Circular economy

for the preservation of resources and the climate

A flows and channels approach towards a territorial ecosystem

CLIMATE AND CIRCULAR ECONOMY

LABEL
PARIS2015
COP21·CMP11

orée
Entreprises, territoires et environnement

Document drafted with the support of:

SNCF · LA POSTE · RhôneAlpes · GrDF · DS Avocats

September 2015

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

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Editorial line and graphic design
Canopée design & communication agency
www.canopee.cc

Printed on PEFC certified paper.

Acknowledgements

This book, which stems from work carried out by ORÉE's Working Group entitled Circular economy / Territory, is the fruit of the work of a number of ORÉE's members, who have enriched it with their shared experience.
ORÉE would particularly like to thank Cyril ADOUE, Chairman of the working group for his commitment and strategic visions in the development of this book, and also Alice SARRAN, Circular Economy Project leader at ORÉE for her key contribution and the coordination of this document.

We would also like to thank:

- The external and scientific experts for their contribution: Cyril ADOUE (INDDIGO), Geneviève BOUCHÉ (Futurologist), Alain CHABROLLE (Conseil Régional Rhône-Alpes), Christian DUBOST (SNCF), Hélène LEBEDEFF (Veolia), Frédérique LE MONNIER (GrDF), Jean-Claude LEVY (Geographer, Historian), Sophie-Noëlle NEMO (La Poste), Hélène VALADE (SUEZ), Jean-Michel VALANTIN (MEDDE), Patrice VALANTIN (Dervenn);

- The enterprises and local authorities who agreed to testify in this book: L'ARENE Île-de-France, Bouygues Immobilier, Le CERDD, La Communauté d'Agglomération du Grand Guéret, Eco-Emballages, EDF, EIFFAGE, GrDF, La Green Valley, La Poste, Nespresso, Le Pôle Synéo, Ports de Paris, Renault, Roule Ma Frite 17, Séché Environnement, La SPLA 81 « Les Portes du Tarn », SUEZ, Le Syndicat Mixte de la Zone Industrialo-Portuaire de Salaise-Sablons, Veolia, Le Vivant et la Ville, VNF;

- The structures who contributed to the financing of this book: the Conseil Régional Rhône-Alpes, DS Avocats, GrDF and La Poste.

And lastly, for their active collaboration in the development of this book: Pauline LAVOISY, Cécile COUTEAU and the whole ORÉE team

Preamble

Alain CHABROLLE

Vice-President of Conseil Régional Rhône-Alpes
in charge of Health and Environment

By 2040, the world population will reach 9 billion, and over the next 20 years the number of middle class consumers will increase by 3 billion. This will necessarily lead to an increase in the consumption of natural resources, along with the emission of greenhouse gases, responsible for climate disturbances.

We cannot hide that our current economic development model is not able to provide efficient and sustainable answers to face human-generated environmental and health impacts. The «extract – manufacture – consume - discard» linear system on which our economy has been based since the Industrial Revolution has thus reached its limit …

Citizens, public authorities and economic stakeholders have identified these issues. Aware of the finiteness of Earth, they are convinced of the need for a new development model which will respect the common goods of Earth and its inhabitants and the necessity to switch from a linear to circular economy.

A number of circular economy projects are currently being led on the French territories: industrial and territorial ecology, eco-innovation, recycling, repair, reuse, eco-responsible buying, collaborative economy, etc.

All these actions contribute to the energetic and ecological transition of our societies.

Territorial action is an indispensable lever; circular economy actually relies on the mutual knowledge of stakeholders and of matter flows, on their capacity to set up innovative cooperation projects from a local point of view. However, even if planning tools already exist, they are all too often sector-specific, and insufficiently coordinated: Plan Climat Énergie Territorial (PCET – Territorial Climate and Energy Scheme), Schéma de Cohérence Territoriale (ScoT – Territorial Cohesion Scheme), Agenda 21, etc.

The implementation of the territorial circular economy approach is an opportunity to gather all stakeholders (elected representatives and local authorities, enterprises, social and solidarity actors, associations and citizens/users) on inspiring challenges such as the mutualisation and sustainable management of resources, the lowering of the carbon footprint of activities and the creation of wealth and jobs rooted at local and regional level.

As far as methodology and territorial capacity to implement such projects were concerned, the primary feedback from these territorial experiments is encouraging. Their benefits for preserving our natural resources and reducing greenhouse gas emissions are obvious, and the projects have been characterized by a spirit of trust, sharing and cooperation.

These experiments show that the Region is a particularly relevant scale for economic development, innovation, training, waste management, urban planning and transport policies. The Region acts in a transversal way for the environment (energy, agriculture, Regional natural Parks, Green and Blue Belts, etc.).

For this purpose, the Regions, which are experimental territories and sources of innovation, implement regional circular economy strategies.

With circular economy, the expression “Think global, act local” fully makes sense by developing very practical answers to local issues, with global benefits.

This book will help you discovering a large number of experiments and actions which can be reproduced on your level of action. Their generalisation to the whole France is currently a priority if we want to lead the ecological transition of our society.

Nevertheless, circular economy is not something which can be decreed, and each territory wishing to invest in it has to reinvent its own process to adapt and implement the concept to its own specificities.

Editorial

> Nathalie BOYER,
General delegate of ORÉE

Co-construction, multi-partner governance, dialogue, collective approaches, participation, etc. are today the new ways of meeting the complex stakes our societies are faced with.

And this is what we are defending at ORÉE through our network of enterprises, local authorities, public institutions, associations and bodies. Bringing the actors together, supporting and valorising field experiments, good practices and research works are at the heart of our missions to create, between our members, opportunities which will help practical solutions to emerge.

As historical actor in Industrial and Territorial Ecology (ITE), our association defends a transverse application of circular economy, where all its operational fields (ITE, collaborative economy, recycling, eco-design, etc.) must be mobilised for a more efficient preservation of resources.

This document is the result of the "Circular economy / Territory – Flows and Channels" Working Group, opened in 2013. The challenge of these meetings was of course to show that circular economy goes much further than only waste management in operational implementations. Taking a territorial angle, a large number of actors came to discuss innovative practices in different fields of the management of waste, energy, water, transport, agriculture and town and country planning.

It is also the fruit of rich discussions and the sharing of experience which allow us today to demonstrate the potentials of circular economy where resources and climate are concerned. We hope that these practical examples will be an inspiration for enterprises and local authorities for the transition of their territories.

Good reading!

A word from the Chairman

Patricia SAVIN

Linear economy, circular economy, product-service system, social solidarity economy, etc.

A plethora of vocabularies and concepts which focus on an obvious challenge regarding past, present and future economic models.

Whatever the case, we are obliged to recognize that the current model of growth has reached its limit: depletion of resources, soil impoverishment, air and water pollution, multiplication of waste, disturbance of natural cycles, global warming, etc. The year of the COP21 is a necessary incentive to think about the links between our economic models and the ecological, environmental and human Crisis that our Societies are experiencing.

The model known as circular economy can be one of the tools which can help us to ask ourselves the right questions at the different levels of responsibility from the private and collective point of view. It is time to design and implement new more sober production and consumption modes. It is imperative to structure sustainable recycling and reclamation channels. It is imperative to rethink the development of our territories in terms of local cooperation and synergies between the different stakeholders.

All these actions and challenges may be a contribution to the concert of solutions for reducing our greenhouse gas emissions and allowing a better management of water consumption, energy supply and the end-of-life of materials.

Circular economy – a global, systemic, multi-stakeholder and territorial approach – implies working on all the flows, all the sectors of activity and all types of territories. Even though these are global issues, solutions to these problems are essentially to be found at a local level. Based on collective intelligence, they work for the development of real sober, efficient and sustainable ecosystems. Today, we are at a Crossroads, and it is up to us all, individually and collectively, to make our common Future possible.

"Your task is not to foresee the future, but to enable it" Antoine de Saint Exupéry…

Kindest regards.

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How to understand this document?

> Ecosystems are inspiring!

> Challenges for resources

> Challenges for the climate

> Circular economy solutions


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Introductory comment

Jean-Michel VALANTIN

Doctor and Researcher in strategic studies, in charge of the « environment and safety » column of www.redanalysis.org

"The geostrategic challenge of circular economy"

Circular economy belongs to a worldwide strategic context which is rapidly and deeply changing, marked by the combination of global competition for natural resources and climate change and its effects. This combination, which has been qualified by James Howard Kunstler as the era of the "Long Emergency", is rife with danger.

These new tensions are not "solely" economic, as they challenge the possibility for nations to meet their fundamental needs in water, food, energy, habitat, and transport at a time when climate change is imposing permanent and ever-increasing tension on the cycle of water, food production, the well-being of populations and wildlife.
Throughout the twentieth century, complex relationships of political, economic and military forces were set up between the production and consumption of food, mineral and energy resources, such, for example, as oil, whose history is dotted with a considerable number of crises and wars… and whose uses, with those of coal and natural gas, are largely responsible for climate change and the resulting threats it implies.

As answers to this enormous crisis, the growing tensions which result from it, and even the armed conflicts which could be triggered for access to energy, water, food and raw materials, circular economy brings other possibilities to light, by allowing companies and their economies to become "lasting and sustainable", and by preventing the risk of violence.
This approach which is intrinsic to circular economy is one of the main strategic stakes of this century, inasmuch as it accompanies the toppling of international power distribution.

Over the years and decades to come, the demand for resources will continue to increase and access to them will become even more difficult, due to their relative scarcity.
Therefore the capacity of circular economy to integrate the uses of water, energy and agriculture into "virtuous loops", and have them intersect, integrating at the same time waste into new life cycles, will make it possible to single out the countries capable of meeting the "long emergency" through an emerging socio-economic and political model which will allow them to "live" while others will be endangered due to their insufficient capacity in this field.
Moreover, this new economic model is based on a philosophy which is no longer that of exploitation, but of the adequacy between the planet's "carrying capacity" and the needs of people and societies. It is explicitly designed to improve the link between human societies and the biosphere and mitigate climate change.
Circular economy therefore contributes towards the prevention of the possible devastating conflicts which would go hand in hand with a generalized resources crisis and the surge of climate change, by helping to re-establish a balance between Humanity and the Earth.

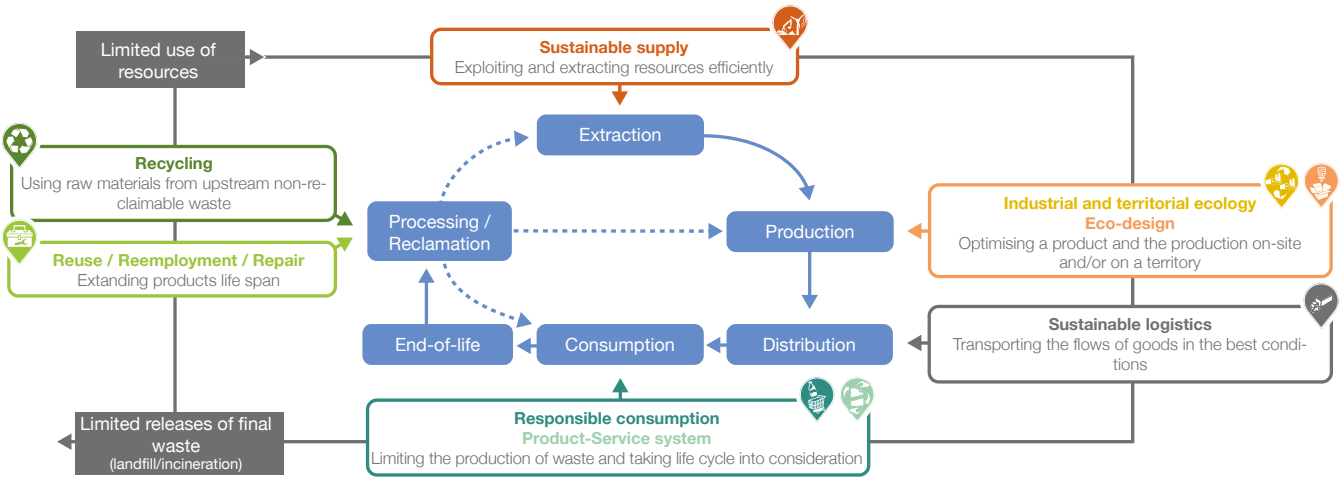
Latest publication :
"*Climate nightmare in the Middle East*",
at www.redanalysis.org

Circular economy

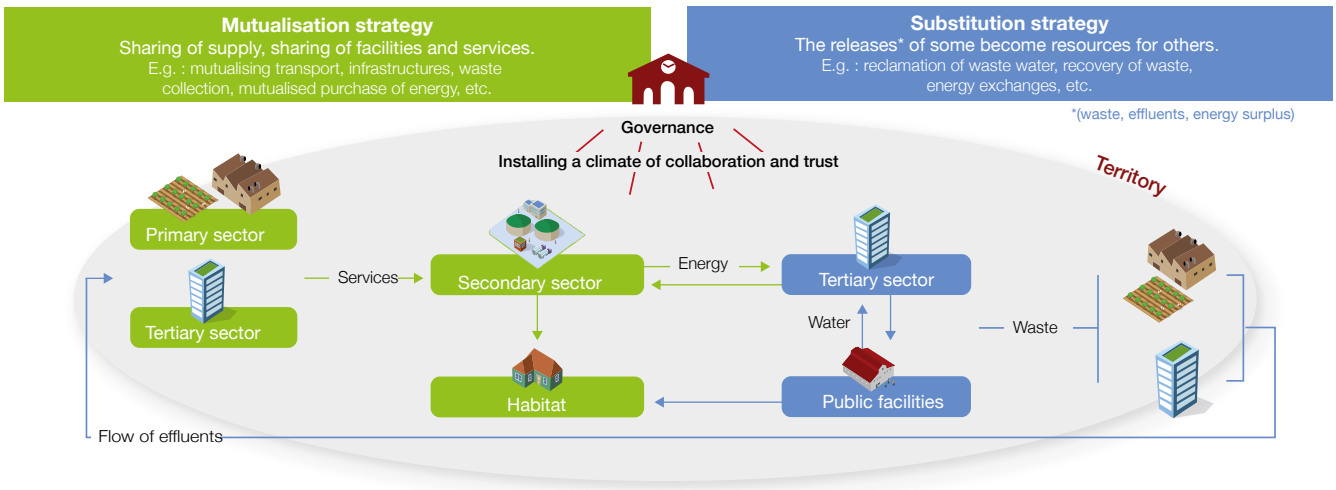
/ industrial and territorial ecology

What are we actually talking about?

