost what is known as carbon-intensive energy.

Three complementary and inseparable courses of action should allow us to reach such objectives. Firstly, energy sobriety; the best energy being energy which is not used, this challenges our behaviour. Next, energy efficiency which stimulates techniques and lastly the use of sustainable energy which we focus on in this document.

These forms of energy are sometimes known as «green», or «clean» and are grounded in the territories. Their development overlaps biodiversity issues on different scales (of time and space). Moreover, if thinking the energy of energy transition often means «natural renewable energy» for actors, the notion of flow or closing the cycle is very rarely mentioned and the use of unavoidable energy forgotten.

This document considers and defines this sustainable energy for current issues. This sustainable energy groups together «sustainable» renewable energy and recoverable energy (R&RE).

So this is an opportunity to combine the issues of climate and biodiversity to help us to approach the boundaries of what is possible for a sustainable development energy transition.

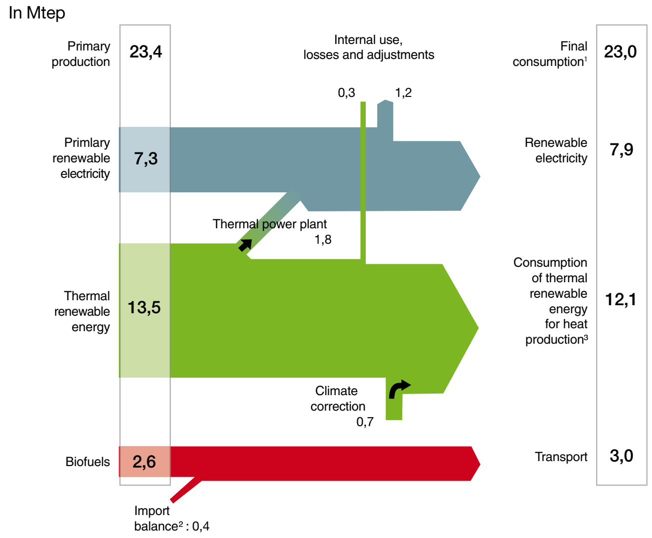
Intersection between issues

According to the dictionary, «*energy is the physical value characterizing a system, that retains the same value throughout all the system's internal changes (law of conservation) and expresses its capacity to modify the state of the other systems with which it interacts*»[13].

In this work, we will be dealing with the actual use of this value. In the same way as all living systems, we produce energy, but Homo sapiens has developed something called «energy assistance». This assistance helps our societies to free themselves increasingly from natural constraints. At first it was «animal» and then «machine» and at the end of 18th century, it took on a truly «destructive» proportion for the planet with the extraction and combustion of coal, which was followed by oil extraction. Its implementation sets off a technological, industrial and economic headlong rush.

Man produces, transports and uses energy through a series of transformations which are known as the «energy chain» (see diagram).

This chain is made up of three types of energy: **primary energy** which is the «source» form of energy to be found in nature prior to any transformation (for example: wind). When it cannot be used directly, it must be transformed into **secondary energy** prior to being transportable and then used (for example: electrical energy). The energy used is **final energy** and is in three forms: **transport, electricity and heat**[18].



¹ Corrected data of climate variations
² Imports – exports
³ Except for external use, losses and adjustments

« Chiffres clés des énergies renouvelables – Édition 2016 », coll. Datalab, SDES.

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Greenhouse effect – Sustainable energy

The atmosphere's greenhouse effect acts like a blanket to limit heat loss and is mainly due to water vapour, carbon dioxide, methane, nitrous oxide and fluorinated gases. The quantities of atmospheric CO_2 released during the combustion of fossil energy are so large that they modify the planet's greenhouse effect. Limiting this modification means turning to another energy offer system, a "sustainable" one.

This transition must therefore rely on all the so-called «**sustainable**» energy sources along the lines of the Brundtland report[5]: all the energy capable of meeting the energy requirements of the moment without compromising the capacity of future generations to meet their own energy requirements.

This includes all the sources present in the form of permanent flows on the scale of human time: renewable and recoverable energy (R&RE).

Renewable energy

Primary renewable energy (RE) is comprised of primary natural energy sources whose **consumption does not limit their future use**. They therefore recover faster than they are used.

Renewable primary energy exists in form of permanent flows which can be discontinuous over a shorter period of time (e.g. variable sunlight during a day) but their future use is not limited by their consumption. This is not the case for so-called non-renewable energy sources which come from stocks from deposits (limited to human time-scale) of fossil fuels (oil, coal, gas) or fissile fuels (uranium, plutonium, etc.).

There are four natural sources of **permanent flows** of primary energy: the **Sun, the atmosphere, the hydrosphere and the inner Earth** (lithosphere, mantle and core). We can add a fifth: the biosphere or non-fossil biomass. But it is only considered to be renewable if its regeneration is higher than its consumption over a given period of time[8].

In 2012, all over the world, RE represented 19%, fossil energy 78.4% and nuclear energy 2.6%. A little under half of the 19% of RE was linked to «traditional biomass», i.e. wood combustion or organic waste. The modern forms of «RE» therefore represent around 10% of the final global energy consumption (not counting the energy consumption of the energy sector). If we consider RE alone, the rise in energy consumption over the last few years is practically entirely due to «modern» RE (wind, solar, hydraulic, modern biomass) (biogas, biofuels and solid biomass) thanks to an increase in capacity and yield[18]. In France, a considerable number of sectors are covered by RE.

The challenges of storing renewable energy

Wind strength varies, rain frequency too and the sun goes down: renewable energy (RE) is very often intermittent. Energy storage is therefore a major challenge in the development of RE. There are few storage technologies that are cost-effective both at technical and economic level.

Two of them are currently being used on a very large scale for energy storage: pumped-storage and electrochemical batteries (lithium).

The former is the oldest and the best controlled. In France the structures account for 6 000 MW of power.

Thanks to their potential, lithium batteries are gaining ground on worldwide storage capacities, to such an extent that the demand for lithium could increase by 1 000% in order to meet the 2°C objective by 2050[24]. Very large surfaces are necessary for its extraction as its concentration decreases considerably with depth. This leads to high *in situ* impacts on ecosystems, and heavy *ex situ* pollutions due to chemical leaks from the extraction sites, which cause considerable damage to biodiversity.

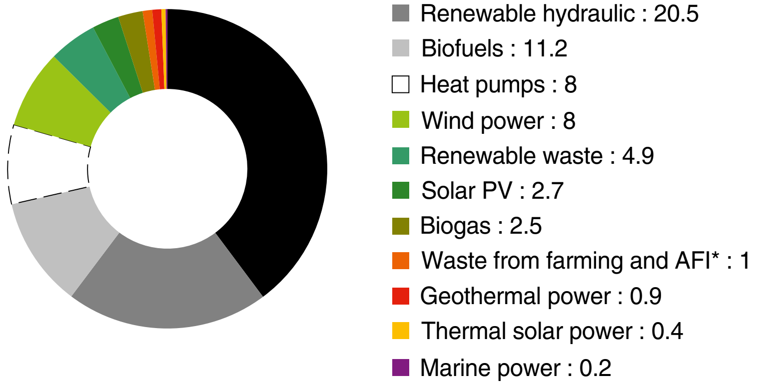
Recoverable energy

Recoverable energy covers the non-natural sources of secondary energy which stem from human activities and release what is known as «residual» or even «**unavoidable**» energy.

The life cycle of any service or asset takes place in three major stages: upstream, use, downstream. For each one, the system has an incoming flow and an outgoing flow. These flows always include energy. The outgoing flow, if its primary vocation is not to be used for energy purposes, is known as unavoidable energy. Thus, unavoidable energy can be found at all levels, with three types of source: process', utility, or waste. Unavoidable energy is to energy what waste is to materials. When unavoidable energy is used by a consumer, it is known as recoverable energy.

Unavoidable energy is only renewable, and therefore sustainable, if its regeneration is higher than its consumption (the same condition as for energy from biomass).

PRIMARY PRODUCTION OF RENEWABLE ENERGY BY SECTOR IN 2015
TOTAL : 23.0 MTEP
In %



AFI : agrifood industry
Field : metropolitan France
Source : SOeS, from the sources per sector

« Chiffres clés des énergies renouvelables – Édition 2016 », coll. Datalab, SDES.

A context favourable to the territorial approach

The energy sector is currently extremely centralised. A limited number of industrial units produce almost all the national energy.

Sustainable energy (RE and recoverable energy: R&RE) relocates the energy production activity on a smaller scale (known as the territorial scale). Almost all the R&RE use the resources in the form of flows which are present at a local level (sun, water, wind, unavoidable energy, etc.). The capacity of the new production units is low.

Energy transition to fight climate change decentralizes and fragments the energy production system to bring it down to a local scale. This relocation of the energy production activity is part of a context of local grounding which requires a systemic approach to the territory and energy issues. It serves as a background for this document.

At the economic and social level, the «new» forms of energy have the wind in their sails. Most of the sectors are growing rapidly and initiatives are multiplying. At the political level, Action Plan 13 of the Climate Scheme specifies the will to accelerate the deployment of RE[12].

Legal reforms such as the simplification of the national regulatory framework were introduced more recently and encourage this energy transition of production methods. The ratio between production and consumption is broadly discussed and in particular the self-consumption of energy which supports the new decentralized energy approach.

Editorial choices

In the framework of this document, a few examples of renewable and recoverable energy were chosen. Their biodiversity stakes are explained by means of diagrams with keys. Although it is not exhaustive, this approach makes it possible to illustrate the different spatial and temporal dimensions for relatively important technologies in terms of installed or potential power, from the point of view of their development and maturity at French level.

The examples broached in this way will be energy from biomass, hydro-electricity, wind and solar farms, some marine energy and recoverable energy.

RENEWABLE ENERGY AND BIODIVERSITY: FRIENDS?

Energy – biodiversity: 2 laws passed in 2 years.

Patricia Savin
Lawyer Partner, DS Avocats,
doctor of law

On 18th August 2015, France passed Law No 2015-992 of 17th August 2015 relative to energy transition for green growth. The law aims to contribute to the fight against climate disruption and to reinforce France's energy independence. The so-called sectors of the future are favoured, such as renewable energies, by raising the share of this sector to 23% of the final gross energy consumption in 2020 and to 32% in 2030. The procedures for the development of renewable energies are therefore simplified…

On 8th August 2016, nearly 40 years after the law on the protection of nature, France passed Law No 2016-1087 on the recovery of biodiversity, nature and landscapes. This text aims at protecting, restoring and valorizing biodiversity and particularly avoiding, reducing and offsetting the negative impacts of human activities on the environment. New principles and concepts were adopted: environmental harm, actual environmental liabilities, non-regression of environmental law, no net loss of biodiversity and ecological solidarity. The last principle «calls for the interactions between ecosystems, living beings and natural environments to be taken into account in public policy»...

Two major legal texts with distinct and potentially contradictory stakes. This issue can be illustrated by wind power: a number of legal actions speak of the death of birds. The proponents of renewable energy and those who defend biodiversity are opposed... The loser in this litigation game will be the environment and the future of our planet!

It is essential to balance these stakes: the energy challenge must be met and won without aggravating the dramatic destruction of biodiversity. Before being a legal one, the solution is above all technical and scientific. The legal tools are largely sufficient: Coastlines Acts, impact studies, public inquiry, Environment Charter, precautionary principle, water rights, etc. The operational approach would appear to be the most relevant. Objective 15 of the SNB 2011-2020 requires that «the generalisation of the methods and tools which make it possible, in all sectors, to make the best choices regarding the consideration of biodiversity, be ensured»…

Finding a way to combine the production of renewable energy with the respect of biodiversity is the challenge. To do this, we need to take an undogmatic, objective and dispassionate look at the subject… In this respect, courtrooms are not the ideal place. It's time to listen, discuss and co-build solutions in collective intelligence.

The links between Biodiversity and Climate

The issues of the climate disruption and the erosion of biodiversity are often dealt with in a fragmentary way, even though they are inseparable. On a biosphere scale, climate and biodiversity are interdependent and interacting permanently. The living world depends on the climate but shapes it in return[20].

In order to limit their impacts on climate change, our human societies try to find solutions which concern biodiversity. Whatever their type and their scope may be, outlining their consequences on biodiversity is crucial to help making a coherent decision easier. This allows a better distinction between them and examination of their implementation, on territories particularly.

In the fight against climate change, renewable energy is a quality solution regarding the energy supply. But such solutions are automatically connected via their dependencies and impacts to biodiversity.

R&RE depend on biodiversity for different resources: resource procurement (e.g. raw materials for building), ecosystem services and also inspiration (biomimicry). For example, dam production capacity relies on water availability, which depends on climate. When thinking of energy transition, one needs to take into account the climate and biodiversity stakes.

Geothermal energy

Geothermal energy is the exploitation of the heat stored in the subsoil. It is the only renewable energy which does not use the direct (radiation) or indirect (wind, water cycle, biomass) effects of the sun.

Depending on the operating temperature, it enables the production of heat or electricity. Geothermal energy would appear to have little impact on biodiversity in comparison with the other sources of energy mentioned in this document. Nevertheless, there are consequences of this type of activity during drilling, operation and when the drillhole is abandoned.

Surface geothermal energy requires a heat pump and therefore an input of initial energy. These geothermal plants which are called «very low energy» plants tap heat at a low depth. The probes can be horizontal or vertical. In the first case, the surface area required is large (around 1.5 times the surface to be heated), which may have a considerable impact on soil ecosystems. For the vertical probes, their installation is delicate and in certain cases may lead to pollution of the soils and aquifers around. The rise in the soil temperature around the probe (thermal plume) is very variable but may in some cases cause a local impact on the soil ecosystem. Lastly, the extremely harmful refrigerant used for some types of pump raises problems for its end-of-life recycling[4].

For very deep geothermal power stations, there are other types of impacts[9]. Extensive drilling programmes can trigger earthquakes as in Soultz in Alsace and in Switzerland with an event of nearly 3.5 magnitude. In certain cases where operations take place in granite, potentially radioactive natural deposits can be observed in the well. It is not yet known whether this can have significant effects of local biodiversity.

BirdLife INTERNATIONAL

Edward Perry,
Coordinator of the CMS Energy Task Force
Coordinator of BirdLife's Global Climate Change Programme

The political stakes of RE and biodiversity

Meeting the growing demand for energy, while holding global temperature rise to 1.5°C, will require large-scale deployment of renewable energy. Scaling up renewables helps biodiversity by mitigating climate change, but it can also have negative impacts if poorly planned. For example, expansion of biofuel crops can drive conversion of natural ecosystems, hydropower schemes can degrade and fragment habitats, and wind turbines can lead to bird and bat mortality from collision.

The Paris Agreement and the 2030 Agenda for Sustainable Development not only provide a robust framework and ambitious targets for global action; they represent a shift away from a siloed approach, towards a more integrated one that explicitly recognizes the interdependencies between, and within, environmental, social and economic systems. The task today is to translate these international frameworks into action. This requires strong national biodiversity, climate and energy policies that complement rather than undermine each other, and collaboration between all stakeholders to identify and manage risks and opportunities across the whole planning cycle.

Sustainable solutions are emerging. The environment and energy agencies in Egypt are collaborating to integrate bird conservation into energy planning. BirdLife's Sensitivity Mapping Tool is providing information on the distribution of bird species to help developers and planning authorities select appropriate sites for new energy developments. Radar-assisted shutdown-on-demand systems that selectively turn off wind turbines during intense periods of migration are reducing bird collisions. The Energy Task Force established under the Convention on the Conservation of Migratory Species of Wild Animals is bringing together governments, industry, investors, and non-governmental organizations to identify, share and scale-up such solutions. Our aim is to ensure that all energy sector developments avoid negative impacts on migratory species.

Spatio-temporal links

In the context of mitigating climate change, the development of sustainable energy must be considered by taking into account the **geographical and temporal** dimensions of the choices to be made.

From the geographical point of view, the issues can be considered as «*in situ*» and «*ex situ*». On a local *in situ* scale, links appear between biodiversity, production structures and their use (e.g. dependency on local ecosystems). Biodiversity is seen here as an element which is localized on the territory: we're talking of direct links.

Just as important and often less considered by actors, the *ex situ* links can be «global», when we are talking about the links to planetary biodiversity or to climate. But they can also be highly localized and remote at the same time as in the case of the resources used to build production units. The *ex situ* biodiversity issues of the first then become the *in situ* issues of the others: the question is whether one can be «virtuous at home» with a harmful behaviour elsewhere.

From the temporal point of view, the issues can be broached by the temporality of human activities. Thus, **upstream, during operation time,** and **downstream** of a project using sustainable energy sources, the biodiversity issues are different. This approach, which is already used particularly in Life Cycle Analysis (LCA) or carbon footprint, is not highly developed for biodiversity. It helps however to understand the existing links between a development and its environment, throughout its lifespan.

Lastly, it is important to keep another temporality in mind, a «global» temporality which is that of biodiversity and is always dynamic and evolving permanently. The inadequation between this temporality and human activities is behind a number of issues. Each R&RE project should be questioning.

Grey energy

Grey energy is the sum of all the energy needed for production, manufacture, use and recycling of materials or industrial products. Grey energy can be measured using Energy Returned On Energy Invested (EROEI), which corresponds to usable energy / spent energy.

Renewable energy production units use energy (from all sources) upstream and downstream of their use[15]. We can quote the example of the extraction of resources for building or transporting materials. This energy, which is incorrectly referred to as carbon-free, therefore has a non-zero carbon footprint, but significantly lower than fossil energy. The same applies to biodiversity.

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Philippe Bihouix

The need for resources, the Achilles heel of RE ?

So-called renewable energy does of course have an enormous potential. But to capture, convert, transport and store this less concentrated and more intermittent energy, large quantities of non-renewable metallic resources are required. Copper, of course, but depending on the technologies, rare metals too: neodymium/dysprosium in high-power wind turbines; silver, gallium/indium/ selenium, cadmium/tellurium in certain solar panels; lithium/cobalt/nickel in batteries; and dozens of other metals (tin, germanium, tantalum, palladium, gold, etc.) in power electronics and future *smart grids.*

The mining and metallurgical industries are among the most polluting human activities and cause the destruction of natural areas, consuming water and energy, emitting sulphur or heavy metals, using dangerous chemicals such as cyanide, generating long-term harmful mining waste, etc.

The manufacturing of equipment also has environmental consequences. For example, solar-quality silicium needs large quantities of water – water that has to be purified upstream and treated downstream – and also petroleum coke, coal and a whole range of chemicals – ammonia, chlorine and acids, which are supplied by the chemicals and oil industry. Not to mention installation and maintenance: dams must be built, along with access roads, port installations have to be created or adapted for offshore operation… Using renewable energy also has impacts on natural environments: anti-fouling paint releases,local effects of concentrating solar power plants and wind turbines on wildlife, etc.

So, we are a long way from zero impact and «100% clean» energy. A massive, unthought-out deployment of huge RE programmes (built here) will have a systemic effect on the consumption of resources and fossil energy (elsewhere on the planet). As of today, RE does not allow us to get away from the «extractivist» paradigm of our industrial society.

Even if they are interesting, on condition that the choice goes to the most sober and resilient technologies, their deployment and generalization cannot be considered in a sustainable fashion if they are not accompanied by energy saving of unheard dimensions and which has yet to be imagined.

Wood biomass energy

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DE LA TRANSITION
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ET SOLIDAIRE

Biodiversity and energy policies, the case of forest biomass

How can the development of the wood industry for the energy sector be reconciled with biodiversity challenges ?

The Multiannual Energy Programme targets +50% for the production of heat from renewable energy, equivalent to an increase of 3 to 4 Mtep from wood-energy biomass, by 2023. At the same time, the Plan National Forêt-Bois (French Wood-Forest Scheme) forecasts a harvesting of +12 Mm^3/year by 2026; the share of this wood for energy harvesting would represent around 2.3 Mtep.

Whether the targets of this Scheme are realistic or not, it does not describe how this harvest will be carried out without jeopardising forest biodiversity (particularly by taking into account the Habitats Directive and the Birds Directive). Then comes the question of the forest's contribution to 2nd generation bio-fuels from lignocellulose. There is reason to fear new deteriorations of the state of the forest ecosystem, specifically through the decrease in dead wood, the development of short rotation coppice, monospecific plantations and the fragmentation of areas.

The «Sciences pour l'action» meetings project launched by the Agence Française de la Biodiversité – AFB (French Biodiversity Agency), the Fondation pour la Recherche sur la Biodiversité – FRB (Foundation for Biodiversity Research) and the French Ministry of Ecological and Solidarity Transition (MTES - Ministère de la Transition Ecologique et Solidaire) aims at obtaining the available knowledge through public policies and operators who, in return, feedback their scientific research needs.

One of the themes of the talks, which will take place in Porquerolles in October, is precisely biodiversity and energy and a workshop will result in recommendations regarding all the stakeholders, based on the recent forecasts made on the subject, including that of the CGDD: «Biodiversité et Territoires 2030». These interdisciplinary exchanges (ecologists, economists, foresters, etc.) will deal specifically with the limits of multifunctionality, interfaces with agriculture and links with territorial developments, particularly in mountain areas. Forest development and management methods must integrate climate change and are part of a global reflexion on soils.

This is the use of wood as fuel, in different forms (wood chips, ancillary sawmill products, end-of-life wood products, pellets, logs), in domestic, industrial or collective installations. There are three different sources of wood-energy: forest harvesting, co-products from the industry and waste recovery (furniture for example).

The French wood-energy sector is an important industrial activity which represents 47% of RE in France, ranking it first in Europe for the use of wood for energy.

Directly linked to biodiversity, its impacts on ecosystems are primarily local but also *ex situ* ones.