Extracting fewer raw materials, discharging less waste, operating with renewable energy, etc. a challenge that circular economy can meet! Even though its use is fairly recent, the concept of circular economy currently makes it possible to take the fields to which it is linked into account on a wider scale: the production and offer of responsible goods and services, responsible consumption, reuse, recycling, uses and needs, territorial management of materials and energy, etc. The diagram below shows each stage of the life cycle, the conditions to be implemented in order to deploy circular economy on a corporate and territorial scale. Each symbol represents operational solutions for ensuring sustainable development, from supply to end-of-life. ADEME defines the 7 fields of action of circular economy by sustainable supply; eco-design; industrial and territorial ecology; product-service system; responsible consumption; increasing the length of use and recycling.

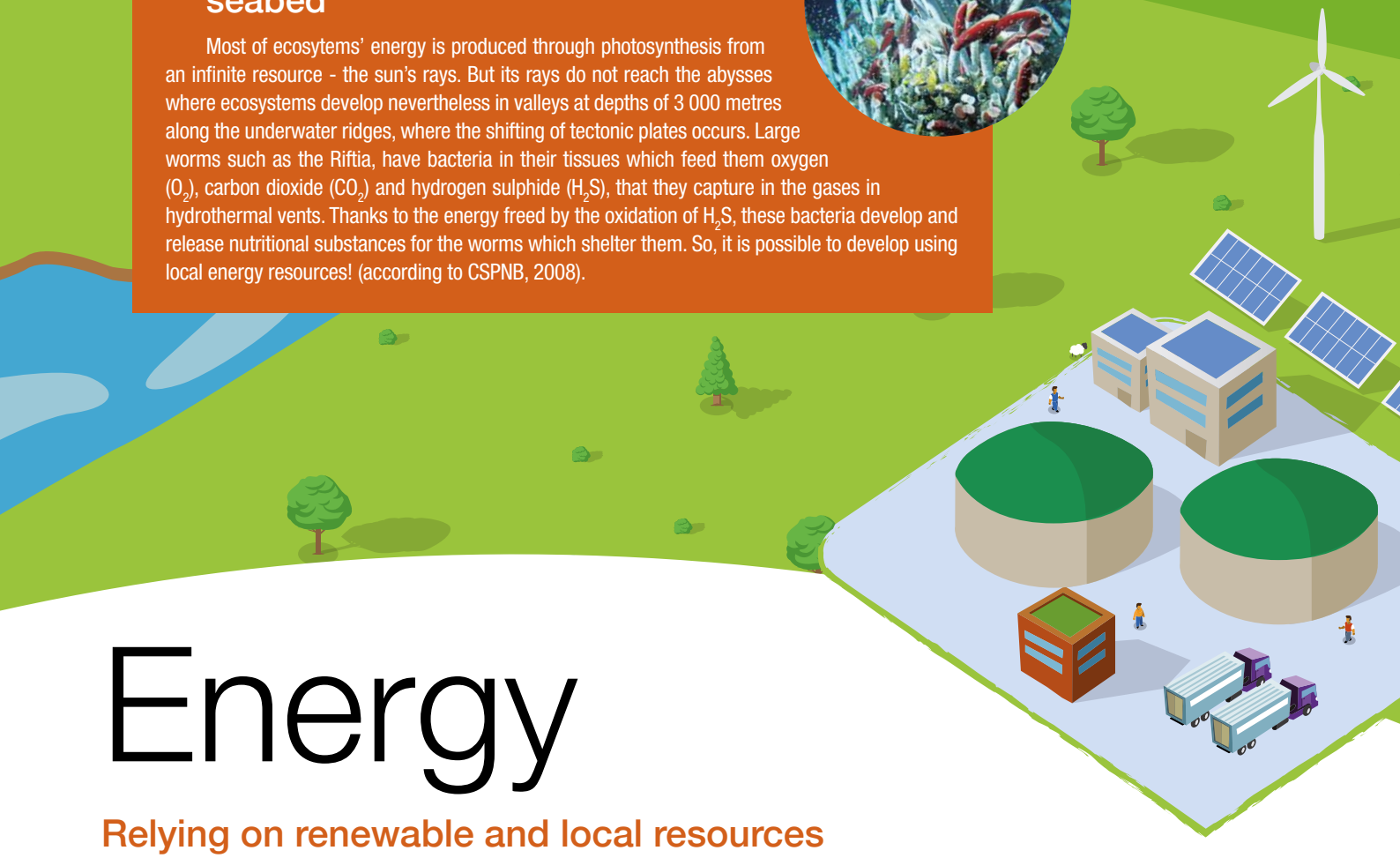


The territorial application is an essential link to locally deploy the solutions promoted by circular economy. Developed for a number of years by industrial and territorial ecology, the model offers opportunities for the creation of value, and valorising local potentialities and resources. It implies the implementation of synergies of mutualisation and substitution. Mutualisation strategies which are shown in green on the diagram, consist of mutualising goods, resources and services, thus making it possible to make economies of scale and lessen some of the economic activity's environmental impacts. Substitution synergies (exchanges of flows), in blue on the diagram, consist in reclaiming the externalities discharged from certain enterprises by other neighbouring bodies. They may also necessitate the presence of interface activities to allow the recovery of by-products, the development of products or services and the management of a common resource.



A sunless world on the deep seabed

Most of ecosytems' energy is produced through photosynthesis from an infinite resource - the sun's rays. But its rays do not reach the abysses where ecosystems develop nevertheless in valleys at depths of 3 000 metres along the underwater ridges, where the shifting of tectonic plates occurs. Large worms such as the Riftia, have bacteria in their tissues which feed them oxygen (O_2), carbon dioxide (CO_2) and hydrogen sulphide (H_2S), that they capture in the gases in hydrothermal vents. Thanks to the energy freed by the oxidation of H_2S, these bacteria develop and release nutritional substances for the worms which shelter them. So, it is possible to develop using local energy resources! (according to CSPNB, 2008).



Energy

Relying on renewable and local resources alone and optimising their use

Depletion of fossil resources faced with increasing demand

Heavy contribution of energy supply to CO_2 emissions

Circular economy & **energy**

Reclaiming organic waste for the production of heat, electricity, biogas, fuel, etc.

Decreasing energy losses by reclaiming unavoidable energy:
- from incineration plants,
- from industrial firms,
- from waste water, etc.

Optimising consumption:
- energy efficiency (buildings, etc.)
- mutualisation of energy purchase,
- recovering energy from surface waters, etc.

An energy model based on limited resources

We need to produce energy to be able to transform the indispensable resources and meet our needs: lighting, cooking food, comfort, mobility, communications, etc. The use of fossil fuels (coal, oil and natural gas) represents almost all the world's energy needs. Fossil resources supply over 85% of our primary energy at international level (BP, 2014), and also their extraction, transport and conversion into electricity, heat, etc. Energy such as hydraulic, biomass and even wind and solar power represent just over 1% of global consumption.

However, fossil fuels are not inexhaustible. Where oil is concerned, an estimated 1 300 billion barrels have been used, which is about half of the reserves. And what is more, the second half cannot be used entirely because more and more energy will be needed to extract it. The same goes for coal – in around thirty years, peak consumption will have been reached. On the other hand, the exploitation of non-conventional gases stretches the prospects of reserves by 120 to 250 years at current consumption speed, even though its use is highly controverted (OCDE/IEA, 2011).

An energy model which disrupts the carbon cycle

The power supply sector is the most energy intensive and emits the highest global rates of GHG emissions (IPCC, 2014). The main source of these emissions is the combustion of fossil fuels (in the following order: mainly coal, oil and natural gas), which represents 31.7 gigatonnes of CO_2 emitted in France in 2012 (+ 1.2% in comparison with 2011) (CGDD, 2015). With the liberation of the carbon trapped between several tens of millions and a billion years ago, the combustion of these resources has triggered a considerable imbalance of the carbon cycle with an increase in the greenhouse gases in the atmosphere. To this must be added the fact that high energy losses occur at each of these stages and that, as mentioned above, the energy needed to extract fossil fuels from the sub-soil is always on the increase. The production of electricity for urban heating represents the largest part of the GHG emissions of the power sector in France, i.e. 71.6% (including the incineration of waste with energy recovery), well ahead of oil refinery, emissions linked to extraction activities and the processing of coal and its by-products.

EXPERT'S WORD

Energy transition must take place via the territories

> **Frédérique LE MONNIER**, in charge of Sustainable Development, GrDF

Since the Grenelle laws initiated the development of Regional Climate, Air and Energy Schemes and Territorial Climate and Energy Schemes, we have seen the development of an actual territorial approach on questions of energy to serve sustainable development, with the reconciling of economic, social and environmental stakes. Both schemes invite local authorities to set themselves ambitious goals in terms of improving energy efficiency, particularly where the development of capacities for producing energy is concerned. The future law on Energy transition for green growth will soon provide more possibilities for local authorities, not only for the strategic steering of energy transition, but also for its integration into the territorial project. As regional or local solutions emerge, intricate stakes and scales of action appear, which refer to very concrete issues such as the consideration of the logics of territorial solidarity, the balancing of networks and securing supply on regional and national scales, or even of tariff equalization through national regulations to ensure the economic viability of certain projects.

For territories, this means developing an energy strategy which meets local stakes, and which gets the most out of the particularities, resources and synergies which exist locally. This integrated territorial approach makes it possible to generate mutualisations, to enter into a logic of partnership, based on trust, and to co-build actual territorial energy development projects. Projects which tend increasingly to integrate all local actors, including citizens. The implication of citizens in energy transition projects is a further guarantee of the local control of orientations and projects, and also of their appropriation and social acceptability.

With energy transition, a whole new field in terms of value creation and innovation is opening, which specifically means experimenting new solutions, with positive effects on local development - effects which must be optimized by creating virtuous economic loops so that the value created continues to circulate on the territory (by reinjecting profits into thermal rehabilitation, etc.) and that it causes a spillover effect on the local fabric.

At GrDF, we are convinced that energy transition must be done through the territories. We accompany them in their projects, especially those in connection with the production of biomethane, which is a solution at the crossroads of territorial stakes where waste, energy, climate and agriculture are concerned. These projects belong to a circular economy logic, which encourages territorial synergies and creates activities and jobs which cannot be delocalized. To adopt systemic approaches is an opportunity to remove barriers, to favour collective and transverse logics which are indispensable for the development of a true energy and ecological transition.

FEEDBACK

Methanisation of organic waste: an energy mix for the community

> GrDF and Sydeme

Sydeme, a mixed transport and household waste processing association in East Moselle, in Forbach, has been managing the sorting and reclamation of household waste on the scale of 14 intermunicipal organizations for the last 10 years. It currently recovers biomass, packaging, glass, wood, green waste, biomedical waste, WEEE* and textile waste in adapted fields.

Methanisation was chosen for the reclamation of the organic waste from 298 municipalities in the surrounding area which numbers 385 000 inhabitants. The proximity of exemplary solutions in Switzerland and Germany, visits of the sites organized for the public, an awareness raising campaign, and reflexions on how to reduce to zero pollution for the local residents, made it possible to convince the elected representatives and inhabitants of the municipalities of the interest of methanisation.

Thanks to Méthavalor, its methanization unit, Sydeme reclaims 45 000 tonnes of biowaste from biogas per year in an optimized manner, and produces electricity, heat and biomethane injected into the network operated by GrDF. By increasing the decentralized production of renewable energy, the use of fossil fuels is limited; particularly as Sydeme supplies in biomethane fuel, with the 1st BioGNV station open to the public, the fleet of its 40 heavy goods vehicles and light goods vehicles, and also the « Forbus » buses of the transport authority of the Forbach Porte de France conglomeration, corporate or private vehicles. The digestates (residue from the methanisation of biowaste) are also recovered as natural fertilizer for local farming land.

Contacts:

- Serge WINKELMULLER – General Manager of Sydeme
  serge.winkelmuller@sydeme.fr
- Frédérique LE MONNIER – Delegate for Sustainable Development, GrDF, Strategy & Territorial Management
  frederique.le-monnier@grdf.fr

Towards a local reorganisation of the power supply

In its 2014 report, the IPCC (Intergovernmental Panel on Climate Change) highlights the combination of three solutions: reduction of the end consumption of energy and the power demand, decarbonisation of the electricity supply, and rebalancing the carbon cycle by enabling its storage in the ground and the biomass. In the regions, this means rethinking the organisation of the energy production and supply system by using local resources. In circular economy, two types of initiatives stand out: the reclamation of organic waste and unavoidable energy*.

Methanisation*, as a solution for **reclaiming domestic and industrial organic waste**, or farming waste and livestock manure, enables the production of heat, electricity or fuel as shown in the Sydeme example (see insert opposite). It avoids methane releases during the storage of effluents and makes it possible to return elements to the soil, particularly carbon-containing elements, by spreading the digestate which enables the storage of carbon in the biomass and the soil.

Used frying oil, which is high calorific waste, can also be reclaimed. The Roule Ma Frite 17 association based on the Île-d'Oléron, collects and reclaims used frying oil from the island's restaurants as fuel and heating (more information in the WASTE / RESOURCES section – example: Roule Ma Frite 17). Some industrialists also reuse used oils in industrial processes. AT France in Troyes (cured meat specialities manufacturer), reclaims its high NCV (Net Calorific Value) fat in order to produce the heat needed to cook its agrifood products, and the excess makes it possible to supply a laundry with heat.

Circular economy also helps to **limit energy losses** and find other resources by recovering the unavoidable energy from industrial processes or flows (green waste, water, steam, etc.) of the local authority. The port of Terneuzen (Netherlands) supplies companies with electricity through a biomass power plant and also enables the supply of heat and CO_2 from a company to an agricultural greenhouse. In the region of Dunkirk, DK6 processes Arcelor's blast furnace gases and returns electricity to the firm by means of a combined cycle power plant. The energy yield of these blast furnace gases is around 50%. This synergy makes it possible to supply Dunkirk's heating network*. It is also possible to use the calories and frigories from waste water as in the quarter of Roquebrune-Cap-Martin thanks to EDF installations (see insert hereafter).

Other initiatives show **optimisation solutions** such as the mutualisation of energy supply and purchase. The Pôle Synéo shows us a practical case (see insert below).

Lastly, the use of surface water for the requirements in calories or frigories is also a good way of reclaiming a resource through the production of renewable energy. This is the case for the lake of Geneva which is used to air-condition or heat several professional and institutional buildings. There are cases in France such as the cold network of Climespace which uses the Seine's water in Paris to cool refrigeration machines all year round.

FEEDBACK

Recovering the high calorific value of waste water: a new energy for heat networks

> EDF Optimal Solutions

For the « Cap Azur » Eco-quarter in Roquebrune-Cap- Martin, EDF Optimal Solutions designed and developed an innovative and ecological energy solution: 100% of the quarter's requirements in heating, domestic hot water and cooling are covered using the energy reclaimed from the STP* located 500m away.

Firstly, calories from the effluents of the sewage treatment plant are collected to supply a warm water loop. This water is next heated using electric heat pumps installed in the basements of each building.

This novel process makes it possible to ensure a production of low carbon heat, made up of 70% renewable energy. Thanks to the low energy requirements of low-energy buildings and an efficient renewable energy solution, the energy bill for the 7 buildings in the eco-quarter is reduced and controlled in the long-term, with around 85% less CO_2 emissions in comparison with a basic solution.

Contact:

- Alain TORDO – Energy Chargé d'Affaires
  alain.tordo@edfoptimalsolutions.fr

More information:

- www.edfoptimalsolutions.fr

FEEDBACK

Mutualisation of energy supply: motivating economies for competitiveness and energy efficiency of enterprises

> Pôle Synéo

Pôle Synéo is an association of enterprises set up in Valenciennes in 2007, for the implementation of Circular Economy and Industrial and Territorial Ecology.
In the framework of Energy transition and the Third Industrial Revolution of the Nord-Pas de Calais Region, Synéo has been implementing an Energy Performance action for enterprises since 2013, and the creation of a new economic model. Based on the 3 pillars of energy performance (reduction of purchasing costs, reduction of consumption and improving user behaviour), the action is based on the mutualisation of energy supply (gas, electricity) for, initially, companies on the first Industrial Estate of the Valenciennois. The principle is simple: part (ideally 50%) of the savings made by the mutualisation of purchases can be used to implement actions focusing on energy efficiency: metering and monitoring of use, energy coaching, implementation of tools and the means to make it possible to reduce consumption volumes, etc. In order to do this, the companies on the territory are currently taking part in the creation of a Société Coopérative d'Intérêt Collectif (SCIC).
In order to bring together the different partners on the territory, a public/private partnership could be set up; the legal form of a SCIC enabling public funding to 20% of the capital. The method of governance, democratic, would also make it possible to involve all the recipients of dividends in this structuring project, to meet the regional energy stakes.

Contact:

- Wesley JANSSEN – Industrial Ecology Chargé de mission
  wesley@polesyneo.eu

More information:

- www.polesyneo.eu

The development of these local energy channels will only be able to evolve if it is encouraged through territorial planning tools and the harmonization of energy policies, for waste management and town and country planning specifically (further information in the TOWN AND COUNTRY PLANNING section). In addition to reducing GHG emissions, these solutions meet the challenge of making regions energy self-sufficient and show multiple benefits: the reduction of air pollution, the creation of local jobs, improved energy safety and a reduction of fuel poverty (IPCC, 2014). Cooperation with economic and public actors thus enables the forming of a new energy-efficient ecosystem which offers considerable possibilities for efficient resource management. But, even though these solutions promise to lower the contributions of greenhouse effect energy production, we must be wary of possible rebound effects*. The reduction of energy costs can encourage increased use and production, and does not therefore reduce the emissions in absolute value. It is imperative to give thought to both our behaviour and our consumption!

Deadwood recycling, the result of a staged cooperation

There is no such thing as waste in Nature, everything is a resource. It is the case of deadwood which is made up largely of lignin which lends it rigidity and which is a priori somewhat indigestible. In European forests, thanks to the cooperation of over 10 000 species of micro-organisms, mushrooms, plants, insects and arthropods, the mineral salts and nutriments are reincorporated into the humus of the soil where they will be collected by tree roots. This biodiversity is organised into a succession of specialized communities according to the stages of decay. This cooperation makes it possible to reintroduce deadwood materials into production cycles! (according to CSPNB, 2012).

Waste / resources

Optimising the use of materials by giving a second life to waste

Depletion of resources through over-consumption

GHG emissions from raw material supply to end-of-life of products

Circular economy & **waste/ resources**

Reducing waste at source by rethinking designs and uses:
- product-service system,
- eco-design, etc.

Expending product lifespan:
- reuse,
- reutilisation,
- repair, etc.

Sorting and recycling to reclaim co-products and by-products

Limiting incineration and dumping and reclaiming energy from this treatment

A hyper-materialised resource-depleting economy

Current resource-depleting consumption modes are resulting in particularly serious economic impacts (increase in the price of raw materials) in a context of growing demography and the desire of all to improve lifestyle. During the 20th century, worldwide extraction of building materials was multiplied by 34, minerals for industry by 27, fossil resources by 12 and biomass by 4 (UNEP, 2011)! The depletion of these natural resources results in the deterioration of the ecosystemic services that we draw from nature such as food, clothing, housing, moving around and entertainment. The risks of depletion are real – at a global level for metals, but more locally for building materials (sand, stone, clays, etc.) given the difficulty of transporting them – disturbing the life cycles of resources also engenders other environmental impacts linked to the change in land-use, extraction techniques, emissions of pollution, GHG and waste due to our activities.

This heavy use of materials leads necessarily to an increased production of waste. With 590 kg of residual waste produced per year and per inhabitant, France releases twice the waste it released 40 years ago (ADEME, 2014). Economic activities are also heavy contributors with 90% of national waste from the building and public works sector. Linked to the evolution of our modes of consumption and production, the management of waste represents a real challenge for the territories as much for the depletion of resources as for the reduction of GHG emissions.

Waste management: a challenge which is also one of climate change

Waste treatment-related GHG emissions doubled at global level between 1970 and 2010 (IPCC, 2014) mainly due to the related dumping and methane emissions. Even if they only strictly represent between 1 and 8% of emissions in developed countries (4% in France), we must add the important contribution which stems from their collection and transport (especially by truck) and also at all the stages of manufacture of products before they become waste (extraction, transport, processing, packaging, distribution). The quantities and types of gases emitted depend on the modes of processing. Their incineration (44% of waste in France in 2010) essentially releases CO_2, and half of this is due to the combustion of fossil-origin products (plastics, etc.). Buried organic waste releases CH_4 *, during decay, and this has a heating power 25 times higher than that of CO_2. N_20 is produced mainly when it is composted and spread, and also during combustion. The quantities are minimal, but the impacts are nonetheless important as this gas has a heating power 298 times that of CO_2!

The management of our waste and more broadly speaking our resources, influence climate change, and it is also a challenge in terms of vulnerability. With storms and floods becoming more frequent, our storage and processing facilities must be better protected in order to avoid local pollution of soils and water.

EXPERT'S WORD

Changing ideas about waste

> **Sophie-Noëlle NEMO**, Director of the Energy Transition Delegation, Groupe La Poste

The total volume of material resources (minerals, wood, metals, fossil fuels and biomass, building materials) extracted or collected all over the world multiplied by 8 during the last century. And faced with a surging global demand, we continue to collect them dangerously, even if we are aware that the resources are not infinite and are actually depleting. We cannot avoid the fact that we are exhausting our planet.

The global economic crisis is a lasting one. Our planet is on its last legs with global warming and a level of unemployment which is excluding more and more people from the labour market. Faced with such challenges, we have to invent new socio-economic development models. Among the avenues that are emerging is so-called circular economy, which could also be called « resource economy », which encourages the recycling of already used raw materials, short circuits between production and consumption and use over possession. It proposes a new pattern without encroaching on the growth of consumption by gaining inspiration from natural ecosystems where waste is recycled.

The advent of a recycling and reuse society is answer to the urgency of the environmental challenge. But it is also a real lever for economic performance. The increasing scarcity of natural resources raises the price of those resources and thus creates a new market, that of the second, third or even fourth life for resources and objects. A dynamic, creating value, jobs and innovation for the territories. A market which leaves room for a collaborative, social and solidarity economy whose organisations for integration through economic activity see, in the creation of recycling and reclamation activities, opportunities to offer a new chance to those who are excluded from the workforce. An economy which also steers away from the traditional financing patterns with, for example, participative financing which was born thanks to the Internet and the social media. This emerging of new modes of consumption, production and financing go hand in hand with the emerging of a new way of thinking by consumers and industrialists of waste: it becomes a resource, a recyclate. Circular economy is a robust economic development model which not only creates jobs but also generates purchasing power by helping to lower useless costs. A great number of actors believe in it, one of them being the Groupe La Poste which currently has all the cards in hand to act as a leader in this both responsible and virtuous model. Circular economy is an economy with a future, a sustainable and positive economy.

Towards a new management of the end of life of materials

The dematerialisation solutions of our economy are multiple but must be mobilised in a prioritized fashion to achieve maximal environmental efficiency. The 2014 IPCC report focuses on the prioritisation of waste management and reduction approaches, also recommended in the French transposition of the November 2008 EU Framework Directive: prevention and reduction at source – reuse, reemployment and repair – recycling for a material and energy reclamation and, as a last resort, dumping and elimination.

If a preliminary global reflexion on our consumption is necessary, product-service systems and eco-design are solutions for **reducing waste at source**.
Product-service systems propose to limit the production of goods by rethinking the use of products and associated services: optimising the use of materials, reflecting on the usefulness of our purchases. In addition to reducing waste, these solutions make it possible to lower the GHG emissions linked to the different stages of the life cycle of products. Besides the well-known offers of shared vehicles (Vélib' and Autolib' in Paris for example), and even the renting of photocopiers (Xerox) and tyres (Michelin), the economic models linked to the sale of products and services can be transformed even further and in depth. In these examples, the advantage is that the manufacturer remains the owner, agrees to ensure maintenance, and therefore reduces the turn-over of products, increasing performance for the user at the same time. Lyreco has gone even further by going from the sale of office supplies to a solution which is oriented towards the management and reduction of the consumption of supplies. In a solution co-built with the supplier, the client is encouraged to reduce his needs. And lastly, according to their activity, the company can also rethink their offer directly in connection with the territory in which it is implanted and for which it meets a specific need.
To match these practices, the products must be designed to guarantee a maximum life span. Eco-design challenges the whole life cycle of the product, and must be mobilised. Its application makes it possible to integrate recycled materials, to lower the quantities of materials used for manufacture (and therefore those to process at end-of-life), to optimise energy consumption, reduce packaging, etc.

FEEDBACK

A challenge for recycling light packaging: experimenting new sorting techniques for aluminium

> Nespresso and Eco-Emballages

Only 35% of aluminium packaging is recycled in France. This low rate can be explained by the fact that this packaging is often too small. Aluminium jar lids, sheets, food trays, cans, and capsules are actually ejected from selective sorting due to a lack of adapted equipment. This is really ridiculous for a material which can be recycled almost infinitely, and whose recycling enables a saving of 95% of energy versus primary aluminium.

Nespresso is working on better collection and recycling of aluminium capsules, and also, at the same time, on the deployment of its own circuit of collection and treatment. Nespresso is aiming at its used capsules being integrated into classic sorting system for packaging to make the job of sorting easier for consumers.

After 4 years of experimenting technical solutions, Nespresso, supported by Eco-Emballages and other actors in the sector grouped in the Club des Petits Emballages en Aluminium et Acier (CELAA), has demonstrated the economic and environmental interest of sorting small aluminium objects and more widely small steel objects. The innovation consists of adapting the sorting techniques to small packaging using an electromagnetic induction field, a process which has up until now been reserved for larger aluminium packaging.

Since 2014, this device which is known as « PROJET METAL » is offered to all the local authorities under the terms of an agreement signed with Eco-Emballages, CELAA and the Association des maires de France. Nespresso provides additional funding with the Nespresso Fund.

Result: a recycling loop for small metal packaging is emerging in France. 3 million people living in 500 municipalities of the Hauts-de-Seine, Essonne, the Var, the Alpes-Maritimes and the Lot, can now throw their small aluminium and steel packaging into their recycling bins.

Contacts:

- Katarzyna RENIE – In charge of Sustainable Development, Nespresso France
  katarzyna.Renie@nespresso.com – 01 72 06 21 59
- Aurélie MARTZEL – Director of Awareness Communication, Eco-Emballages
  aurelie.martzel@ecoemballages.fr

FEEDBACK

Collection of dispersed deposits: using the postman's rounds for reuse and recycling

> La Poste

La Poste's RECY'GO service was launched in 2012 to enable the collection of dispersed deposits of office paper from SMEs* and local authorities and to ensure their recycling in France. Currently only 40% of office paper is actually recycled. The rest is burned or dumped, mostly because of the complex nature of the collection of small flows from SMEs. After two years, 29 000 tonnes of paper have been collected and the offer has around 3 000 clients. 100% of the paper collected is recycled in France.

The environmental impact of collection is minimized as postmen use the collection or distribution of mail to companies to collect used office paper without emitting the extra CO_2 linked to transport. The service also has social advantages thanks to the partnership with the organisations of SSE, among them subsidiary of La Poste Nouvelle Attitude and l'Esat Les Genêts d'Or.

Today, La Poste is expanding the perimeter of the recyclates collected. Last March it launched an experiment on the collection of cardboard packaging for the clients of RECY'GO and of used telephones by La Poste Mobile. The company also associated with Nespresso to test a collection service for used capsules from companies in Paris. The postmen collect the capsules which are then sent to a processing centre which separates the coffee grounds (agricultural reclamation, compost, etc.) and the aluminium which is to be remelted. This action completes Nespresso's experiments in improving the sorting and recycling of light aluminium packaging (see insert forgoing).

With RECY'GO, La Poste wishes to accelerate circular economy loops by structuring an efficient and solidarity collection network of dispersed deposits in order to improve the rate or reemployment or recycling.

Contact:

- Sophie-Noëlle NEMO – Director of the Energy Transition Delegation
  sophie-noelle.nemo@laposte.fr

The **lengthening of products' lifespans** can also result in reuse, reemployment and repair (removable parts, less composite materials, etc.). These practices (the "3R") avoid the emissions linked to the elimination and production of new products. Eco-design will make it possible to develop at source the means to be implemented (exchangeable parts, repairable products, etc.).

Sorting and recycling solutions avoid using new raw materials but have certain limits. According to the materials, the loss of technical properties can be high, and recycling is not always possible (for example: the problem of composite plastics) and processing can be very energy intensive. So here we must again think of the materials used upstream of the design process. Collection, sorting and the collection of dispersed deposits of materials in their totality is not yet evident, above all for domestic waste and that of small enterprises. This is therefore an obstacle that Nespresso and Eco-Emballages and even La Poste are attempting to overcome with projects to improve the recycling of dispersed deposits (see inserts foregoing and opposite).