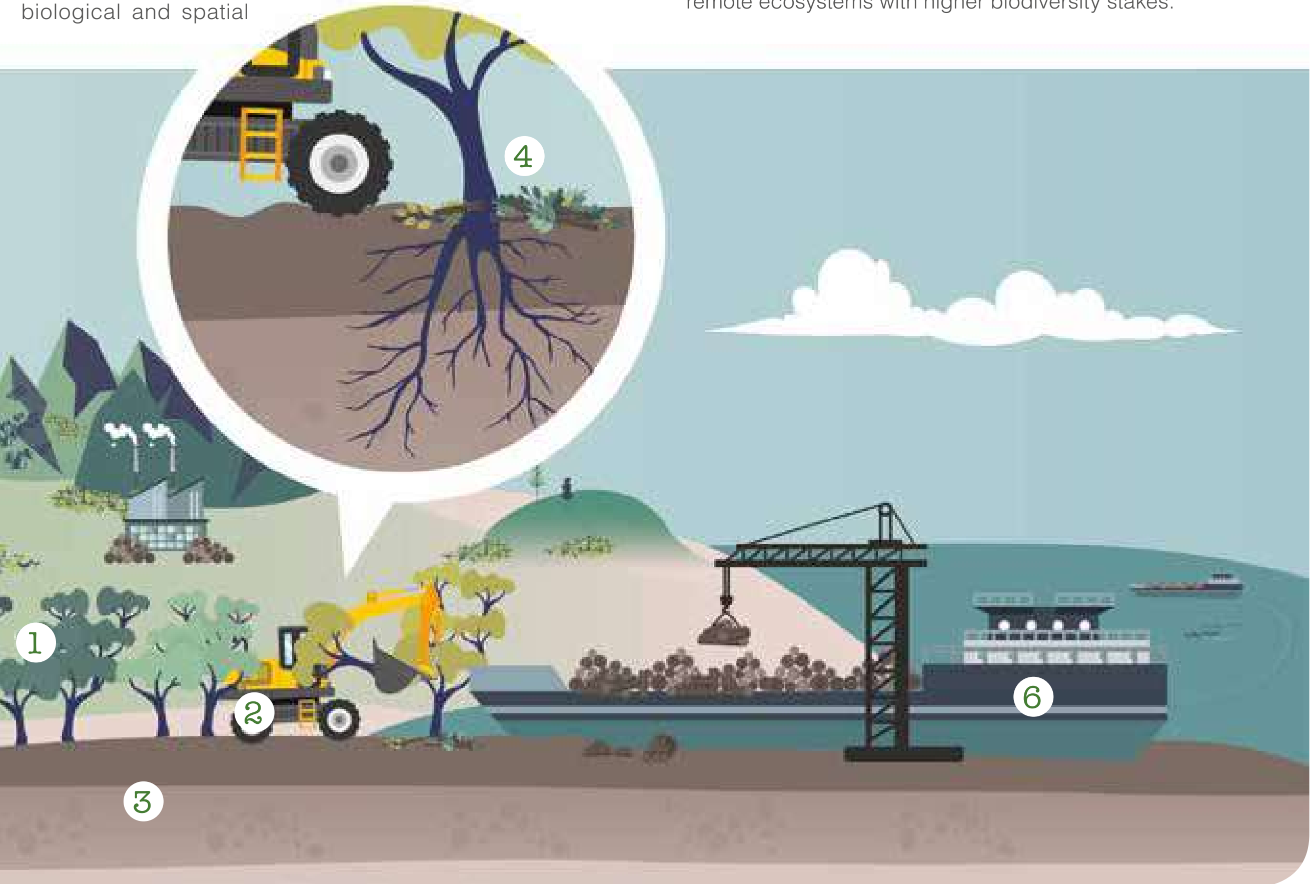
① Loss of biodiversity
The destruction of old trees which are home to a much more important biological wealth (particularly microscopic, mushrooms, lichens, insects), and native species to make room for exotic species leads to a loss of biodiversity (genetic, specific and ecosystems).

To reduce such impacts, the protection of several degrees of forest exploitation, late felling for certain trees, and planting the correct choice of species all make it possible to maintain the ability to adapt to global change.

② Forest logging
- The increased frequency of machines, compared with the lumber industry, additional machines and the installing of new specific operations disturb the local ecosystem all the more. Water flows are thus modified, vegetation impacted and wildlife disturbed. A possible solution could be to act according to the breeding and nesting seasons to limit these impacts.
- Soil compaction limits the soil's porosity and therefore its aeration. The biological activity of the soil (particularly fungal activity) is decreased which impacts the growth of certain plants (to the benefit of those which are adapted to hypoxia). Lastly, work on the soil brings minerals to the surface, thus disadvantaging the organisms which decompose the soil.

Forest ecosystems are all the richer due to there complexity. Forest ecosystem management will condition the possible damage regarding biodiversity, depending on the species of trees chosen for planting, the stand density, the operations carried out in the forest and the rotation and operating times. Harvesting very often results in a reduction of biological and spatial diversity which weakens the forest ecosystem and the local biodiversity dynamics.

Moreover, when the wood-energy demand becomes higher than the local supply capacity, the territorial development choices can be challenged or this may lead to the importing of resources from remote ecosystems with higher biodiversity stakes.



YVES ROCHER

Between energy, territory and biodiversity, back to the way for common good at micro scale

The energy issue approach led by a group of actors on a micro-territory, the municipality of La Gacilly, in Brittany, is an original one because it involves several municipalities, a cosmetics industry and a group of associations, all of whom are not «major consumers» of energy on a national scale and whose professions are not directly linked to energy.

The firm is of course committed to its energy consumption reduction, with a decrease of over 17% of its consumption per finished product between 2010 and 2015 and a new target of an extra reduction of 10% for 2020.

We would like to share here the knock-on effect or the ability of local initiatives to emerge by showing how, without it being directly correlated, a change in mentalities, once it has been triggered, can spread among actors.

The example we would like to highlight is the installation of wood-fired boilers for the firm's 3 sites. These boilers enable a better heat production performance than the previous non-renewable fuel boilers. In addition to this they are subject to a local wood procurement contract (distance under 70 km). And above all this their installation has resulted in positive collateral effects. The choice was made to maintain the firm's forests for the production of wood energy, and the remaining plots of land belonging to the Group were converted back into agricultural land for organic vegetable crops to supply the company canteen with a permanent offer of organic dishes for the employees (600 meals/day). From the energy point of view, by its progressive swing towards renewable energy, the firm has added a biodiversity-related activity, a short-circuit organic food supply and the perpetuation of jobs for self-employed market-gardeners.

The link between energy, territory and biodiversity, even if modest in this example, is very exciting when imagining future work themes and actions.

③ **Soil impoverishment**
The export of wood and residue from the forest environment jeopardises the ecosystem at all levels: the tree, shrub, grass, insect, fungal and mesofauna strata. Left on the ground, slash favours moisture retention and buildup of minerals. If it is removed, the physical and chemical parameters of the soil are modified, along with the distribution of the plant species present, the fertility of the soil and the growth performance of the trees. However, the slash removal lessens the risk of unwanted species developing.

Seasoning operations (drying out the wood) and the spreading of ashes on parcels contribute to the reintegration of part of the organic matter, and therefore to the relative return of minerals (apart from nitrogen for the ashes). Soil amendment is a subsidiary technique for maintaining the fertility of the soils.

④ **Prioritizing the parts of the tree to be exploited**
Priority is given to the systematic export of coarse cuts (trunk + large branches). This enriches the forest in fine debris. It favours certain species rather than others in the grass stratum. Enriched slash therefore increases the protection of short plant species against herbivore predation. Alternating the exploited parts of the tree favours ecosystem diversity.

⑤ **Wood storage**
Storage sites for wood seasoning are an ecological trap. Saproxylic insects that digest the wood clump together in it before being destroyed by the combustion of the wood.
It is therefore preferable to limit storage.

⑥ **Importing wood**
See introduction

Hydroelectric energy

AGENCE FRANÇAISE POUR LA BIODIVERSITÉ
ÉTABLISSEMENT PUBLIC DE L'ÉTAT

Biodiversity impacts

Despite the fact that from the purely physical point of view, hydropower is actually a renewable energy, because it uses the energy captured by the natural water cycle, this does not mean that it is devoid of environmental impacts, particularly with regard to issues of biodiversity protection.

Mobilizing «white coal» actually implies the modification of the natural functioning of watercourses, by displacing the flow volume in time or in space, or by constructing hydroelectric dams that exploit the potential gravitational energy of water.

These developments may have a number of impacts:

- on the hydrology and suspended solids transport, which are likely to cause carving and erosion downstream, the lowering of associated ground water levels and the drying out of riparian wetlands;
- on water temperature, specifically by a reduction in the depth of the water column downstream or by the storage of water upstream, with all the consequences in terms of the biology of animal species (reproduction, availability of dissolved oxygen, etc.) and primary producers (favouring eutrophication), and more generally on self-purifying processes;
- on the quality of habitats, by changing the alternating sequence of riffles, alluvial channels and refuge areas, which are crucial for fish and invertebrate life;
- on the movement capacity of migratory species, of course, by the creation of more or less insurmountable obstacles which can significantly alter the life cycle of «highly migratory species» such as salmon, eels or shad, etc.

These impacts must therefore be carefully assessed, based on scientific knowledge but also on the feedback from international experience, by implementing the principles of the Avoid Reduce Offset sequence.

In the search of an approach for the «best balance» between energy supply and biodiversity conservation, this also pleads for:

- making the best possible use of hydropower facilities which have already been developed and which are often those with the highest energy potential;
- most certainly giving up on those where the energy interest is or is becoming minor with time;
- remaining vigilant regarding the development of new projects.

This is the leading renewable source of energy in France and all over the world. There are three major types of power plants: impoundment, run-of-the river and pumped storage. The latter is not considered renewable due to the fact that the global energy balance is negative. However they do make it possible to adjust energy production in a context of varying supply and demand.

For what is known as «renewable» hydraulic power[18], there are over 1 860 plants in France. There are more small plants, with a power of under 1MW (60%) but they only represent a very small part of hydroelectric energy production.

Here we will only be talking about medium-sized (1 to 10MW) and big (> 10MW) structures on mountain lakes, locks or run-of-the-river.