A number of initiatives on the territories show all the same that recycling of materials is relevant both for the coproducts from manufacturing processes and for the goods at end of life.
The enterprises on a territory can create synergies which enable recycling by reintegrating the waste from other industrial processes into their own production chains. The companies club of the Périgny industrial park ensures multiple synergies: recycling of PVC by an enterprise in the park, dismantling of WEEE* by a social rehabilitation enterprise in a neighbouring department.
Organic waste is a special dispersed deposit as it has a high recycling potential and is the object of a number of synergies. Upstream of production, agricultural and agrifood, and even forest products and coproducts, make up large dispersed deposits for biomaterials or the integration of other industrial processes (further information in the AGRICULTURE section). Downstream, the restaurants of Paris can for example set up solutions for the sorting, collection and recycling of their biowaste as offered by Moulinot Compost & Biogaz in Paris. The organic materials are valorised locally for the production of fuel as demonstrated by the association Roule Ma Frite 17 (see insert below), or more generally of energy through methanisation – a solution that Séché Environment is developing for the maintaining of traditional local agriculture (further information in the AGRICULTURE section – example: Séché Environnement).

In order to **limit incineration and dumping**, the aforementioned solutions must be used as much as possible so as not to waste the materials and energy contained in the products during their life cycle (grey energy). Incineration often necessitates the use of fossil fuel due to the low calorific value of some waste (specifically biowaste) (CNIID, 2009). If it is implemented, it is important to reclaim the heat in order to compensate in part the emissions thus generated, as well as the grey energy* wasted in the destroyed products.
Dumping was still the outlet for most of the waste in the DOM-TOM a few years ago. Even though they have been removed for a long time from these issues, these insular territories, which have also known high demographic growth, must now meet important pollution stakes. On Mayotte for example, selective sorting entered households in 2014 and Eco-Emballages, in partnership with local authorities, set up 78 voluntary disposal drop-off points for metals, plastics and glass. It is encouraging to note that the population has mobilized in this issue and this has enabled, from the first year, the collection of 243 tonnes of domestic packaging and the creation of 5 jobs. For the time being, the packaging collected is recycled mostly in Asia and South Africa, but the aim is to create a recycling channel in the long run.

On a local scale, it is therefore the logistics which must be optimised: sorting centres, waste management facilities, methanisers, reclamation platforms, etc., in order to create a really efficient network for the optimisation of the use of resources and to promote local reclamation of waste to meet territories' needs. Sydeme in Moselle optimises collection and sorting (for example through optical sorting) to reclaim the department's organic waste (further information in the ENERGY section – example: GrDF). Recycling processes often necessitate the centralisation of sources retrieved from all over the country, and even further abroad, in order to reach the required quantities. Even if reverse logistics make it possible to optimize the organisation of these channels – a concept that Renault is developing for the recycling of ELV* (further information in the TRANSPORT section – example: Renault) –, the distances travelled by the materials are still considerable. And once again, the prevention of the production of waste by giving more though to our consumption, the use of products, their lifespan, etc., still remains the field in which the most is progress to be made.

FEEDBACK

Collecting used oil: the premises of a recovery channel for polluting waste

> Roule Ma Frite 17

The "Roule Ma Frite 17" association collects used frying oil in a short circuit as fuel, and demonstrates that the development of an economic channel can have a proven social impact. The aim is to encourage social mobility: the first results have made it possible to run the little train on the Ile d'Oléron.
To be collectable, fried oil must not contain palm oil, which, besides the deforestation problems it causes, cannot be reused. Using a utility vehicle running on the recycled oil, RMF17 does around 135 rotations a year, from approximately 150 professional members (restaurants, camp sites and some local authorities). In 2014, it collected around 40 000 litres of oil, which allowed several tens of Oléron families to move around or heat their homes economically and ecologically… This technique also makes it possible to avoid illegal discharges of oil into water pipes along with the cost and pollution that they engender.
Currently, this activity is ensured in several regions by associations with the same circular economy philosophy. It is for this reason that RMF17 and their partners are currently structuring themselves into a federation. This new organisation will work on having frying oil recognized as a fuel. Moreover, the association is considering new outlets linked by a common denominator – the replacement of an oil-based product by plant waste. And it may launch into the recovery of other materials: the methanisation of organic waste; the recycling of mussel shells as an additive in plastic.

Contact:

- Myriam DUPUIS – Secretariat coordinator
  secretariat.rmf17@gmail.com – 07 52 64 62 72

More information:

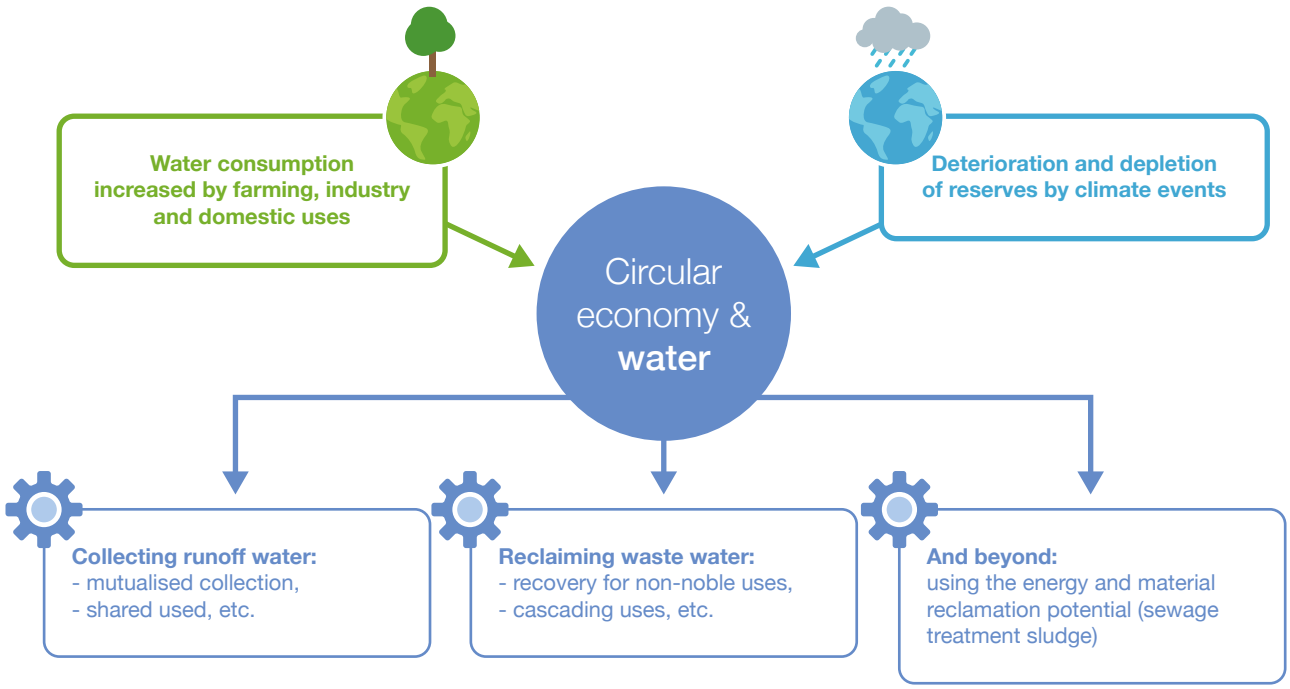
- www.roulemafrite17.org

Finding water where there is none and preserving it

Water is a vital resource. In desert environments, living beings cannot afford to waste it. In the Namib desert, for example, a beetle, the Head stander beetle (Onymacris unguicularis) takes up position at the top of the crests formed by the dunes, head down with its back to the wind, presenting its abdomen to the air. Mist condenses on the bumps of its carapace in fine droplets which then trickle down grooves to its mouth. The hard and convex integument of its carapace also protects the beetle from dehydration. Under its sealed elytra, an air bubble even allows it to avoid water loss through breathing. The whole thing is to find and use water in a reasonable way in order not to waste it! (according to CNPSB, 2007).

Water

Optimising the use of the resource and limiting losses



Water: a vital resource

Water, which is a common good, is an excellent example of a resource which is absolutely necessary to life and for which there is no substitute. Above all, the health of ecosystems and humans depend on it. But our sectors of activity rely heavily on this resource. If globally 10% of water consumption is linked to domestic use, 20% are due to industrial use and 70% to agriculture (Green Cross, 2015)! The preservation of water resources must therefore make it possible to cover the needs in water of crops (and livestock) and the growing demand for irrigation, and at the same time support the energy and industrial sectors (hydroelectric and cooling systems, etc.). We also need to think of the sectors of tourism, fishing, and even river transport which also depend on the availability of water resources, the configuration of waterways, etc. Moreover the quality of water is threatened. We observe that in France, only 45% of the masses of surface water are considered to be in good ecological and chemical condition (MEDDE, 2014).

Preserving water: the first challenge of climate change

The climate machine and the water cycle are strongly linked. We know that the rise in temperature affects the intensity and frequency of rainfall, the water content of the soil and vegetation, runoff, river flows, ice melt, etc. (IPCC, 2014). It is therefore through water that the impacts of climate change are mainly being felt. This challenge of preserving water resources in the face of increasing water stress is all the more important in a context where urban demography is on the increase. The problems are different according to the regions in the world or within a country. The rise in temperature naturally leads to a reduction of the quantity of water available in rivers, streams and groundwater. A lower flow triggers a deterioration of water quality. In contrast to this, heavy rainfall can carry sediments and pollutants and damage processing structures. In dry areas particularly, climate change added to unsuited human activities is the cause of the land desertification with retroactive phenomena (less vegetation = more GHG emitted). It is therefore a challenge for food safety and the fight against poverty. The increased risks, linked to droughts and flooding, are responsible for the population displacement and political instability observed in these regions. Generally speaking, the increased demand for water for domestic use, industry and irrigation will increasingly have to face the limits of this resource!

EXPERT'S WORD

Circular economy of water resources:
An innovation priority for adapting to the consequences of climate change

> **Hélène VALADE**, Vice President Sustainable Development, SUEZ

Water is one of the first resources to be directly threatened by climate change: the rise in average temperatures and the modification of rainfall patterns have already had and will have increasing consequences on the quality of water resources, and even more on the quantity of water available: according to the UN, 47% of the world population could be living in water-stressed areas by 2030. And the conflicts of use between drinking water, industrial water and agricultural water may multiply in such a context, particularly in emerging countries.

This is an emergency, but solutions exist for adapting to it, and for reducing the impact of global warming on water resources. Circular economy is one of these solutions as it can increase the quantity of water available, by recycling it. In the same way, reusing treated wastewater also meets economic and ecological objectives: upstream, it enables the saving of water by supplying an alternative resource, while at the other end of the chain, it lessens the volume of wastewater releases into the environment. For example, the West Basin wastewater treatment and recycling plant operated by SUEZ in California produces 240 000 cubic metres of treated wastewater per day – the equivalent of the consumption of over one million inhabitants. Moreover, it produces several different qualities of water, to meet the specific requirements of municipal and industrial clients: irrigation, public watering, cooling water and process water for petrochemical plants, water for other industrial uses, water reinjected into the water table to serve as a « hydraulic barrier » against the intrusion of saltwater linked to the overexploitation of the water table in the past. Desalination solutions also belong to circular economy, as they make it possible to make short loops on coastal areas, between the continent and the ocean. SUEZ operates the biggest desalination plant in the Southern hemisphere in Melbourne, which supplies its inhabitants with drinking water whatever are the weather conditions.

One of the main challenges of adapting to climate change consists in managing the compromises between adaptation and mitigation of the impacts of climate change. The increase in the volume of recycled water in industrial processes, the increase in the intensity and frequency of wastewater treatment and even the desalination of seawater require more energy, leading to an increase in the greenhouse gas emissions linked to electricity consumption. That is why the Group is developing innovative technologies to reconcile adaptation and mitigation, by improving the energy efficiency of its processes, but above all, by using local renewable energy sources capable of reducing the carbon footprint of adaptation solutions.

FEEDBACK

Recycled waste water for industry: drinking water reserved for the population

> Veolia

South Africa, and particularly the town of Durban, has limited water resources. The main challenge is to manage the use of drinking water and keep it as a priority for the population. The solution offered by Veolia was developed in 2001 in the framework of the first Public-Private Partnership (PPP) signed in this country: the Durban Water Recycling plant, built, financed and operated by Veolia, supplies the town's industries with recycled water whose properties are sufficient to ensure the running of manufacturing processes. 98% of Durban's waste water are recycled.

For industrialists, the supply of water for different requirements (process water, cooling water, washing water, etc.) can amount to a heavy budget. In Durban, the project guarantees them a volume of water of constant quality, resold at 60% of the price of drinking water, which is an annual saving of 5 million euros.
Recycling waste water enables the municipality to avoid drawing on local resources to satisfy the needs of industrialists. An extra 40 000 cubic metres of drinking water are thus offered every day (14.6 million/year), the equivalent of 15 Olympic swimming pools. A result to which can be added, firstly the benefits of an innovative economic model in which Veolia shares part of its profits with the town to favour access to water, and secondly a commitment to diversity, local employment and training.

Contact:
- Hélène LEBEDEFF – Deputy Director for sustainable development
  helene.lebedeff@veolia.com

Towards a local optimisation of water consumption

To preserve this freshwater capital, its use needs to be rethought by reducing its consumption, by avoiding wastage and optimising its use locally. The stakes of preserving the quality of the water and the correct state of natural environments (which use it and purify it) are to be found mainly at the level of drainage, of the treatment of sewer sludge, of collecting rainwater and agricultural water.

The circular economy model applies to the **local reclamation of waste water** to reduce extraction while maintaining its uses at the same time. We can then imagine building sequences where a volume of water ensures successive functions according to the deterioration of its quality. This entails reclaiming grey water, i.e. water already used for domestic, industrial or agricultural uses, and reusing it, after treatment if necessary, in industrial processes or for irrigation, according to quality requirements.
There are a large number of initiatives among them the approach led at Lagny-sur-Marne by YPREMA and SIETREM (Syndicat intercommunal de traitement des ordures ménagères – Intermunicipal domestic waste treatment), which illustrates a solution for the appropriation of water uses. SIETREM produces clinker* from the incineration of domestic waste which are taken by inland waterway to a recovery plant. The industrial water from this recovery is then used to cool the same incinerator

Other practical cases answer the problem of the scarcity of water such as the eco-industrial park of Kalundborg (in Denmark), with the use of cascading water* systems. The same water can be used by several users such as hot water (steam), cooling water, rinsing water, etc, and can thus enable several loops from a same resource. A symbiosis which enables a water saving of around 3 million cubic metres a year. It is nevertheless important to note that this cascading use can engender problems of pollutants concentration. It is therefore necessary to think upstream about the prevention of pollution and the eco-design of processes and products (uses) which use water.
The agro-industrial complex of Les Sohettes in Pomacle-Bazancourt also offers a practical case of reuse. By reclaiming excess condensates of hot sugar as steam, an agrifood industry saves around 50 000 cubic metres of water a year and thus limits extraction from the water table. Local authorities are not behind in this either as, for example, the town of Durban in South Africa supplies the town's industries with recycled water (see insert on left) and the town of Yerres (91) cleans its streets and waters its flowerbeds with recycled water from the municipal swimming pool's showers. This represents a saving of 7 000 cubic metres of drinking water and 28 000 euros a year.