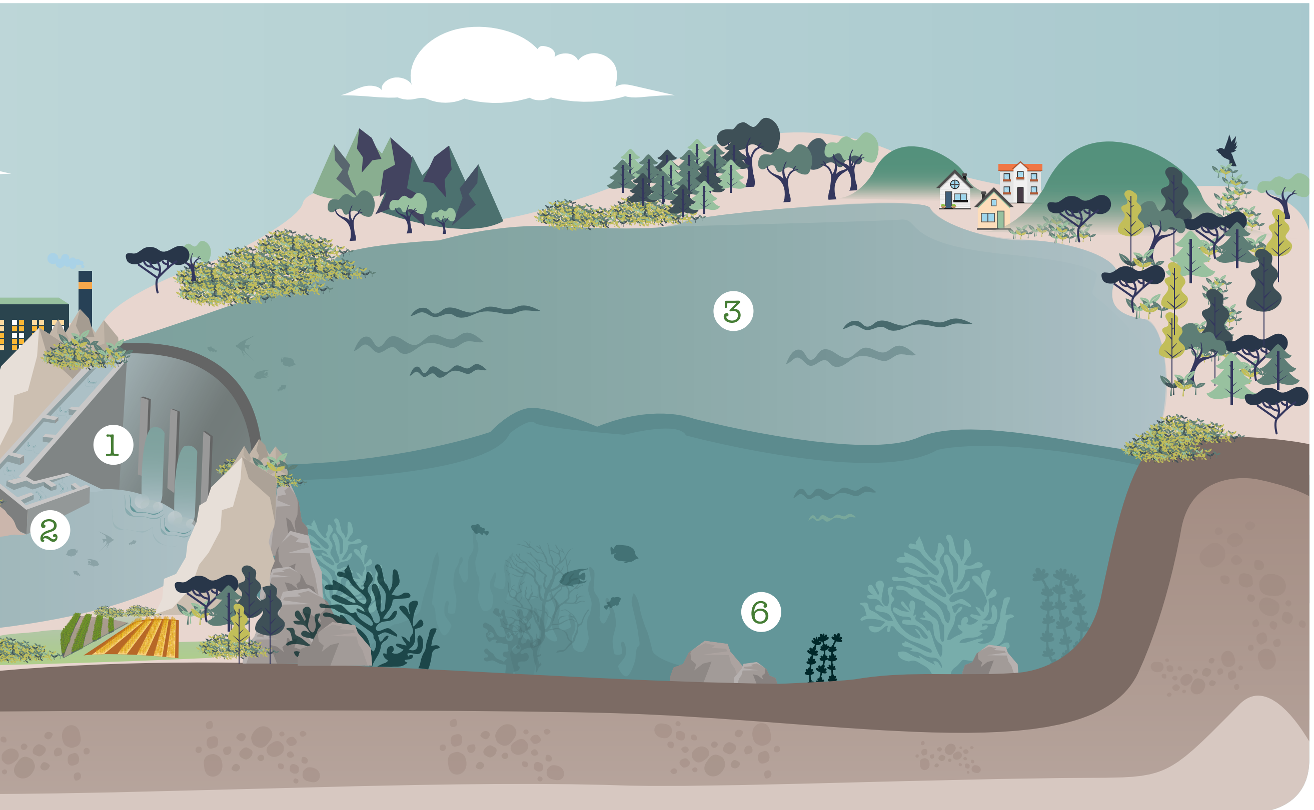
This source of sustainable energy drastically transforms terrestrial and maritime ecosystems upstream and downstream of the infrastructures, which depend on more remote ecosystems. The whole region's biodiversity is modified, often with heavy losses in terms of biological wealth at all levels.

① Dismantling the structure
Even though the manufacture of the armature emits a considerable amount of CO_2, the long lifespan of the structures enables a short energy payback. Nevertheless, the structure does not last forever due to the accumulation of sediments upstream. Dismantling of these concrete giants requires complex and costly logistics, and outlets for the materials are very limited.

The reopening of a river valley (the case of the River Elwha) can result in unexpected ecological benefits, without actually restoring the ecosystems which were initially to be found there.

② Ecological fragmentation
Fragmentation is one of the main causes of biodiversity erosion, before pollution (MEA 2005): the multitude of small installations disrupts initial biodiversity. Fish ways are one of the most efficient impact-reducing methods used.

Regarding the resources used, the frame is mainly in reinforced concrete which is made up of sand, gravel and cement. However, sand is the 3rd most-used resource on Earth, after air and water, and the 1st non-renewable one [23]. Desert sand is not suitable for building, and construction groups have been exploiting rivers and quarries for a long time. They then turned to the sea, triggering what is now becoming a real ecological upheaval. Excessive dredging of marine sand favours the intrusion of sea water into the groundwater and its being contaminated by the salt. It disrupts marine ecosystems through the destruction and fragmentation of habitats. Moreover, extracting from water increases turbidity and disadvantages organisms which need light to develop (e.g. coral, phytoplankton). The effects on the environment are unquestionable and can be observed all over the world. The volume extracted has heavy repercussion on rivers, deltas and coastal and marine ecosystems. It results in loss of land through river or coastal erosion, the lowering of the saturation surface, and a decrease in the accumulated quantity of sediments.



Hydroelecticity and biodiversity

Hydroelectricity is the dominant renewable energy and currently represents over 60% of renewable production in France. In addition to the renewable nature of its resource, it stands out from other means of production by its capacity to facilitate the integration of intermittent new energies (wind and solar) into the grid thanks to its capacities of flexibility and storage. Hydroelectricity therefore plays a dual role in the major energy and ecological transition of society.

The need to reduce our greenhouse gas emissions by strengthening the production of carbon-free energy, the need to take into account the links between climate change, biodiversity and the uses of water induced by changing social expectations (specifically irrigation, leisure activities, etc.) are all subjects which converge towards hydroelectricity. Hydroelectricity actually contributes to the mitigation of climate change and its consequences. It is therefore indispensable to find the right balance between social expectations, the reduction of environmental impacts and the economic balance of hydraulic concessions, and to combine the trajectories of each of these components with a full understanding of each of these issues.

Whether they are dedicated to hydroelectric production or to other purposes, dams have modified the biodiversity of the surrounding ecosystems from the moment they were built. Past impacts were studied over time and largely taken in account from both the technical and the regulatory point of view. EDF has considerably contributed to the evolution of science in this field through the implication of its R&D. It is vital to pursue this dynamic by taking into account the possible prospects of climate change and the evolution of water uses, in order to reach future ecological balances in the best possible way in coherence with the renewable and carbon-free energy requirements of our society.

③ Impoundment lakes: from running water to standing water
The rise in water level leads to the death of flora which in turn triggers a methylation of mercury through its anoxia. In the absence of oxygen methyl groups appear and bond to the mercury creating methylmercury, which is highly toxic for living beings due to the fact that it is extremely bio-assimilable. In addition to this, the impoundment creates an environment favourable to certain disease-carrying species (mosquitoes): the risk of biological invasion is 2.4 to 300 times higher in an impoundment lake than in a natural lake. Lastly, the algae population increases and the valley-bottom species rapidly disappear.

Brutal variations in the level of the impoundment disrupt the ecology of the banks, for instance during the compulsory ten-year emptying of dams over 20m high which disrupts the ecosystems.

④ The ecological upheaval of construction sand
See introduction

⑤ Downstream hydro-geomorphologic modifications
The decrease in resources downstream can result in the interruption of the sedimentary transit, which can cause a deepening and modification of the riverbanks, and of the coastline of the mouth of the river. All of this leads to a disappearance of ecosystems and a considerable decrease in the number of species they harbour. We can observe a new distribution of fish populations (detritus-feeding species favoured). This type of impacts nevertheless depends strongly on the location.

⑥ Accumulation of silt upstream
Certain heavy metals (mercury) can accumulate or be bioaccumulated in the sediments of impoundment lakes and particularly in the hydroelectric dam complexes and the bottom of the impounded water. The silts retained upstream in turn set off the eutrophication of the water and therefore a deterioration of its quality.

Terrestrial wind energy

AGIR pour la BIODIVERSITÉ

Allain Bougrain Dubourg,
Président de la LPO

The «Wind Farm File» actually summarizes ambiguous environmental management quite well. How can we not subscribe to the indispensable transition towards renewable energy and how, at the same time, can we remain indifferent to the side-effects, particularly where biodiversity is concerned?

Taking these two imperatives into consideration, the LPO (Bird Protection League) engaged a vast programme whose objective was to assess the impacts of wind-turbines and look for solutions to reduce them.

The first observation bears on the establishment sites. A forest of wind-turbines grounded in an intensive farming region will have less disturbing effects than in the natural areas of the Massif Central in France. Thus the number of cases of bird collisions is extremely variable from one wind farm to another. Migratory birds and particularly passerines represent 60% of the corpses found (firecrests, common swifts, etc.). Diurnal birds of prey, which are more frequently impacted during the nesting season, nevertheless pay a heavy price with regards to their population stocks.

Globally speaking, out of the hundred or so species of birds found dead at the foot of wind-turbines, 75% are officially protected.

It must be noted that the environmental impact is not limited to the direct death rate of birds or bats. Disturbance during the operating phase, the artificialisation of soils and the loss of food territories or nesting must also be taken into account.

The technical equipment designed to reduce the impact of wind-turbines on birds is only partially efficient, so priority must go to avoiding sites with heavy stakes. It is for this reason that the LPO is opposed to all installation projects in the Special Protection Areas (SPA) classified under the European «bird» directive and in Special Areas of Conservation (SAC) under the European «habitat» directive.

In either wind or solar farming, energy transitions cannot be exempt from taking biodiversity into account and are condemned to succeeding together.

Between 2005 and 2015, French terrestrial wind energy production was multiplied by 18. The momentum is still there: the installed capacity in the first quarter of 2017 was the highest ever recorded for this period[19]. The lifespan of a wind turbine is between 20 and 30 years.

The production units can take on various forms. Nevertheless, 3-blade horizontal axis wind turbines are becoming the «standard». The installations vary in power and can exceed 12 MW/unit.

Wind power can only operate in specific wind conditions. It thus requires power storage capacities which raise biodiversity issues.

Most of the power plants in France have a unit capacity of 8 to 12 MW. According to the power capacity, the materials and the consequences on biodiversity vary.

Regarding resources, the manufacture of wind turbines generates a considerable number of impacts on *ex situ* biodiversity:

- energy transformation technologies use a variety of materials: steel, copper, aluminium, lead, PVC (from petroleum)

① Disruption during the works phase
The scouring and earthworks carried out on the works area, the building of strip roads, the digging of trenches for cables, the presence of machines and the noise generated are all negative impacts on local biodiversity during the works phase. The wind-turbine assembly stage specifically takes up a lot of space and generates noise. A reduction of the assembly area is possible by assembling the wind turbine blade by blade and not in one single block.

② Operating noise and maintenance
The noise of a wind turbine is largely due to friction between the blades and the air. This may affect local wildlife; some species are more sensitive than others.

Moreover, wind turbines must be regularly serviced which causes additional disruption for the surrounding environment.

and rubber, which all represent resources and impact during their extraction and transport;

- the components are often encapsulated, which makes the separation of the materials technically and economically difficult (particularly in the case of rare metals);

- the blades are made from composite materials, to make them lighter, more resistant and all purpose. In order to manufacture them, extraction with all its impacts is the dominant method. At the end of their lifespan, they are often incinerated or crushed because separating the resins from the fibres is a complicated process;

- the mast is in aluminium alloy which in theory has a good recycling rate, but is actually mediocre. Several stages in the manufacture of aluminium have heavy impacts on the environment, particularly in terms of pollution[11], and thus damage to *ex situ* ecosystems.

In addition to this, new generations of permanent magnet wind turbines (see p.20), using rare earths are emerging.

agrosolutions

Wind energy and agricultural land

As a source of energy, wind energy is an alternative to fossil energy and is considered as green because it is sustainable. However, it has a negative impact on the biodiversity and ecosystems of a territory and on the use of agricultural land. The negative effects on biodiversity are processed by means of an impact assessment following the Avoid Reduce Offset principal. The reduction and compensation measures in turn have an impact on agricultural land due to the fact that they are deployed within a functional distance of the sites involved, which are often rural territories.

These constraints can be alleviated using solutions, which combine biodiversity and efficient agriculture, by mobilizing farmers as soon as the compensatory measures are defined and associating them for their practical implementation. The intervention of a third party, known as an «offset operator», combining agricultural, legal, environmental and socio-economic expertise, helps to identify these measures and to deploy them with global socio-economic coherence and consultation with territorial stakeholders, retaining at the same time the required level of ecological demands. Agriculture is therefore a vector of solutions for the energy issues of the territory, and can be remunerated for environmental services rendered by farmers.

To set up a wind farm in the Vienne department in France, a contract of this type was signed with a farmer so that the management of one of his meadows would be in the wet zone imposed by the compensation of the wind farm site. A 12-year contract ensures the durability of the measure, the management specifications guarantee the respect for the technical conditions, and thanks to this extra income over a long period of time, the farmer was able to consider maintaining his farming activity more serenely.

The remuneration compensates the loss of cost-effectiveness induced by the ecological measures and supports the environmental services rendered by the farmer. It is however controlled and harmonised in order to avoid speculation.

Legal constraints therefore become an opportunity to build territorial projects and also innovative stories around biodiversity and agriculture.

③ Collisions with flying fauna
A wind turbine blade tip can rotate at up to 300 km/h which produces a large amount of energy. The movement of the surrounding air create draughts which can be fatal to flying fauna (see LPO insert).

④ Ground coverage
In order to consolidate the structure, reinforced concrete foundations of a volume of 500 m³ are required. The ground coverage of the base is considerable (1 000 m²) if we include the strip roads, the machine room and even parking space. This contributes to soil artificialization, a major cause of the erosion of biodiversity on a global scale. The presence of cables also leads to electromagnetic fields whose effects on wildlife are currently very little known. During end-of-life deconstruction, the wind turbine is only partially dismantled due to the fact that the technical means required for removing concrete base are too heavy. A possible solution may be to reconcile diversified agricultural territory with wind farms (see Agrosolutions insert)

See introduction :

⑤ Nacelle materials

⑥ The mast and the aluminium

⑦ End-of-life of composite materials

Solar photovoltaic energy

The issues of end-of-life and biodiversity

From the point of view of biodiversity and ecosystems, everything can be boiled down to resources: a circular system where there is no loss, no waste. Human societies function in a linear fashion. Manufactured products reach the end of their lifespan after their production and consumption. Man has manufactured new components which are not naturally biodegradable and has concentrated others (e.g. carbon and nitrogen) to such an extent that they are no longer integrated into the ecosystem. When a good arrives at the end of its lifespan, it can be dismantled and its components then become waste.

A specific classification sorts the waste into categories[2], and its components can sometimes be upgraded, i.e. can be assimilated by ecosystems, reused or recycled. When they are not, they go directly to landfilling or destruction : the resulting variety of pollutions harms biodiversity. When the materials can be recycled, they are reintroduced into the production cycle of an item in a logic of circular economy. This has direct consequences on biodiversity by reducing the tonnage of waste and at the same time reducing the pollution associated with end-of-life.
Moreover, reducing the extraction of new matter, for a same production and indirectly, helps to protect natural resources and ecosystems.
However, the recycling of waste, in addition to using energy significantly, has certain constraints:

- the first are technical:
  - access to separate materials is sometimes difficult and this limits recycling
    - when, for example, they are encapsulated in plastics or alloys;
    - in the case of alloys, two metals are combined to reach certain technical properties: they cannot be separated on recycling without a loss of purity hence a loss of characteristics;
    - certain combinations of materials are impossible to recycle (composites);
  - the recycling plant may not be accessible.
- but there are also economic constraints: cost or lack of outlets can be factors which strongly limit recycling.

The useful life of solar panel lasts around 30 years. After 25 years of use, they have already lost 20% of their initial capacity. In France, since August 2014, end-of-life disposal is a legal obligation: manufacturers, importers or sellers have to recuperate end-of-life panels. In theory solar modules have a high recycling rate (over 80%)[21]. Nevertheless the reality is quite different : in 2014 the EU estimated that nearly two-third of the electric waste (including solar panels) never go to recycling centers. There are two ways of recycling, but both use chemical techniques to separate materials. These are highly polluting for the environment and biodiversity.

The use of sustainable energy requires developments with a limited lifespan. In this case, the issue of end-of-life and its links with biodiversity is raised. Though some of the older developments such as dams have reached the end of their lifespan, most of the «new» technologies for producing energy have not yet reached it. For example, the first units of French wind farms will only reach the end of their life in a few years. The issue is henceforth all the more important.

The solar sector is made up of three branches: photovoltaic (PV), classical thermal, and concentrated thermal. We will not be talking about the thermal sector because it only represents 0.4% of RE in France and does not appear to be developing significantly.

In 2015 the solar photovoltaic sector represented 2.7% of French RE production. It is not a large amount, but in the same way as for wind power, the sector has achieved a certain impetus since 2009. With more recent legislation, and in particular the ordinance of 27th July 2016 on self-consumption, the sector has a good future.

There are two main types of PV module: polycrystalline and thin film. The first is more efficient than the second, but also more expensive. There are more panels using silicon on the market (approximately 90%).

As in the case of any other industrial product, these panels have an impact during their production phase. Their manufacture requires large quantities of silicon, from sand, whose extraction has impacts on biodiversity (see p.14).

① Module shading
There is an impact on the wildlife species to be found on the site, due in particular to the shade created by the modules. A decrease of the habitat can generally be observed.

② Ground fencing of photovoltaic solar farms
It is compulsory to fence in the production parcels for safety and insurance reasons. This creates a considerable physical barrier for wildlife and can have implications on local biodiversity.

Solutions such as the setting up of crossing points for wildlife can limit these impacts.

Traces of toxic elements (Pb, Br, B, P) and silver, which is a limited resource, are used to produce the frames. The PV panel industry is very energy-intensive with an energy pay back for the modules of around 3 years. Lastly, it may result in chlorinated discharges, silicon-laden sludge and gases and effluents from the use of chemical products. All of this can jeopardize ecosystems.

Photovoltaic technologies require a large amount of space to produce energy. Photovoltaic power plants can be in fields or on rooftops[7]. For a ground installation, this may result in conflicting uses of soil and the artificialization of soils in France is already causing the loss of the equivalent of a *departement* every ten years.

In addition to this, the photovoltaic modules only operate when the sun is shining: this intermittent source of energy raises the issue of storage which is essential to optimize the yield and lessen power losses. It must be noted that storage can have significant consequences on *ex situ* biodiversity of the sites (see p.7).

Solar PV panels and roofs

Foncière des Régions is accumulating experiments regarding photovoltaic and thermal solar energy on a European scale.

In France, *Foncière des Régions* uses photovoltaic energy on several buildings and particularly thermal solar energy for domestic hot water. This is the case for offices (specifically in the framework of recent developments) and hotel installations with Accorhotels. In Italy, the Garibaldi towers renovation, delivered in 2011 and 2013 and located above Milan railway station, was an opportunity to set up 402m^2 of photovoltaic panels on the South-East facade of each of the two towers. Their production - 70,000kWh in 2016 - is well beyond expectations.

In Germany, its subsidiary Immeo SE has installed photovoltaic equipment on residential property, in five towns located mostly in the West of the country. Their production exceeds feasibility studies estimates. Installed on the (angled) roofs of the residences, the 5,200 m^2 of photovoltaic panels give Immeo SE an extra income with a nine-year payback period. Immeo SE, as a long-term actor, preferred to be the owner of the facilities (average investment: €436m^2 excl. VAT/m^2), to reap all the income generated by the production of electricity and to develop new know-how, in anticipation of the development of passive buildings by 2020. Sold to the electricity companies of each region concerned, the 609,218kWh produced in 2016 have generated an income of €256K, i.e. 49.20€ excl. VAT/m^2.

There is increasing demand from local authorities for the greening of terrace-roofs. But the question here is of a fair balance between energy production and greening with a sometimes necessary arbitration between them. The solution might be a solar installation on the facade as in Italy, the use of solar glazing (still expensive), etc. Whatever the case, Foncière des Régions is focusing on a global approach that integrates the stakes of mastering the tenant's specifications. Life cycle analyses of the facilities for renewable energy production (particularly photovoltaic and wind) raise recycling issues. This is a key challenge for a long-term actor like *Foncière des Régions*.

③ Ground coverage of photovoltaic power plants in fields
The panels' impact on soil layers is low due specifically to the absence of ground foundations. Ground coverage is considerable, but is not incompatible with certain farming activities such as sheep breeding.

④ Use of soils
One solution for the conflicting use of land consists of developing PV installations on land with «less biodiversity» such as in polluted areas, on former military land, in areas near transport infrastructures, etc.

⑤ Use of professional buildings
The development of industrial-scale photovoltaic roof projects is authorized by Article 86 of the French Law on biodiversity of August 2016 which obliges shopping malls of over 1 000 m^2 to set up panels or green their roofs. We must however be wary of the «competition» which may exist between nature and energy.

⑥ Roof modules
Ground panels have more direct and local impact on biodiversity than roof panels.

See introduction :

⑦ Panel end-of-life

⑧ Impacts of the modules during their construction

⑨ Storing the electrical power

Marine energies

Pauline Teillac-Deschamps,
Ecosystems Programme Manager
of the French Comittee UICN

Renewable energies & biodiversity: the need for a strategic planning

To find a balance between the development of renewable marine energy and the protection of biodiversity, we must design an integrated strategic planning of marine activities together with marine biodiversity preservation objectives. RME infrastructures generate impacts on marine ecosystems during prospection, worksite and operating phases that must be taken into consideration. The impact of dismantling and the accumulated effects of the various installations must also be integrated.

Since 2012, IUCN's French Committee has hosted an exchange group on the subject of RME and biodiversity and has published recommendations designed to reconcile both of these environmental objectives in mainland France and Overseas France (see link below)

IUCN France experts have identified as the main impacts of RME on biodiversity:

- noises and vibrations in the operating phase (turbines and vibrations) and also in the prospection and preparation phases (drilling and test hole boring), as well as in the building phase (pile driving);
- electromagnetic fields (due to the farm layout and the connections);
- modification of habitats (modification of the sea bed, turbidity, disruption of hydro-sedimentary flows, pollution by biocides, etc.);
- the induction of temperature variations and artificial upwelling effects;
- the direct destruction of habitats (for example, artificial lagoons);
- barrier effects and collisions (birds, chiroptera marine mammals and other taxa) linked to species migrating seasonally or to find food.

RE development must therefore integrate the protection of biodiversity and its ecosystem component right from the planning stage (life cycle of species, mobility needs, landscape and interaction between species). This must take into consideration the long-term impacts of the development of these energies (sectors, use of space, conflicting uses, connections, invasive exotic species, etc.), remote impacts (the impact of a power station on its geographic area and also on all the zones of energy supply and transport, etc.), as well as the accumulated impacts of all the projects. Finally, the dimensioning of the projects is a key element into which the consideration of the impacts on biodiversity must be integrated.
RME should therefore only be developed in areas which balance high energy potential and low biodiversity stakes.