Recycling waste water must also make it possible to meet the different uses according to the needs, and this is the ambition of the waste water treatment and recycling plant managed by Suez in West Basin (California) (see insert on right).

FEEDBACK

"Tailored" wastewater recycling: limiting water withdrawals

> SUEZ

For over twenty years, droughts have been worsening in frequency and intensity under the effects of climate change in southern California, resulting in excessive groundwater withdrawals and a recrudescence of saltwater intrusion in groundwater tables. In order to reduce this water stress, SUEZ offers "tailored" wastewater recycling solutions to its customers in the Los Angeles region. The Edward C. Little Recycling Facility wastewater treatment and recycling plant produces 240 000 cubic metres of water per day, the equivalent of the consumption of over one million inhabitants. It supplies with water the municipal district of West Basin – 6th largest district in California – as well as industrial clients and a number of farmers for irrigation purposes. Its speciality consists of producing several different water qualities, meeting in this way clients' specific requirements: irrigation, public watering, cooling water and process water for petrochemical plants, water for other industrial uses, water reinjected into the water table to form a hydraulic barrier against the intrusion of saltwater linked to the overexploitation of the water table in the past. The West Basin facility contributes to reducing the dependency of the Los Angeles region on conventional resources and imported water, despite a growing demand. It supplies a reliable water in quantity and quality to its different customers, contributing at the same time to the protection of costal water by limiting the releases of wastewater into the Santa Monica Bay. The facility is also efficient from an energy consumption point of view: it enables to reduce by 105 megawatt hours per day the consumption of energy used to produce irrigation water.

Contact:

- Sébastien PELLION – Sustainable Development Department, Projects Manager
  sebastien.pellion@suez-env.com – 01 58 81 55 51

FEEDBACK

Mutualised management of rainwater: an alternative resource to drinking water for industrial uses

> The Communauté d'Agglomération du Grand Guéret

Since 2007, la Communauté d'Agglomération du Grand Guéret has been certified for the design, planning, management and marketing activities of its business parks. It has committed to a novel industrial ecology approach in France and in Europe which consists of the permission to capture, store and treat rainwater (in the public domain and on private parcels). The Communauté d'Agglomération has signed waste water agreement with industrialists, taking responsibility for water polluted by hydrocarbons. It has set up a tailings pond for the water collected from roads, completed by a sludge separator and a shut-off valve in the case of incidents. This system is equipped with a storage capacity of 6 000 cubic metres. Currently, an automatic industrial water supply unit (always for non-noble uses, public works, pumpers and parks and garden maintenance companies) is being installed.

For the time being, there is only one enterprise connected to the water service. The real challenge for Grand Guéret is therefore to extend its service to more industrial enterprises (there are about ten on the park), to render the investment cost effective. The system is competitive compared with the conventional water system. Industrialists pays around 1 euro per cubic metre of water, which is about a third of the normal price. They also pay a subscription of 180 euros for the maintenance of the shut-off valve unit.

Contact:

- Arnaud BERNARDIE – In charge of economic affairs
  arnaud.bernardie@agglo-grangueret.fr

The **collection and treatment of water run-off** from roads, roofing and other impermeable surfaces makes it possible to reduce the consumption of raw water, and also to minimize the pollution of water tables where this water loaded with pollutants ends up (if the site is not obliged to treat it). To rise to this challenge, the Communauté d'Agglomération du Grand Guéret has set up a collective tailings pond (see insert opposite).

The **recovery of waste water** represents a considerable potential which is increasingly exploited, to reclaim the materials, calories (more information in the ENERGY section – example: EDF) and even frigories contained in the water.

Local authorities have the responsibility of detecting leaks and the maintenance of the drinking water and sanitation, and they can also support the local strategy of optimisation of the resource. By mobilising a systemic approach, they can understand better how the water cycle works on their territory. By identifying volume exchanges between the underground reservoirs, surface water and soiled water, it is possible to imagine a new organisation of way water circulates through natural environments, its domestic uses and economic activities.

Pollination and seed dispersion or ways plants have found to meet up and move around

For an immobile plant, finding a partner with which to reproduce is possible thanks to the cooperation of pollinating insects and birds foraging for food. Plants and animals have evolved side by side and enabled the surge of a rich plant and animal biodiversity. The nectar contained in the flowers is a source of food for some insects and birds who detect it thanks to its smell and the colour of the flowers. When the bee comes looking for nectar, its back is then covered with pollen. Plant dispersal also benefits from animal behaviour. Animals disperse the seeds which stick to their fur or are rejected after the fruit has been eaten. Energy for moving around is therefore used with double efficiency! (according to CNPSB, 2012).

Transport

Optimising the use of different modes of transport

Heavy consumption of fossil energy resources linked to the increase in distances

Highest carbon-emitting sector in France

Circular economy & **transport**

Reducing travelled distances:
- reverse logistics,
- optimisation of logistical places, etc.

Prefering clean transport (river, rail, etc.) and clean fuels (NGV, BioNGV, etc.)

Mutualising transport (people/goods):
- shared fleets,
- Inter-company Travel Scheme

Mutualisation of logistical functions

The second largest consumer of fossil fuels in France

Current modes of transport (automobile, truck, plane, etc.) have changed our lifestyle (long trips from home to work, holidays in distant places, etc.) by encouraging urban spread and a global organisation of logistics which draws on ever increasing externalities: decreasing reserves of fossil fuels, local pollution, sound pollution, etc.

The transport sector is the second largest source of energy consumption in France with around 50 million tonnes of oil equivalent consumed every year (twice the amount 30 years ago). With 80% of the total consumption, road transport is the most energy-intensive, well in front of air transport (12.6%), sea and river transport (5%) and rail transport (1.7%) (CGDD, 2013).

Transport is necessary throughout the whole life cycle of the material which places it in pride of place for meeting the challenges of decreasing resource consumption and also reducing environmental impacts.

Road transport: main cause of CO_2 emissions in France

GHG emission stemming from the transport of people or goods has more than doubled since the 70s on an international scale, and represents therefore the highest growth of emissions among energy-intensive sectors (IPCC, 2014).
The transport sector represents in France, with 36% of national emissions (against 14% at global level), the largest producer of GHG (ADEME, 2013). With 95% of emissions of CO_2 over the whole transport sector on French scale (against 72% on a global scale), the road mode (goods and passengers) is the highest contributor to climate change. 94% of the trips are made by road in France, and over half of them by private individuals (ADEME, 2013).
The reduction of energy consumption and the GHG emissions from transport represents a real challenge in a context where demand is increasing both for the displacement of people and for goods

EXPERT'S WORD

Rail transport and Circular economy: paradox and reality

> **Christian DUBOST**, Director of Sustainable Development, SNCF

A first brief analysis could show an apparent contradiction between the different objectives highlighted in this chapter: road and river modes often see their fields of relevance focused on long-distance travel, whereas a major ambition of circular economy is to reduce the distances and favour short circuits as much as possible.

But this contradiction is only apparent because the objectives of reducing distance and using clean transport are not exclusive from each other, far from it. If we think, immediately, especially in 2015, about rail's low GHG emissions, we must also insist on the other advantages of this mode in terms of atmospheric pollution, of low space occupation… And as it is utopian to believe that the globalisation of exchanges will not continue in the future, even if we can imagine a sharp curbing of its rate of increase, the long distance transport market has a bright future!

Because of this, there are real opportunities for rail transport to revive: enterprises, which in the world of logistics are known as freighters, are going to be ever more inclined to use it, as a commitment to sustainable development and as a strategic choice, because of regulatory constraints (for example, the law on Energy transition), or even as a result of pressure from their clients. These opportunities will be strengthened in the case of COP21 being a success; SNCF is one of many enterprises who are militating in favour of a price on carbon, significant and spread progressively to the whole planet.

On long distances, the difference will be made by rail's capacity to cooperate with other modes: with the maritime mode which supposes a strengthening of rail's capacities for processing goods in large French ports and through an extensive work on final haulage legs. Work carried out by SNCF Logistics in Paris with articulation from our railway base in Bercy is progressively bearing fruit with various types of electric vehicles.

But the rail mode can be relevant on short distances. In the Midi-Pyrénées region which I know well, transport of materials is carried out partly by rail, for distances of less than 100 kilometres! A well-oiled organisation of the logistics with dedicated material allows this to work efficiently. Massification and longer trains are another element of solution, and we are ready to work with regions capable of mutualising flows.

Solutions: reducing kilometres and alternatives to “all road transport”!

Faced with an ever-increasing demand for transport, current logistics are no longer able to meet the expectations of the general public in terms of accessibility, mobility and consumption, and limit the social and environmental impacts at the same time. Moreover, improving the efficiency of transport will not be sufficient to meet the major challenges the sector is faced with. In addition to reflexions on the development of clean vehicles, the whole chain must be rethought: particularly via the optimisation of vehicle loading by avoiding unladen return journeys and by reducing the weight and volume of packaging, by optimising the location of logistic nodes, favouring multimodal or combined transport and mutualising needs.

First and foremost, to **reduce the distances to be travelled**, it is essential to place the demand for transport further back upstream. This means generating relationships of proximity by preferring local resources, products and cooperation, and also optimising the loading rates of vehicles. A large amount of feedback for the transport of people, products, materials and even waste, offer efficient and approved solutions!

Regarding optimisation of the filling of trucks, reverse logistics aims at reloading after delivering goods. La Poste, with its RECY’GO system, uses an already existing round to collect reclaimable materials (more information in the WASTE / RESOURCES section – example: La Poste). It is also the case for the Renault site in Choisy le Roi (production of remanufactured engines), which recovers spare parts collected throughout its commercial distribution network of replacement parts through reverse logistics. The group is working on optimising the installation sites and the rounds, both for product supply and waste recovery (see insert opposite).

In addition to this, **clean methods of transport and fuels** must be developed both for people and for goods by encouraging multimodal transport. For goods transport, multimodal solutions have large progress margins with only 5% of the tonnage transported by rail and inland waterway, which actually emit far less CO_2 (Grenelle objective: 25% for 2020). Even if there are a number of solutions each case is unique, this is what for example the feedback of Franprix and Ports de Paris shows. They have switched from road to inland waterway transport for supplying Paris shops, representing a saving of 450 000 km travelled and a 37% reduction in CO_2 emissions.

For barge transfer to become cost-effective, a number of technical arrangements and collaborative work with all the partners have had to be initiated to promote the setting up of the device. Ports de Paris and VNF are working on a daily basis for this transport mode to guarantee the client cost-effectiveness and environmental performance (see inserts hereafter).

FEEDBACK

Optimized organisation of logistics: lever for « short-loop » industrialisation

> Renault

Since 1993, Renault has been working on the introduction of recycled materials (copper, polypropylene, precious metals, aluminium, steel, textiles, etc.) in the manufacture of its vehicles in order to reduce its dependency on the price of raw materials and has positioned itself as a leading actor in the field of recycling. From the stage of reducing certain dangerous substances, to the homologation of new vehicles and its “recycling” demonstration through the Life+ “Icarre 95” project, the group has set up, in association with four partners and a number of industrial actors, short loops for the reuse of parts and materials, of the circular economy type.

Launched by the Direction du Plan Environnement Renault, the idea of exploiting further the incredible source of materials represented by ELV, to manufacture products for new vehicles or other uses, has been materialised through the Valver and Valtex projects. Cooperation with other industrialists with the same preoccupations (SNCF, Mulliez Flory, etc.) makes it possible to massify the sources, to secure the future channel and ensure a flexibility of technical answers and a varied offer of products from recycling.

Besides the development of efficient technical solutions, logistics organisation is an essential lever for economic and ecological cost-effectiveness considering the volumes of material which need to be circulated.

Therefore, in order to reduce these trips and also to define the implantation of processing plants, Renault and its partners have developed a modelling tool which makes it possible to optimise the logistical management of recycled materials. It is possible to identify and reject suppliers of more expensive waste in terms of collection and the suppliers of small deposits far from the processing plants. The haulage of the materials is then organized in two stages: a capillary transport from the some 5 500 sources of dispersed deposits in the country to grouping platforms ; followed by massified transport to the preparation sites for reintegration into new Renault vehicles. This intermediary makes it possible to densify (using a baler technique) the materials and ensure maximum filling of the trucks.

Lastly, Renault is making efforts to make multi-modal work better, filling the trucks more efficiently, reducing the kilometres travelled, working on management (training), designing engines which are better suited to the reduction of CO_2 emissions and encouraging reverse logistics as much as possible, especially for empty packaging.

Contact:

- Toni GALLONE – In charge of the industrial recycling of materials and the deployment of the recycling plan, Renault
  toni.gallone@renault.com

More information:

- www.icarre95-programmelife.com

The feedback from Séché Environnement also illustrates a practical case of modal transfer. For the management of dangerous waste, the firm has found less polluting solutions which are cost-efficient and adapted to territorial constraints (see insert hereafter).

To reduce CO_2 emissions, these solutions must be completed by low carbon clean fuels such as BioGNV* (from methanisation processes) and GNV (more information in the ENERGY section – example: GrDF).

Transport mutualisations are also an answer to logistical stakes. For example, some firms increasingly make shared fleets available. Two structures in l'Aube (AT France and Lincet) have actually managed to reduce their transport-related costs with the joint creation of a mutualised fresh produce logistics platform. Since they have the same clients, this has allowed them to optimize the filling of trucks and therefore to lessen their fuel consumption. Lastly, urban areas are places where the supply stakes are major ones for impact in terms of pollution.
There are a number of examples for travel. In its book "Agir ensemble pour des mobilités urbaines durables" (Acting together for sustainable urban mobility), Comité 21 highlights a number of feedbacks such as the Plan de Déplacement Inter-Enterprises (PDIE, Inter-company travel Scheme) which aim at limiting the uses of the private car and privilege alternative modes (carpooling, public transport, etc.).