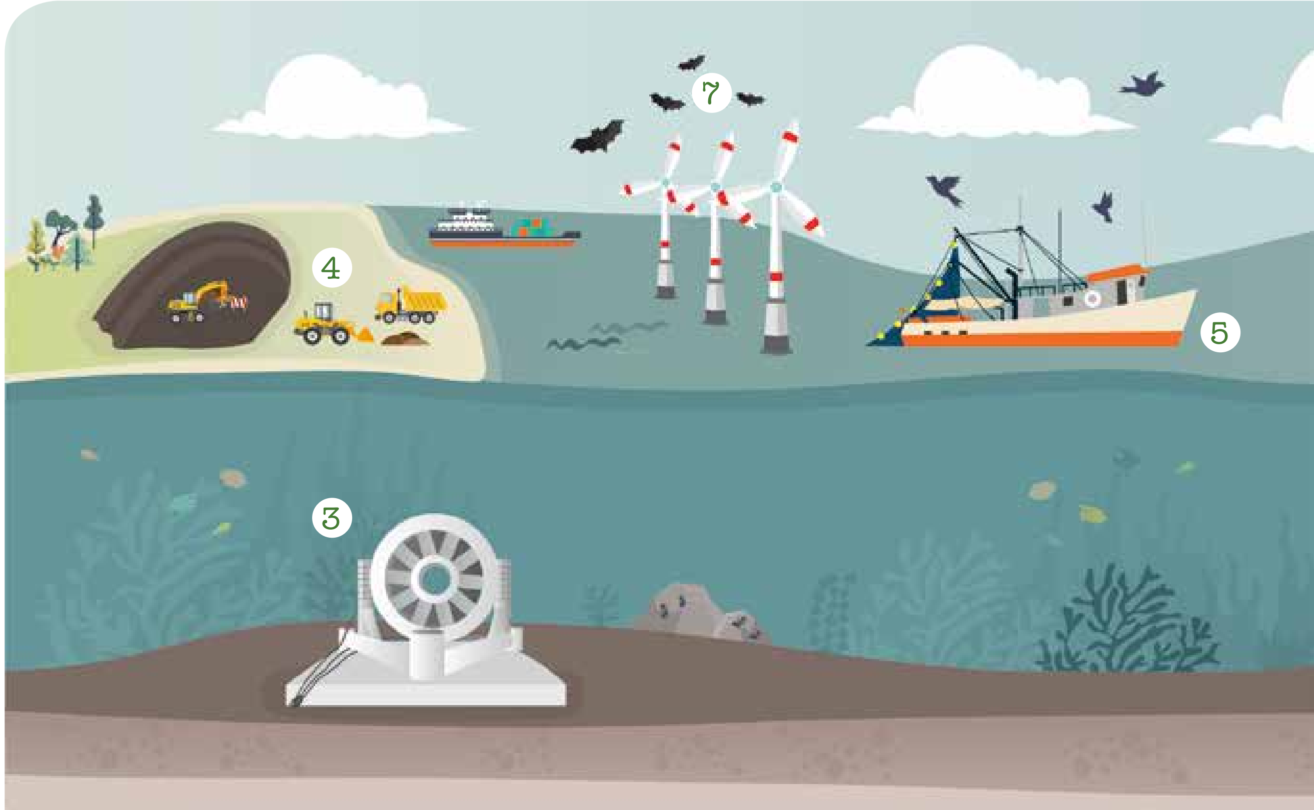
(http://uicn.fr/wp-content/uploads/2016/06/Energies_renouvelables_marines-bd.pdf, http://uicn.fr/wp-content/uploads/2016/06/Actes_Seminaires_NRJ.pdf).

France has a maritime territory of over 11 million km² and therefore an enormous marine energy development potential.

We will only be dealing here with offshore wind turbines and tidal turbines. Despite the fact that these two technologies are still in the research and development stage in France, they currently have the highest development potential for the years to come.

Even though they are very similar to onshore wind turbines, offshore wind turbines have better performances, due to the strength of the wind at sea. However, they are less developed and in 2017 there are only three construction sites in France and no wind-turbine fleet. According to the European Wind Energy Association, the development potential is very high and the share in the total production of electricity could reach 15% by 2030.

To decrease the frequency of maintenance and significantly increase yield, new generations of offshore wind turbines have permanent magnets. They use rare earth oxides (neodymium),



① **Prospecting locations and building site**
- vibrations and noise (e.g. levelling using explosives, vessel traffic) due to drilling and boring;
- disruption of the physical and chemical conditions of the water (turbidity affecting the development of micro-algae, lack of light essential to the development of phytoplankton, disruption of hydro-sedimentary flows);
- modification of sea bed ;
- use of chemical anticorrosion products.

All of this contributes to the destruction of natural habitats and to considerable physical effects: barriers, collisions, lighting, etc. Knowing which areas are the most sensitive in terms of biodiversity and improving techniques makes it possible to limit the impacts.

② **Cables for connection to grid**
Connection to the terrestrial grid results in:
- barrier effects or the destruction of habitats by deep electrical cable laying;
- in the same way as for any production structure, an electromagnetic field to which marine organisms are particularly sensitive.

These impacts can be avoided by the intelligent positioning of the production units: avoiding sensitive areas, limiting the connection distance, etc.

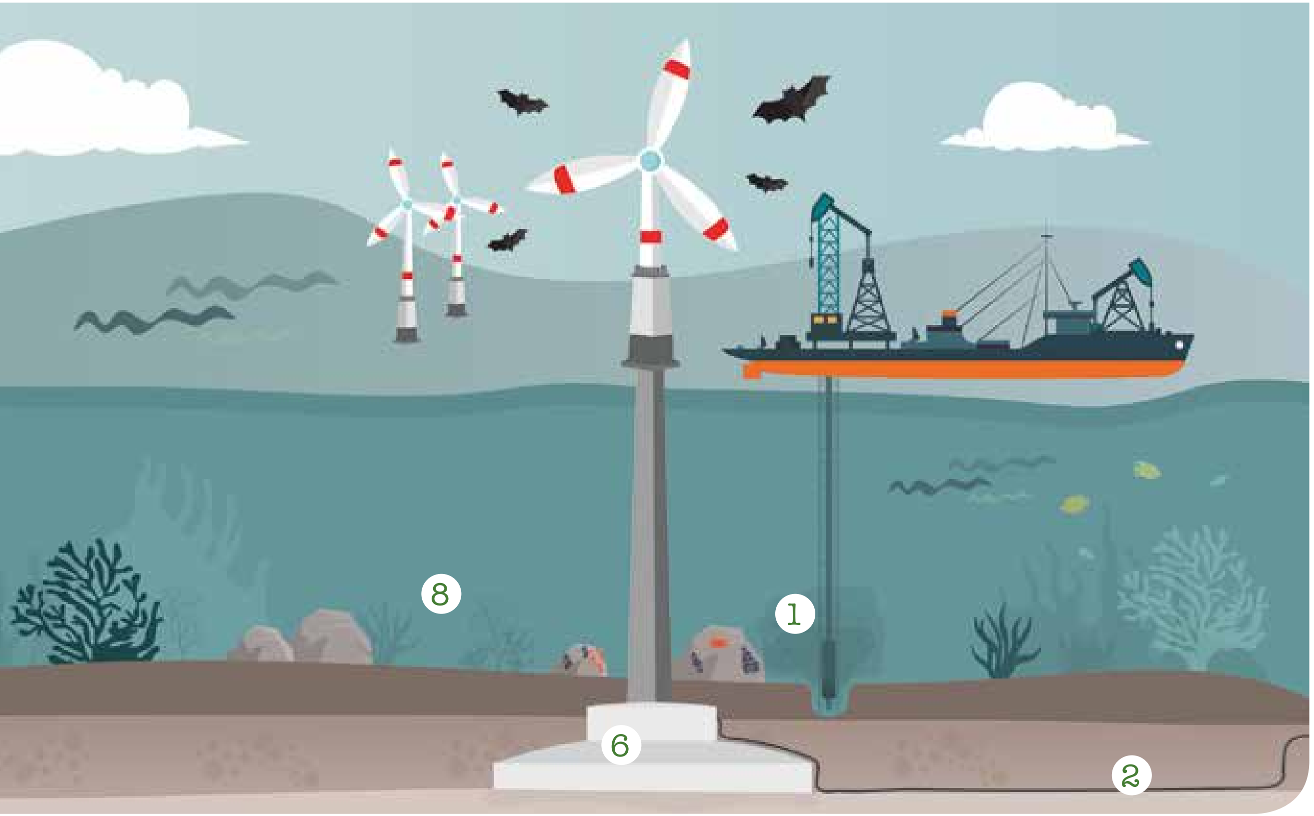
whose stocks are limited and whose extraction proves to be highly polluting: therefore the issue of recycling is still a fundamental one.

On the other hand, tidal turbines are submerged production units which capture the energy generated by sea currents. This type of turbine has a great potential, particularly in France where the tides are large. There are currently only two pilot farms.

But marine environments, the places where life emerged around 4 billions years ago, are precious and fragile biodiversity reservoirs.

Whether during their installation or in operating phase, these marine energy infrastructures have significant impacts on local biodiversity, more generally speaking the marine world and related activities (tourism, fishing, etc).

France is responsible for a large number of marine biodiversity «hot spots» in its waters. These marine ecosystems are home to a wealth of biodiversity and their importance is such that the development of this source of energy gives rise to a certain number of issues.



EIFFAGE

Marine energies, new sources of innovation for biodiversity

Eiffage is fully committed to the challenge of developing marine energy through its subsidiaries Eiffage Génie Civil and Eiffage Métal. With its partners ENGIE, EDP Renewables, Caisse des Dépôts, Principle Power and General Electric, Eiffage Métal won the entire tender for the Mediterranean floating wind turbines pilot, off the coast of Leucate. The group's interest in the marine energy market has been growing for several years, with regards to the large offshore windfarm market in France and internationally, concerning both metallic structures and concrete structures. Eiffage also has several plants that manufacture marine structures in France and in Europe.

Investing in marine energy activity means taking part in the development of cutting edge technologies that use the different forces or resources of the marine environment: wave power, currents, tides and temperature gradient. This is therefore a huge opportunity to experiment for sustainable development, in the same way as ecodesign.

But setting up in marine environments means reducing the impact of the installations…

There are a number of solutions which can help us to improve the resilience of the marine environment and encourage the growth of new habitats, along with the already well-applied research on eco reefs.

For example, a number of innovations in biomimicry, which copy the shape of algae, are integrated into port facilities and make it possible to improve the ecological quality of the deteriorated environment.

Therefore, ecodesigning these marine infrastructures provides undeniable environmental additional value, and also make it possible to deliver a solid argument to energy operators during the consultation phases with users and the general public.
This strengthens our brand image as an ecoresponsible multiprofessional group capable of standing out and innovating on these marine stakes, and as a trustworthy partner for the living decision-makers and economic actors of the sea.

③ Collisions with marine fauna
The frequency and intensity of the considerable risks depend very much on the structure. Rotating at an average of 2.5 m/s, the blades of a tidal turbine disrupt sea flows: wildlife which is not «fast enough» can easily die.

④ Impact de la construction
See introduction

⑤ Fishing banned on the farm
The reduction of the fishing area and therefore its *ex situ* concentration heavily impacts marine ecosystems, particularly fish, *ex situ*.

⑥ Anchoring the production units to the sea bed
There are a large number of anchoring techniques which have significant effects on local wildlife: the benthos (sea bed organisms) is systematically disrupted. During the almost certain recolonization following construction by new species for the artificial structures, a «reef effect» can sometimes be observed: an increase in the biomass due to the structure but also the disappearance of certain species (phytoplankton) whereas others spread (lobsters, mussels).

Floating technologies, a mapping of migration corridors and a good choice of materials all help to reduce the impacts.

⑦ Collision and displacement of birds
The rotation of the blades creates a barrier effect for birds during migration and everyday movement, in the same way as for bats who feed on insects up to several kilometres from the shore.

⑧ Diverse disturbances
The hydrosedimentary conditions are modified cumulatively over a whole farm. This can have repercussions at large distances and disturb *ex situ* ecosystems. Light pollution and noise are also disrupting factors for wildlife. Lastly, the corrosion inhibitors on the structures and maintenance operations can pollute the environment.

Using techniques which generate less noise, vibrations, light, etc. lessens the impacts on marine wildlife.

6 Recoverable energies

Butterfly effect

The historic site of Séché Environnement uses the bioreactor technique to valorize domestic refuse-type final waste from the energy point of view. Once the methane from the biogas has been converted into electrical energy resold on the distribution grids, what is left over is coproduced heat.

Used locally in favorable economic conditions to dehydrate fodder in view of its conservation to ensure food for livestock all year round, this source of RE has made it possible to maintain the traditional cropping of alfalfa rather than using imported soya cakes from countries where deforestation is carried out.

Alfalfa has the ability to capture the nitrogen in the air directly through its root system and can therefore do without nitrogen-based fertilizers. It also captures the excess nitrogen dissolved in the soil and the porosity created by its roots encourages micro-fauna. This plant is a very good rampart against water and wind erosion due to the fact that it covers the ground all year round. As the cooperative operates in organic farming, phytosanitary input is low which means that the undergound water resource – one of the preoccupations in the management of the Séché Environnement landfill site from which the biogas is extracted – is protected.

Alfalfa in a preserved Mayenne bocage offers shelter to a number of animal species and is home to an infinite variety of useful insects for integrated pest management in the crops. As a honey plant, it is an important base for local beekeeping.

The cropped areas adjacent to the Séché Environnement site create actual ecological corridors. The adapted management implemented on the processing site itself which has protected areas reserved for the protection of biodiversity, ensures the perfect integration of an industrial activity in natural surroundings and the territories.

It is partly thanks to this by-product, heat energy used for fodder conservation, that this environment rich in biodiversity is developing and creates the symbiosis between human life (and its contingent production of waste), industrial valorization and good management of farming areas.

As described previously (p.4), recoverable energy stems from the unavoidable energy which is inherent to any production of goods or services.

The capture and upgrading of recoverable energy belongs to the flow logic, which more generally speaking, is at the heart of Industrial and Territorial Ecology (ITE). As an approach inspired by natural ecosystems, ITE favours an optimal management of resources and a high recycling rate of matter and energy[17]. It is a potential answer for the territories to resource, adaptation and resilience issues. Set up upstream, or during requalification, it encourages a symbiotic relationship between the actors and the activities of a territory. Collaborations, pooling of means, intersecting intelligence and a strong development of local fabric are emerging from this method of "integrated" governance. The issues of each must be considered, to make it possible to insert the protection of biodiversity into the debate to be led by other actors (farmers, foresters, natural parks, etc).

Recoverable energy, whether it is integrated into an ITE approach, has a double positive impact on biodiversity:

- it decreases the demand for other produced energy (renewable or not) and thus impacts on *ex situ* biodiversity. Recoverable energy is part of a logic which consists of upgrading existing losses intrinsically. The finality of the source of production of this unavoidable energy must not therefore be its upgrading ("waste must not be produced just to be upgraded");

① Data centre and upgrading of thermal energy
The cooling systems of computer components on these sites generate unavoidable energy which can be upgraded locally. However, it must not be used as a substitute for an energy sobriety approach.

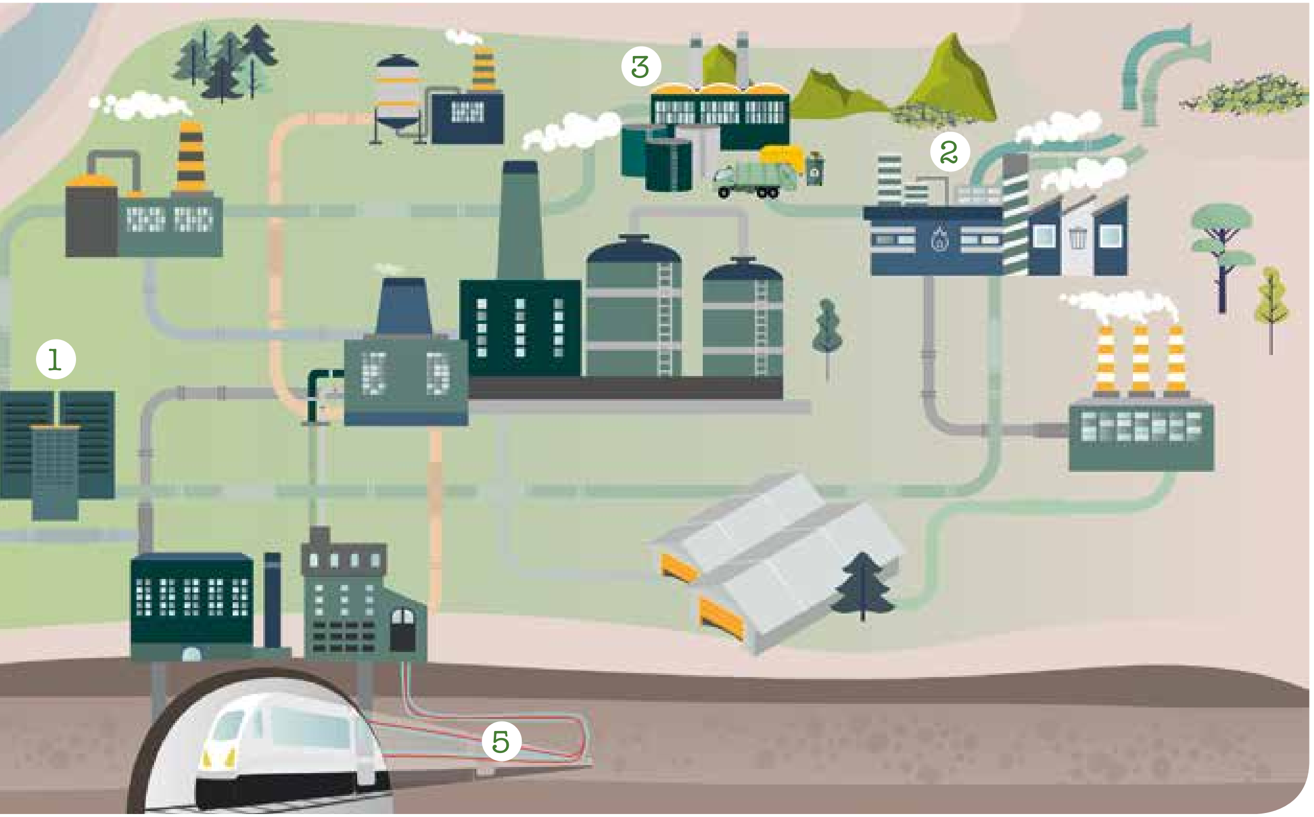
② Incinerator and waste upgrading
When materials are burned, a large quantity of energy, created in the form of heat, can be recovered and upgraded. The cost and energy loss of heat transport makes this upgrading economically and ecologically profitable only in the case of a very local use.

③ Methanisation of non-agricultural waste
Also known as anaerobic digestion, this is a microbial degradation process which transforms complex organic matter into a biogas (CH_4 + CO_2) and solid or liquid waste known as digestate. The digestate can be upgraded from the agronomical point of view, which actually raises the problem of waste traceability and its impact on biodiversity.

- they set up, in the same way as ITE, a dialogue between economic actors, local communities and citizens. The activities which are the source of recoverable energy are varied and can be found at different geographical levels: urban, periurban, and rural. They form a network of the territory in local resources.

Nevertheless, as for all human activities, this type of energy is not devoid of damage to biodiversity, due specifically to the considerable artificialisation of soils, reinforced by the networking of actor's sites. Once again, in the global, systemic and territorial approach, it is necessary to reconcile human needs, the industrial means to develop them, and ecosystems' capacity of resilience.

Where resources are concerned, here they are specifically made up of the original main activity: incineration, big data, methanisation, transport…. But they have a considerable number of impacts on biodiversity: through their location, their waste or non-recoverable unavoidable energy, or through their dismantling. In the case of sources grounded on the territory, the post evaluation of impacts can be facilitated, either by collaboration with neighbouring actors (fishermen, doctors, farmers, etc.) who act as "sentinels" when carrying out their professional activity, or indirectly by remaining attentive to their feedback.



④ **Upgrading the heat of waste water**
See Veolia insert

⑤ **Recovery of energy in transport systems**
The braking of trains is a phenomenon which dissipates a large quantity of energy. This energy can be recovered and reinjected into the network, and then redistributed locally, particularly on the train busbar.

⑥ **Natural cold network**
"Free-cooling", "free-chilling", or "geo-cooling" makes it possible to limit or replace, depending on the time of year, the use of classical cooling systems, by using the coolness of the air or the ground, directly or indirectly. The consumption of water and chemicals is thus decreased. Nevertheless, the impacts of discharges or the installation of a circuit in natural water are not significantly studied.

VEOLIA

Exemple of recoverable energy : wastewater produces energy for urban needs thanks to Energido

80% of French housing is connected to the public sanitation network. The average temperature of waste water in the networks in France varies from 13 to 14°C in winter to over 20°C in summer.

Heat recovery from waste water therefore represents a potentially important source of energy for urban needs. This recovered heat from wastewater is local, renewable and directly available in the vicinity of consumers' needs.

Heat recovery from waste-water is carried out by heat exchangers, that can be installed at the bottom of the buildings that produce the wastewater for its own needs, on the wastewater in the public sanitation network, as near as possible to the final user of the heat, or at the end of the line on the WwTP (Wastewater Treatment Plant), for the plant's own needs or for a user in the vicinity.

EnergidO (commercialized by Veolia) is a solution which provides energy for the heating and cooling requirements of the territory using a heat exchanger, directly installed on the sanitation networks or on wastewater treatment plants. In this way, EnergidO can supply energy for:

- ecodistricts;
- specific facilities: aquatic centres, greenhouses, malls, offices, etc.;
- administrative buildings and technical wastewater treatment plant facilities.

The recovery of the calories contained in the waste water is therefore a sustainable, reliable and innovative solution to meet the energy requirements of the urban population, that avoid GHG emissions and protect biodiversity and non-renewable resources.

EnergidO's (commercialized par Veolia) references: Cap Azur ecodistrict of Roquebrune Cap Martin), aquatic center Aquarena à Arras, cercle des nageurs de Marseille, Ginestous-Garonne sanitation services. The Energido solution can also be applied to drinking water networks.