There are, therefore, a large number of solutions and their setting up must be facilitated by the cooperation of regional actors to find efficient technical and organisational solutions. The efficiency of their implementation depends first and foremost on a good network grid and a territorial coherence: connexions between rail and inland waterways, a massification of the flows for long distance transport using these modes, dense and mixed urban forms (more information in the URBAN MANAGEMENT and TOWN AND COUNTRY PLANNING sections). The regional, departmental and communal scales must be complementary and ensure the optimisation of existing mobility solutions. The solutions highlighted by circular economy offer direct advantages to the territories: reduction of sound pollution, problems of congestion, accidents, space consumption, water and soil pollution, attractiveness of territories, etc.

Levers for developing inland waterway transport: mutualised logistics solutions (1/2)

> HAROPA Ports de Paris

Inland waterway transport, which is a mode of transport which serves circular economy, is an alternative to road transport. With 2.5 times less CO_2 emitted per ton of goods transported and 5 times less fuel used, this mode of transport is increasingly preferred for general cargo and waste.

Since 2010, Ports de Paris (since 2012 a member of GIE HAROPA*) has been striving to develop circular economy and more specifically industrial territorial ecology as port planner and developer. Using a palette of tools, Ports de Paris continuously aim to massify (an indispensable condition to ensure the economic relevance of inland waterway transport in comparison with road transport) and to optimize flows (laden return journeys), in order to create materials synergies and mutualisation.

Some synergies work at the level of infrastructures: mutualisation of barges between several industrials in Building and Public Works between Bonneuil sur Marne and Gargenville for the delivery of building materials for several shops in Paris; mutualisation of containers and handling equipments between two industrials for a more competitive price.

Shared-use quays (around 30), rented out to enterprises on an ad hoc basis, enable industrials who are not implanted on the ports to have access to the waterway and thus to develop synergies with other enterprises by using an environment friendly transport mode. Experiments on inland waterway waste collection centres (led in 2014) also showed an interesting potential in terms of massification of citizens flows. Ports de Paris is trying to strengthen the logistical role of inland waterways as an easy way to exchange all types of goods and waste between territories.

***GIE HAROPA** : 5th largest Northern European port system. It covers the ports of Le Havre, Rouen and Paris and forms a transport and logistics system connected to all the continents thanks to an international maritime offer (over 550 ports served).

Contact:

- Emilie MALLET – Project leader Development Management
  emilie.mallet@haropaports.com
  01 40 58 43 44 – 07 86 28 86 65

FEEDBACK

Levers for developing inland waterway transport: mutualised logistics solutions (2/2)

> VNF

VNF, in charge of the management of 6 700 km (out of a total of 8 500 km) of France's inland waterways, is also an actor who supports the principles of circular economy. Inland waterways have shown their relevance for a long time for the transport of certain types of waste, as for example building-related waste. However, other channels are emerging, particularly via the development of container transport which makes it possible to collect a wider variety of waste and offering in this way a real alternative to road transport. The flows developed in the Seine basin by a group of actors of which Ecosystèmes and Fluvéo are a good illustration.
Moreover, and in a logic of service eco-design, inland waterway transport is also working on the optimisation of its own global footprint. To do this, VNF offers technical and financial tools, such as the State Aid for Modal Shift Scheme and the State Aid for Modernisation and Innovation Scheme to accompany boatmen in identifying and improving the environmental performance of the boats (engine, alternative fuels), and also to strengthen the competitiveness of the fleet by encouraging innovation and the development of new types of boats.

Lastly, the development of initiatives in the field of urban inland waterway logistics is another element to relate to the integration of circular economy. By (re)using the advantages of the natural and historical link between the actors of a territory that a waterway represents, we are reinforcing the major role of inland waterway transport from the point of view of industrial and territorial ecology. VNF, in partnership with France Nature Environnement, has developed a practical guidebook to encourage the emergence of the project where sustainable urban logistics are concerned: "Acting for urban waterway logistics".

Contact:

- Thomas DELVALLE – Channels Chargé de mission, Transport and modal shift division, Development management
  thomas.delvalle@vnf.fr – 03 21 63 49 71

FEEDBACK

Mobility of goods: alternatives to road transport and local trade

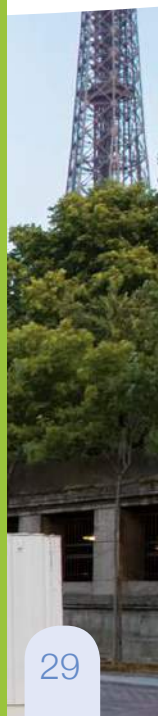
> Séché Environnement

On the Salaise-sur-Sanne site, south of Lyon, where Séché Environnement treats dangerous industrial waste, the organisation of transport is particularly optimised. That plant treats waste produced in a 35 km long chemical industries corridor. After their recovery they are returned to their producers as thermal energy used in their own processes. More locally, the principles of local trade that the industrial and territorial ecology promotes are applied with a neighbouring industry which has its dangerous gases treated with a return of steam.

The site is located in a "multi-modal triangle" between the canalized Rhône to receive dangerous imported waste, a motorway connection, and the rail network to send the waste (clinker) to the storage facilities in Laval (Mayenne). The 70 000 tonnes of clinker produced annually by the combustion of waste were transported by road, before a rail link between Château-Gontier (near Laval) and Marseille was opened, with a stop at Salaise-sur-Sanne. In order to justify the creation of this new line of freight train, a partnership with other industrialists was necessary to generate sufficient freight movements. Today this means one train per working day, and Séché Environment, which represents 20% of this traffic, has thus made the substitution of 12 200 trucks per year. Added to the improvement of equipment, eco-driving training… this new organisation has enabled, over 3 years, a 9.2% reduction in GHG emissions for the firm.

Contact:

- Daniel BAUMGARTEN – Director of sustainable development
  d.baumgarten@groupe-seche.com



The secret of tropical forest resilience: biodiversity

In a context of climate change, ecosystems are having to face up to new temperature and hygrometry conditions. Tropical forests, thanks to a wide variety of species, are ensured of being able to maintain the forest cover and functions to which they are associated. Strategies deployed by plants for their dissemination, their sharing of space and satisfying their light and nutriment requirements, along with their interactions with the other species, are carried out as "complements" to each other. If one of the environment's variables is somewhat modified, the more sensitive species may perish but most of them will be maintained. A diversified system which gives added safety against environmental disturbance! (according to CSPNB, 2012).

Agriculture

Guaranteeing the looping of the cycles of materials and focusing on diversity

Dependence on ecosystems and natural resources: water, soil and even fossil energy

Source sector for GHG emissions and other environmental impacts, closely linked to weather conditions

Circular economy & **agriculture**

Ensuring the return of nutritional elements to the soil:
- composts,
- methanisation digestates, etc.

Procuring and using divesified energy and material resources:
- reclamation of agricultural co-products and by-products (biomethane, agro-materials, etc.),
- substitution of farms' energy inputs, etc.

Reconquering artificialized soils by adapted solutions:
- roofs,
- wastelands,
- public gardens, etc.

A highly resource-intensive sector

Agriculture is a sector whose viability is particularly challenged in a context of depletion of resources. It has always been supported by the way in which ecosystems function and the availability of water resources, the soil's nutritional elements and the genetic diversity offered by biodiversity. As we have seen, the quality and quantity of water resources are deteriorating. Farming soils are threatened by urbanisation, are eroding and being depleted of their nutritional elements which are indispensable to crops (phosphorus, organic matter, etc.) due to the farming practices developed during the last century (mechanisation, single-crop farming, synthetic inputs, etc.). The specialisation and standardisation of productions has triggered a large reduction of biodiversity in fields and landscapes, destroying the auto-regulating capacities of agricultural ecosystems. Agriculture depends not only on the sun to meet its energy requirements. It also draws on fossil energy resources for the production of mineral and phytosanitary fertilizer or for agricultural machinery. Lastly, agriculture is responsible for the largest deposit of mostly organic waste (3/4 of the total production in France): straw, manure, waste from agrifood processing, etc.

A major impact on the climate and a high potential of mitigation

Farming activities, which bring us food, fibres and ecosystemic services, are directly impacted by variations in weather conditions: seasonal irregularity, temperature increase, soil salinization, scarcity of water resources or flooding, increased competition with parasites and « weeds » (RAC-F & FNH, 2010). Yields are therefore going to be particularly affected and will threaten food safety, specifically in poor countries where the population is continuing to increase. These activities are therefore largely concerned by the stakes of adaptation. But agriculture is also one of the main sources of GHG emissions (24% at global level with forestry). The increase in deforestation to provide new farming, grazing and urban land is the cause of 10% of global emissions, destroying the major carbon sinks* – the forests (CIRAD, 2015). And also by farming, crop, soil management and nutriment practices (IPCC, 2014), the sector also emits CO_2, CH_4, and mainly N_2O* (51% of global emissions), essentially for nitrogenized soil fertilization (46% of global emissions):

- When spread on the soil, a large amount of the nitrogen is evaporated in the atmosphere or washed away and directly penetrates the different layers of the soil to end up in the water tables and pollute them;
- During the chemical fertilizer synthesis process.

EXPERT'S WORD

Systemic economy: innovation is above all a question of governance

> **Patrice VALANTIN**, Director of Dervenn

The human species success story began 8 000 years ago, during the Neolithic agricultural revolution. Our ancestors optimized the production of resources by ecosystems, to increase their well-being and safety. Today's society is closely linked to agriculture and ecosystems. Nevertheless, we are mistakenly convinced that we are definitely empowered, which has given rise to the current societal, economic and ecological crises. The ecosystemic services which are indispensable for our economy and well-being are essentially produced on farming and forest land, which covers 84% of mainland France. Land managers, farmers and foresters therefore have a major role to play in maintaining these services which cannot be produced elsewhere (production of biomass, water and climate regulation, erosion, landscape, biodegradation, etc.).

And this is where the revolution of Life begins, by reintegrating our economic models in the functioning of the biosphere. Because it is through an alliance with ecosystems, essentially through agriculture, that we can regain prosperity and sustainability: Life is our future.

Dervenn is an ecological engineering firm and our experience shows that the obstacles are not the ones we imagine. The main obstacles arise not due to technical or scientific difficulties, but due to our methods of governance which inhibit the positive evolution we are talking about. By associating with other firms equally free from political, ideological or commercial supervision, Dervenn has built up a network of actors to develop territorial systemic economy methods, with circular economy as one of its major components. Our main partner is Ter-Qualitechs, an independent engineering and agricultural consultancy firm whose case stories with client farmers show, that the use of inputs can be significantly decreased while the income of farmers is maintained, or even increased.

It is fundamental to re-establish mutual trust between actors who share a same vision of local governance and of the future, and above all, common human values. This mutual acknowledgement makes it possible to build an informal but strong network, with everyone supplying a skill which is indispensable to the whole group. The regions' ecosystemic services and human activities are then mapped in order to identify existing actors, their functions, relationships and interdependencies, and particularly the role of farmers in global economic and ecological dynamics. Governance can thus be organised according to the shared stakes and objectives resulting from them. These networks based on trust offer a realistic alternative to classical hierarchical organisations and aim at truly efficient systemic solutions, inspired by the way ecosystems function.

These are not just theories, but actually operational solutions developed today by independent entrepreneurs and farmers. But an obstacle remains: since these services are free of charge, systemic economy does not encourage financial growth but rather the real economy, the well-being of territories, and Life!

FEEDBACK

Methanisation of waste: renewable energy to preserve the traditional farming landscape

> Séché Environnement

Biogas recovery from methanisation of waste treated on its site in Changé, Mayenne, enabled Séché Environnement to setup a first loop of circular economy in the late 1980s. The biogas coming from waste is supplied to neighboring farmers who formed a cooperative for the dehydration of their fodder. Few years later, new loop, this primary energy is replaced by a steam delivery through the implementation of a cogeneration facility from this biogas.

Biogas energy is used to provide 700 ecological farmers often certified "BIO", in organic feed, available all year (27 000 tons dehydrated per year, including 12 000 tons of alfalfa) and heat 15 000 homes with renewable energy, while providing the electricity needed to 60 000 people.

This new method improves forage conservation and allows the farmers to switch from soybeans importations – responsible for deforestation across the Atlantic – and to live on local production of alfalfa.

This legume has the ability to capture the nitrogen from the air and to enrich the soil, and thus reduces the use of chemical fertilizers and pesticides. The economics of new BIO farmers improves and allows them to remain on their traditional land in a "bocage" landscape bordered by hedgerows and talus. Biodiversity is thereby preserved, the shift to intensive farming have been avoided through local waste recovery.

Contact:

- Daniel BAUMGARTEN – Director of sustainable development
  d.baumgarten@groupe-seche.com

A new place for agriculture connected to natural, urban and industrial environments

A wide diversity of solutions is offered to farmers according to the changes in allocation of soils and practices for reducing GHG: more efficient livestock farming systems at environmental level, forest plantations and sustainable crops to mitigate emissions, agroforestry (trees and crops) and conservation agriculture (crops and plant cover) to store carbon, recycling of agricultural by-products, production of local energy to decrease the combustion of fossil carbon, crops adapted to local climate, etc. (CIRAD, 2015).

Firstly, **the return of nutritional elements to the soil** must be encouraged to rebalance the nitrogen cycle and improve the carbon footprint and to ensure agriculture's role of providing nourishment in the long term. This means reducing nitrogen-based fertilization and the footprint of (French) agricultural ecosystems which is globally in excess where this element is concerned. The use of organic fertilizers thanks to the recycling of local biomass waste (industrial, agricultural or household) makes it possible to reduce the use of nitrogen-based fertilizers by allowing nutriments to return to the soil. These organic fertilizers also have positive effects on carbon capture in the soil and encourage a better structuring of the soil which will be less subject to erosion during rainfall.

Secondly, agriculture may contribute to **the diversification of our material and energy sources** respecting at the same time ecological and physico-chemical balances. Its waste and co-products have a high recovery potential. Materials such as straw, waste dairy products, manure and musts, supply raw materials (cellulose, lignin, lactose and polyphenols) for the cosmetic, paper, plastics and pharmaceutical industries.

The setting up of short circuits for these new « channels » can make it possible to free us from constraints upstream (little choice of varieties, input, etc.) and downstream (standardized products). Exchanges between the agricultural sector and other sectors of activity are actually quite current. For example, in the Aube, a collaboration between a beetroot cooperative and a Building and Public Works firm has enabled, for some years, the reuse of the sand from beetroot-washing in road technique activities. This approach has enabled a saving, of 100 000 euros and 12 000 tonnes of granulates for the two firms every year. Despite the fact that this synergy is no longer operational, it is nonetheless highly representative of the exchanges between two sectors of activity which collaborate little normally.

Energy exchanges are also current. For example the WARM CO_2 Project in Terneuzen in the Netherlands has set up a system for supplying 170 hectares of horticultural greenhouses using residual heat and CO_2 emitted by a nearby organic fertilizer plant. The project enables a saving of over 90% of fossil fuel use. Other examples also exist on the recovery of energy for farms. This is the case of Séché Environnement which supplies biogas from waste to farmers in the neighbourhood (see insert on left).

Without this competing with arable lands, biosourced renewable substitution materials help to preserve resources and supply eco-design (building materials, thermal insulation, agro-plastics). Even though it is for the time being considerably underexploited, hemp represents for example an excellent substitution material. The challenge is therefore to develop the channel and this is what ARENE Île-de-France is working on (see insert opposite).

FEEDBACK

Reviving hemp cultivation: developing a local building market for this agro-material

> ARENE Île-de-France

In 2010, a network of actors in Seine-et-Marne mobilized around ARENE Île-de-France to revive hemp growing and the production of eco-materials likely to be a substitute for classical building materials in order to reduce the sector's carbon footprint. Biosourced materials* are actually renewable materials, which store carbon and do not need much energy during their life cycle. This crop also has the interest of requiring few phytosanitary products because it is not highly sensitive to disease and its thick canopy of plants stifles weeds. Currently a thousand hectares are grown by the 11 farmers of Planète Chanvre. The enterprise's two main products (hemp and wool concrete) are processed in the Aulnoy factory whose opening led to the creation of 10 jobs. Hemp wool is used for the insulation of roofs, and chennevote, associated with lime, enables the production of hemp concrete to manufacture free-standing walls or to insulate buildings from the outside.

After having carried out a feasibility study to validate the economic development potential of the building market, ARENE Île-de-France supports the development of this channel and is now trying to find new outlets in Île-de-France to root the market locally. Sadly, 95% of the production of these materials is still sent to Belgium and Germany because there is no market nearby. In partnership with the Conseil Régional d'Île-de-France, Planète Chanvre is working on the promotion and certification of its products to meet its initial aim of supplying local artisans and builders with materials from renewable resources. L'ARENE will soon be publishing a guidebook with technical solutions for using biosourced materials in renovation and building for which feedback referencing began in 2014. In this way, it will give public and private clients the keys for using such materials and will make it possible to support the mobilisation of the actors of the concrete-hemp channel.

Contact:

- Thierry VINCENT – Ecological transition Project leader, In charge of development
  t.vincent@areneidf.org

Moreover, to conquer artificialized soils, new forms of agriculture have been emerging during the last few years which make it possible to reintroduce crops in neglected urbanized areas (urban and periurban wasteland for example) or certain areas affected by soil depletion. Experiments are currently in progress to grow vegetables on the roof of the engineering school of AgroParisTech with the aim of testing wood-compost combinations and inseminations of mycelium* or earthworms, wild aromatic meadows with the Muséum national d'Histoire naturelle (MNHN), and agro-ecological roof techniques. Les Fermes en ville, a demonstrator of the association Le Vivant and la Ville, also provides soil-less farming solutions (see insert opposite). This is actually a good example of the development of short circuits (making it possible to reduce GHG emissions linked to the transports of products) and giving agriculture a place in the town or on its outskirts (more information in the URBAN MANAGEMENT section).

Of course these solutions must be integrated into a more global transformation of agricultural models enabling the reduction of input, pollutions and soil preservation such as organic farming, permaculture, agro-ecology, etc. It is through a better knowledge and local control of agroecosystems according to specifics in terms of land, climate, plants cultivated, etc., that the best adapted solution can be found to meet food requirements, complete energy and material requirements and preserve the functioning of agricultural ecosystems. If circular economy is inspired by how ecosystems work, it can particularly apply this analogy to agriculture and encourage diversified solutions to guarantee it a viable and sustainable place in economic, environmental and ecological terms: diversity of productions, diversity of agricultural models, diversity of outlets, etc.

FEEDBACK

Recovery of urban wastelands: a short-circuit adapted agriculture to satisfy urban requirements

> Le Vivant et la Ville

Le Vivant et la Ville offers a novel solution for recovering urban and peri-urban wastelands: "Les Fermes en villes". Within this cluster of enterprises, a group (Les Jardins de Gally, Veolia, Hydrasol, Sol Paysage) has developed a model of urban agriculture which is replicable, reversible, resource-efficient and economically viable for local authorities.

Les Fermes en villes occupy 3.5 hectares of a former landfill for backfill not suitable for cultivation on the outskirts of the town. This demonstrator develops 3 activity clusters: a soil-less market garden production (red fruits and aromatic herbs), an area for renting soil-less gardens to the public, and a "showcase" area for agricultural discovery which will welcome educational and professional visits.

This demonstrator develops a sustainable and professional economic model which groups together simultaneously :

- A circular economy, resource-efficient agricultural solution (water, waste, substrates) with uses which recover the soil and land: recovery of drainage water for irrigation, organic waste compost;
- A solidarity economy offer which creates local jobs and social links, guarantees qualifying training and is supported by social integration companies;
- Short-circuit marketing of the production to satisfy urban consumer needs for local fresh produce;
- A system which can be replicated in a modulable, sustainable or reversible manner according to the reclamation requirements of the public and private neglected land in the short or long term

Contact:

- Alexis Lefebvre – Urban agriculture Project leader,
  Le Bureau d'études de Gally
  alexis.lefebvre@levivantetlaville.com

More information:

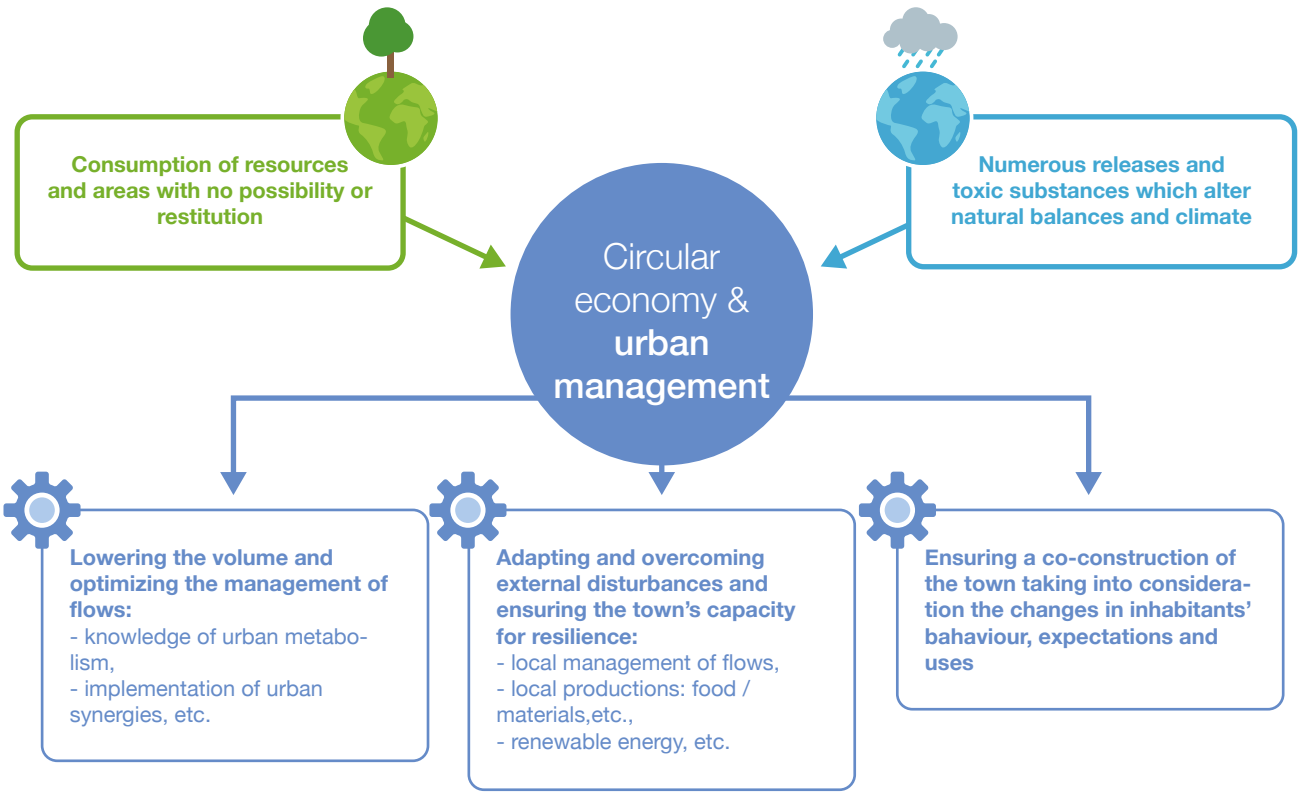
- www.lesfermesenvilles.com

How corals adapt to somewhat hostile waters

A priori, our towns are environments which have no food resources, and they have to be brought in from outside or produced on the spot. Tropical waters did not have much in the way of dissolved organic materials to offer organisms either, but corals learned to adapt and build an environment which is favourable to a wide diversity of species protected by their calcareous skeletons. A micro-algae develops in their cells and supplies them with sugars using photosynthesis. In return, the corals feed it with nitrogenous components and secrete organic products which feed fish. They can absorb and concentrate the carbon dioxide and nitrogenous waste and even tolerate the pure oxygen of the environment. By recycling waste and reclaiming local resources, we can live in coherence with the limits of our environment! (according to CSPNB 2008).

Urban management

Encouraging the "resources" potential of urban environments



Towns which absorb resources without creating new ones

Because they are responsible for three quarters of the consumption of our planet's resources (energy, water, building materials), and for the surge in consumption of natural and/or agricultural species and for daily emissions of pollution, materials and toxic substances, urban areas are perceived as environments which are harmful to the planet, to the health and the quality of life of its inhabitants. Moreover, with the increase in demography, the concentration of populations in towns (over 50% of the world population and 80% of the French population) and urbanisation, the situation continues to deteriorate (Perspective Monde, 2014).

Towns have become clusters disconnected from the natural, rural and even industrial systems which surround them – if only to extract and release the flows necessary for them to function. Capture of resources is thus intensifying without thought on their renewability and with no possibility of replacing them by new ones. The modes of consumption and production have also become linear to generate in fine materials which are no longer compatible with the environment to which they should be returned.

Is this absolute ecological nonsense? Towns are actually the real « locomotives for growth » and also supports for redistribution, mobility, consumption, innovation and creativity (Davezies, 2008) and therefore incredible deposits of material, energy, social and intellectual resources (Barles, 2010). All this should represent a context which is ideal for optimising resource management.

Urban environments: where climate stakes are concentrated

The fight against climate change in urban territories must mobilise two approaches which aim at reducing both greenhouse gas emissions and the associated vulnerabilities.

The systemic functioning of towns impose combined multi-sectoral thought on specific vulnerabilities that they have to face in a context of climate change due to the high concentration of people and the grouping together of infrastructures and material goods on limited areas (ONERC, 2010) (IPCC, 2014). These are most often pre-existing issues but here they are amplified by climate change and increasing urbanisation: more serious heatwaves due to heat islands; associated air pollution and health risks; runoff due to soil sealing and flooding, and therefore the deterioration of infrastructures and services, etc. These stakes need a case by case approach according to the territorial characteristics and urban particularities (physical, urban, social, geographical,etc.). Thus, the adaptation strategies and the measures to be set up must be anticipated in the long term. This is the case for example of the great planning operations which, if they do not consider these vulnerabilities, can create irreversible consequences over the long term (more information in the TOWN AND COUNTRY PLANNING section). Better management of resources and therefore of the associated risks is essential to mitigate the urban instability to which they are linked. Lower water levels leads for instance to an increase in the concentration of pollution to be processed upstream of urban household consumption.

In addition to being strongly impacted by climate variations, urban environments are also the main emitters of GHG. Buildings and homes represent an important part of emissions essentially through heating which contributes, in France, to 80% of GHG emissions from homes (with variations according to the materials used for the buildings, their insulation, the type of glazing, the more or less compact layout, etc.). Transport of people and goods is also an important source of emissions in towns. Urban freight represents 30% of national GHG emissions and daily travel from home to work, over 4% (more information in the TRANSPORT section).

EXPERT'S WORD

Circular economy, a new model for the use of resources for a resilient and low-carbon development of towns

> **Hélène LEBEDEFF**, Deputy director for sustainable development, Veolia

The design and management of urban infrastructures and services are essential leverages for a sustainable city. Most cities today have become exceedingly greedy, with an insatiable appetite for resources; they create very little value-added productions and ignore the pollution they generate.

The "linear" economic model generates both depletion of resources upstream and greenhouse gas emissions (GHG) at all stages.

On the other hand, the sustainable city is characterized by a sober, more economic metabolism, with fewer impacts on the environment; it is less greedy financially and is based on the principles of the circular economy.

Every day, Veolia brings practical solutions worldwide for a more circular economy. We assist cities and industries in the management, optimization and recovery of their water, energy and material resources, particularly from waste, by building circular economy loops with them. Our technological solutions as well as our contractual and partnership innovations (from the remuneration for lower consumption of resources to the insertion of our activities into local ecosystems) contribute to the reduction of impacts (extraction and pollution) and to the fight against climate change while enabling the creation of added value at the core of our clients' activities and helping make regions more attractive and resilient.

Over the last 50 years, the town of Boras in Sweden (100 000 inhabitants) has halved its CO_2 emissions! Its secrets are the massive use of forest biomass, the cogeneration of waste and biomass, the processing of organic waste as biogas which supplies buses, taxis and other urban vehicles, and lastly the largest system of hot water storage in Europe which can meet peak heat demands without using fossil energy. This performance is the result of the early awareness of the need to protect the planet, the constant political will based on a long-term vision, the pragmatic approach using all the possible local synergies and solid partnerships between the local authorities, enterprises, non-profit associations and the local population.

In Ling Hall (Great Britain) Veolia has commissioned a plant to reclaim 10% of the 400 000 tons of material from road sweeping by its services. The plant reclaims precious metals (platinum, palladium, rhodium, etc.) from urban waste which are normally contained in the particles emitted by cars' exhaust. The savings generated enable Veolia to lower the price of its cleaning services for the town by exempting it from part of the high cost of landfilling in the United Kingdom.