ADEME commitment on biodiversity and renewable energies

To reduce our fossil energy consumption, renewable energy (RE) is unavoidable. It also presents environmental and biodiversity challenges in the same way as any human activity. These challenges may involve the different phases of a project, from the extraction of raw materials to dismantling, and are highly diversified: fenced-in ground-based solar facilities can fragment habitats, flying animals can collide with the blades of the wind turbines, etc. The Avoid Reduce Offset sequence (ARO) advocated by the Ministry for the Ecological and Inclusive Transition is one of the most important tools for limiting impacts.

ADEME has been supporting actions on RE-related biodiversity stakes for a number of years: knowledge acquisition, development of solutions coherent with the ARO sequence. As an example, ADEME has been working with the LPO (French Bird protection League) for several years on the national «Eolien et Biodiversité» programme which aims at facilitating the environmental integration of French parks on land and at sea, and particularly for flying vertebrates. ADEME is also launching a study in the autumn of 2017 to realize a literature survey on the impacts of RE on biodiversity, soils and landscapes, and on the means to assess them. This work will carry out the inventory of knowledge in this field and of all the work needed to fill the gaps. It is also supporting the Chirotech research programme initiated by Biotope, which enables the shutting down of wind turbines during periods of high chiroptera (bat) activity. This work, which complements the results of life cycle analysis (taking into account more indirect environmental impacts such as CO_2 emissions), will make it possible to continue the development of the most efficient RE possible on both technical and environmental grounds.

Biodiversity at the heart of the CNR model

For over 80 years, the Government has entrusded CNR (Compagnie Nationale du Rhône) with the concession of the most powerful French river in order to develop it and fulfil three missions for the community: green electricity production, development of navigation and irrigation of agricultural land. CNR, France's leading producer of 100% renewable electricity, has designed an industrial model in the Rhône area which combines the production of green electricity and sustainable development.

Biodiversity and territorial logic are at the heart of its model.

Considering the prospect of a decrease in water resources and biodiversity, territorial water quality and ecological wealth are indispensable: a healthy and familiar river is all the more capable of contributing to the development of territories.

CNR manages over 27,000 ha and more than 100 protected natural sites which are home to a wide variety of biodiversity. It reconciles the protection for biodiversity with hydraulic safety, safety of residents, energy production and economic development.

In 2003, CNR created 5-year action plans for the territories, *Missions in the General Interest*. The 3rd plan is being deployed along the Rhône and devotes €47M to biodiversity. It includes the hydraulic and ecological restoration of the Vieux-Rhône by refilling the dried up former arm of the river. This recreates dynamics which are favourable to biodiversity and improve runoff to facilitate floodplain expansion.

CNR also fights against the propagation of invasive plants using innovative methods such as planting local species: their proximity and the substances they secrete are detrimental to the propagation of invasive plants. Lastly, CNR focuses on fish species and is deploying a new process to identify fish DNA traces in order to rapidly collect accurate data on the species that cross the Rhône. Thus, in one campaign alone, data equivalent to several years of more traditional operations are collected. Improving the knowledge of the environments makes it possible to check that fishways work correctly.

Since 2006, CNR has developed outside the Rhône area with solar and wind production. At the heart of these new developments is this same logic of territory and the reconciling of uses and stakes, along with the protection of biodiversity. Solar PV farms are set up on polluted sites or industrial wasteland, far from agricultural or natural areas. The farms are operated sustainably, particularly by revegetating the sites with local seeds which then serve as grazing for local breeders (grazing management).

The territor
a frame of mind to

We are faced with a multi-dimensional crisis and to overcome it, we must combine a considerable number of solutions in order to face the new challenges. We must therefore seek to attain our objectives by making harmonious and logical choices. The sustainable development logic requires a holistic approach to the system in which we are developing, not to worsen a problem in order to solve another.

This interdependency between human beings, their organisations and ecosystems, makes it possible to grasp them as a single system: the socio-ecosystem.

This notion refers to a strong sustainability approach which considers that ecosystems and human organisations are dependent on each other. For such a system to last in a changing world, it must be as resilient as possible, i.e. have the ability to adapt in the light of global change.

The fight against climate change and therefore energy transition seeks to maintain this resilience but often with a highly «carbon-focused» approach which may result in major issues being neglected or even the increased reduction of the resilience of socio-ecosystems.

The territorial approach would appear to be the most appropriate approach on which to base our choices. It obliges us to consider the spatial aspects of development and also the links and interactions which are established between all the entities in the socio-ecosystem[22]. In the words of Edgar Morin, a «complex» approach.

ial approach : reconcile the issues

Even though the use of energy is inherent to human activities it is also one of the main causes of the crisis the human species is currently going through. Energy transition is required to make our future sustainable. It covers our practices (sobriety and efficiency) but also raises the question of «how to produce». Mitigation through the recovery of energy or the production of renewable energy is the solution. However, this mitigation must be deployed intelligently to avoid worsening other crises such as the erosion of biodiversity.

In the current context of globalization, all the available resources are taken into consideration when energy solutions are developed, often to the detriment of the impacts triggered by their use. During the industrial revolution and the great development of the so-called «countries of the North» the environment was completely left out. Now biodiversity, particularly *ex situ* biodiversity, and therefore the so-called «countries of the South» must not become the great oversight of energy transition. To sum up, the energy transition whose use is local, but whose resources and deployment are global, must be considered globally (*in situ* and *ex situ*) when being assessed.

Bearing in mind these *ex situ* implications of choices, the issue must be focused on a territorial approach in order to reconcile nature and human activities. Energy production must belong to a local context, with its specific advantages and drawbacks. Currently, it is mostly on the scale of territories that the problems of sustainable development are perceived and it is probably also there that both fair and democratic solutions[14] can be found.

Research issues at the interface between energy transition and protection of biodiversity

France's green growth objectives are largely based on the development of energy from the biosphere which represents 40% of the renewable energy in our country. Research can act as a whistleblower when impacts are noted on ecosystems or when the modelling of human activities forecasts damage to ecosystems. It can also provide upstream tools and knowledge for actors in order to base decisions on science and not only on the cost-effectiveness of the project.

If we cannot provide an extensive panorama of research issues here, three aspects appear to be crucial and should be subject to funding by public authorities in order to guarantee the protection of the common goods of mankind and the well-being of citizens.

The first is the measurement of the impacts of new renewable energy sectors on biodiversity, from populations to ecosystems, including their whole life cycle (from the manufacture of equipment to the transport and final recycling of their products or infrastructures) which also integrates indirect or cumulative impacts. Biodiversity's answers to these new human activities, which for example are related to the dissemination of invasive species, must also be broached.

The second is the question of solutions and alternatives to the massive deployment of new sectors (which necessarily generate increased pressure on ecosystems through the consumption of raw materials). Research must focus, with suitable means, on energy saving, sobriety and nature based solutions.

The third is the analysis of the social acceptability of these new technological developments. Understanding the mechanisms whereby groups of people are ready or not to lose elements of biodiversity, as well as training and awareness aspects are essential to guide the action of public authorities towards the building of a more sustainable society.

Programme «Une Rivière, Un Territoire»

EDF SA is a major national company and also an enterprise which is delocalized in territories. A few years ago, the EDF group launched the programme «*Une Rivière, Un Territoire*», by developing several agencies in valleys where the hydraulic power plants operated by the group are located. This initiative does not focus only on the natural ecosystem of the river but also on the territorial and human ecosystem. The programme therefore has two complementary components.

The first is to develop in the short term the links between the actors themselves on the territory, and particularly between industrial actors. It aims to support the actual development of the territories as innovation laboratories. EDF's presence within a territory enables it to develop connections which can only exist thanks to its close relation with local actors and projects. A better understanding of the ecosystem makes the enhancement of industrial performance possible (for example through a better knowledge of the skills of local firms serving EDF's industrial stakes), synergies and collective intelligence.

The second, on a longer term, promotes investment in firms which have a link with the fields of water, energy or the environment. An investment fund supports firms in their growth in the form of loans or by EDF acquiring shares. These initiatives help to maintain or even create an activity and the necessary vital jobs in «hydraulic» territories, which are often isolated from the large employment areas.

These two components support the dialogue and concerted actions between the stakeholders on a given territory. The nature of the exchanges between actors can be varied: expertise, engineering, ideas, projects, etc. In a logic of connection between the actors of a territory and the environment/natural resources, the subject of biodiversity can stimulate strong new links between actors. Grounding in the territory helps to better understand its challenges, to get to know each other better and thus to find better balances. For example, the agency «*Une Rivière, Un Territoire*» Massif du Jura developed an environmental innovation workshop in a FabLab in the Ain territory in June 2017. This enabled several stakeholders to find points of convergence, particularly on the potential regarding the use of robotics for environmental monitoring. Committing and above all committing together will build an adapted and resilient territory for the future.

Conclusion

Decompartmentalizing environmental issues and meeting the stakes in a coherent manner is currently a priority. We must act in favour of climate change without worsening the fate of biodiversity. Biodiversity is the basis for potential.

A change in energy production methods as a solution for the climate actually involves biodiversity. The impacts at all levels are both negative and positive; here or there, upstream, during or after.

As the actors of energy transition, it is important for us all to be aware of them. Already, some of us are mobilizing and reflecting on this coherence which is necessary and all important for our future. A territorial and systemic approach is essential if we want to be able to meet such challenges.

Our ability to imagine, our organizational innovation skills and our cooperation with others, including biodiversity, are the breeding ground for the potential for a desirable development which is compatible with a fight against global change. The living world can inspire us here because it has managed to evolve under energy constraints.

The ORÉE working group proposes to take part in this dynamic by working on a support for decision-making in terms of energy. Supporting actors in their diagnoses and approaches to reconcile in the best possible way the constraints and opportunities and optimize the shared choices which echo Nelson Mandela's recommendation:

«May your choices reflect your hopes, not your fears».

Acronyms and abbreviations

ADEME : Agence De l'Environnement et de la Maitrise de l'Énergie
AFB : Agence Française de la Biodiversité
ARO : Avoid Reduce Offset
B : boron
Br : bromine
CGDD : Commissariat Général du Développement Durable
CH4 : methane
CMS : Convention on the Conservation of Migratory Species of Wild Animals
CNR : Compagnie Nationale du Rhône
CO2 : carbon dioxide
EDF : Électricité de France
EDP Renewables : Energias de Portugal
EROEI : Energy Returned On Energy Invested
Excl. VAT : pre-taxe price
FRB : Fondation de Recherche sur la Biodiversité
GHG : Greenhouse Gases
Hg : mercury
ITE : Industrial and Territorial Ecology
kWh : kiloWatt/hours
LCA : Life Cycle Analysis
LPO : Ligue pour la Protection des Oiseaux
MEA : Millennium Ecosystem Assessment
MTES : Ministère de la Transition Écologique et Solidaire
MW : MegaWatt
PV : PhotoVoltaïque
P : phosphorus
Pb : lead
PVC : polyvinylchloride
RE : Renewable Energy
RME : Renewable Marine Energy
R&D : Research and Development
R&Re : Recuperable and Renewable Energy
SAC : Special Areas of Conservation
SNCF : Société Nationale des Chemins de fer Français
SPA : Special Protection Areas
STEP : Station d'Épuration des eaux usées
UICN : Union Internationale pour la Conservation de la Nature
WG : Working Group

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