Understanding and building resource-efficient urban ecosystems

Towns include a major circulation of physical flows (energy, water, transports, waste, movement of foodstuffs, etc.) which illustrates the fact that they depend on external systems and the need to organise the management of flows in order to decrease harm to the environment.

In order to work towards ecological performance, the urban territory must be capable of **lessening the volume of flows and optimising their management**. Therefore, to develop understanding and systemic and functional projections which would integrate a maximum of sustainable stakes, the levers to be mobilised are particularly inspired by natural ecosystems. The urban metabolism method – defined as "all the transformations and flows of materials and energy which make up the life cycle of an urban area" (Barles, 2010) – aims at producing precise knowledge of the energy and material circulations to highlight the possibilities of synergies between towns, agriculture and industry.

In order to improve its urban metabolism and manage its resources better, the Town of Paris, associated with Paris&Co, is currently experimenting solutions which will contribute to a more efficient management of the natural and material resources used in the framework of the town's activities and missions and which aim at improving its urban metabolism. 13 circular economy projects have been selected (recovery of soil and material from building sites, collection of bio-waste, recovery of furniture, reclamation of runoff water, etc.) to enable a reduction of the ecological footprint of the town's activities.

The eco-cycle model of the quarter of Hammarby in the town of Stockholm also illustrates a real "urban circular system".

A number of urban synergies are operational between habitation and urban services (energy, water, waste, etc.) such as the production of biogas from sewage sludge, reclaiming calories from waste water, car sharing, and, of course, the maximum optimisation of the energy consumption (100% renewable energy), water and waste sorting. This example illustrates also that, in a dense system as that of a town, any planning action taking a systemic approach into consideration is indispensable. On the scale of quarter there is also a multitude of solutions: the densification of built-up areas, positive energy buildings, smart-grids, local resource management, recovery of runoff water, etc. To reduce travelling and its related emissions, there are also solutions involving the functional diversity of built areas and quarters (homes, shops, services) to reduce the distances travelled, guarantee a good public transport service (particularly a rail-based one) and develop infrastructures favourable to "soft" transport (bicycles and walking). This diversity is being increasingly developed in the new quarters and also makes it possible to meet mutualised requirements and provide a variety of solutions to energy consumption needs.

FEEDBACK

Functional diversity and energy efficiency: the inhabitant at the heart of innovative eco-quarter operations

> Bouygues Immobilier

The Hikari operation of Lyon Confluence and the quarter of the Fort d'Issy-les-Moulineaux integrate circular economy concepts by following the UrbanEra approach offered by Bouygues Immobilier for mixed urban projects combining homes, offices and shops.

The Hikari operation is the first mixed positive energy urban island which superimposes the floors dedicated to shops, offices and homes. This functional diversity makes it possible to mutualise the production, distribution and consumption of renewable energy: solar energy, cogeneration (from locally produced rape-seed oil) and geothermal energy thanks to the Saône River for production of cold. This network will be organised to meet in the best possible way the alternating energy needs between the day and the night, and between week and week-end. Mobility services will also be mutualised with a sharing of vehicles and parking spaces to reduce congestion in the quarter.

The size of the Fort d'Issy-les-Moulineaux quarter enabled the setting up of a mutualised network of geothermal energy using the heat of the water table which guarantees 80% of hot water and heating needs. The life of the quarter is based on a local social network used by the inhabitants for repair services, renting of equipment, donations, etc. This situation asks the promoter the question of post-delivery follow-up and the way in which to ensure a durability of the commitments made at the start of the operation. The future integration of this quarter into IssyGrid, the smart network of Issy-les-Moulineaux and the Seine-Ouest business quarter, imposes additional skills resulting from partnerships with other local enterprises, local authorities and start-ups. It will make it possible to consume better at the right time, to optimise the recharging of electric cars and manage the problems of intermittence, to integrate renewable energy, and above all to smooth consumption peaks in order to lower greenhouse gas emissions.

Contact:

- Chloé LEVEQUE – Direction Innovation
  c.leveque@bouygues-immobilier.com

More information:

- www.bouygues-immobilier-corporate.com

Bouygues Immobilier's UrbanEra approach is an example of this (see insert opposite).

In order to work towards ecological performance, towns must also be capable of **adapting to and overcoming the different external disturbances** (high level of pollution, shortages, natural disasters, etc.). This means guaranteeing their durability and above all their resilience*, specifically by offering, in addition to the technical dimensions, an adapted mode of governance.
In the Paris region, the Atelier d'Architecture Autogérer has, for example, created R-Urban with the idea of deploying local networks and ecological, economic, social and cultural short circuits to complement existing urban networks, to favour the urban resilience capacity of the town (self-sufficiency, local production and recycling, waste networks, job creation and circular economy, etc.). In this way a local management of the flow of materials and energy (transport, water, building materials, etc.), to complement with local industry and agriculture, allow the urban territory to ensure its durability. Through a forward-looking exercise on the town of Grenoble, Eiffage's Phosphore 4 laboratory has, for example, modelled these solutions (see insert below).

FEEDBACK

Prospective vision for an urban ecosystem: balancing the components of the town

> Eiffage

Eiffage's Phosphore prospect laboratory has striven to understand the sustainable town as an ecosystem with its actors, its environments and their interactions. Through this work, it has illustrated in the virtual Grenoble of 2030 the new synergies between the components of urbanism which are often dealt with as separate entities – energy, water, transport, materials, green spaces and waste.
Therefore, cable transport would be an opportunity to develop the forest channel, for which steep land is an obstacle in the scope of a "standard" exploitation. The opening of production plants on the spot and the creation of a learning and research centre would make it possible to prefer the use of wood as a building material and to recover the by-products in wood-energy or liquid wood. The model considered to complete the renewable and local energy package would be supported by the seasonal complementarity of solar and hydroelectric power. The storage of the electricity produced on the roofs, motorway cover and waterways would be fed by high mountain artificial lakes. Urban agriculture would ensure ultra-short circuits in the town centre whereas the rural outskirts' production would be processed in the territory and distributed by the network of relay markets and fruit and vegetable markets. Fermentable waste from these farming activities would be collected and methanized to supply the industrial sector in biogas.
Already, Eiffage is mobilizing Mediterranean resources for future users of the Smartseille eco-quarter in the Euroméditerranée 2 area. The quarter will soon be supplied in hot and cold by a thermal sea power loop, while part of the thermal insulation of the buildings will be ensured by locally bio sourced materials.

Contact:

- Sarah LAVAUX – In charge of the cluster, Sustainable Development Management
  sarah.lavaux@eiffage.com

To combine the stakes of urban resilience, **the co-construction of the town taking into account changes in behaviour**, **expectations and uses** remains indispensable. The aim consists of not forgetting to associate the solutions offered by circular economy, and the measures for reducing consumption, striving at the same time to preserve the qualities of comfort and taking into consideration the expectations of the inhabitants, users and enterprises (Lipovac & Boutonné, 2014). To meet these stakes, initiatives are emerging which privilege access to users rather than buying goods and services on a territorial scale. This approach through a product-service system, tested on the scale of an eco-quarter, as in Aulnoy-lez-Valenciennes aims at co-building solutions to meet the essential needs of the inhabitants (see insert hereafter).

All the actors contributing to town management (town councils, planners, builders, enterprises, associations, inhabitants, etc.) must get together and draw inspiration from the solutions offered by the new circular economy models. The co-benefits for the inhabitants are numerous: job creation, improvement of life style, air quality, access to water, a decrease in fuel poverty, etc. Implementing these innovative solutions in the best possible way demands a transition towards a governance of the town and to long-term policies which are much more multi-sectoral and integrated (planning and also employment, culture, education, solidarity, etc.).

FEEDBACK

A Product-service system for social innovation: users as the co-authors of their eco-quarter

> CERDD (Centre Ressource du Développement Durable)

The "Les Hauts d'Aulnoy" eco-quarter project in Aulnoy-lez-Valenciennes (59), was the object of a reflexion on a 5-hectares waste land located between the historic village and the New Aulnoy (ZUP). This wasteland, which had been spontaneously taken over by the inhabitants as allotments, is now a 400-homes eco-quarter (provisional schedule: preliminary work in 2015, delivery in 2018) whose particularity is that it is supplied in energy by a 2-hectares closed market garden greenhouse. By closing the greenhouse, the heat produced in summer is stored in the sub-soil and makes it possible to heat, according to demand, the quarter's homes and facilities all year round. In addition to enabling important energy saving, this closed greenhouse system recovers condensation and saves 75% of water to water the crops.

Beyond being a multisectoral approach (methanisation for the production of electricity and hot water, treatment of grey waters for watering, etc.), the concept of a "greenhouse town" is also intended as a lever for social innovation and an incentive for the evolution of life styles. The inhabitants and users of the quarter are placed in the core of the innovative process as "co-authors" of the solution which will meet their essential needs (accommodation, heating, food, etc.).

The future territorialized service of energy production relies on a new economic and governance model which still needs to be tested. This reflexion was fuelled by prospective work carried out by CERDD and the CCI with the support of Atemis (Laboratory for intervention and research) bearing on the question of "sustainable towns and new economic and development models". Regular work sessions are therefore the opportunity to discuss initiatives, share analyses and confront points of view on the sustainable development of towns and the conditions for new corporate economic models to emerge which will make it possible to take into account the new urban stakes and new requirements.

Contact:

- Antoine BOUTONNE – Sustainable economy Chargé de mission
  aboutonne@cerdd.org

More information:

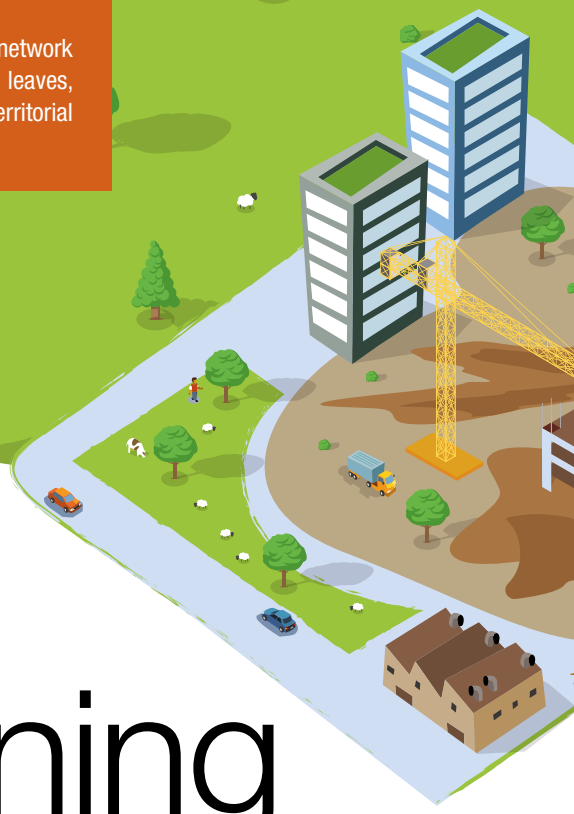
- www.cerdd.org

So there is room for the sustainable town to be reinvented thanks to the development of new local economic models and firms whose aim will be to correspond to urban lifestyles, taking into consideration environmental, economic and social externalities at the same time.

All these links require that we redefine the perimeter. A reflexion at town-scale (a continuous built-up area with at least 2 000 inhabitants (INSEE definition)) will not be sufficient to meet tomorrow's stakes. In order to think and implement integrated solutions, and considering the specific features of each territory, the metropolitan scale may well be one of the adequate answers for better management of the circulation and use of resources and reconciling economic development.

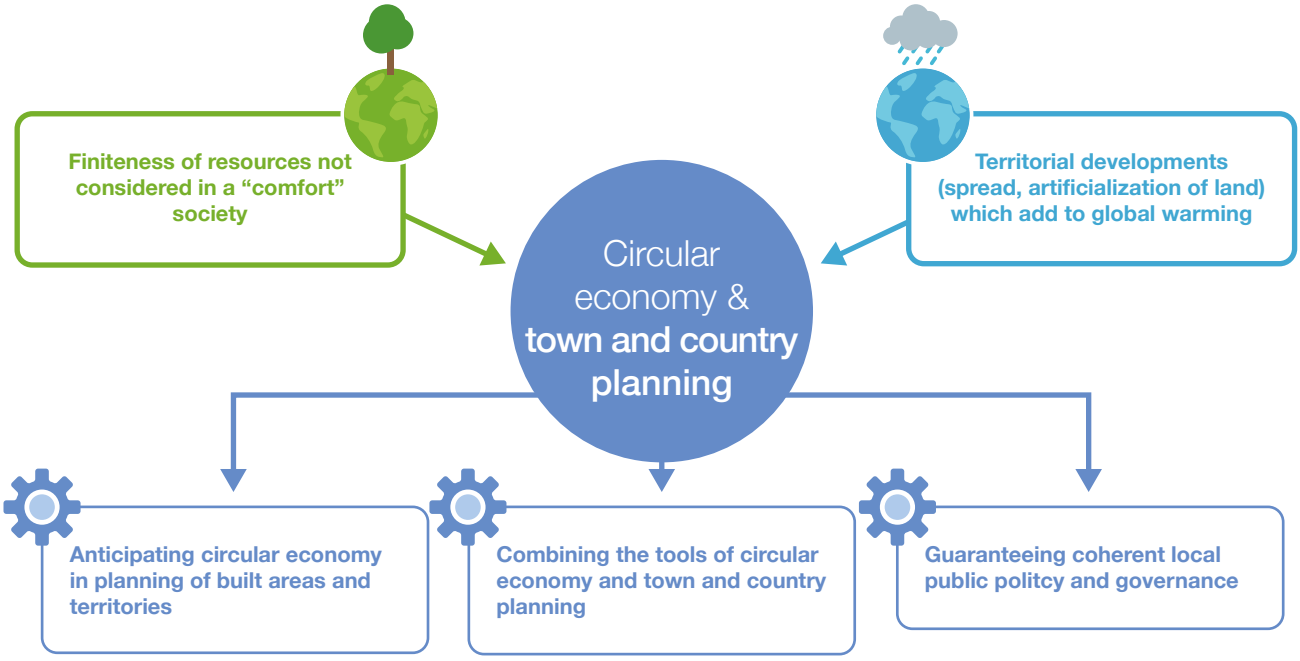
Vital networks hidden in forest ecosystems

Under the soil of our forests, the essential balances of these ecosystems are organised. The main actors in nutritional exchanges taking place there: mushrooms and their giant network of filaments, the mycelium. A tree finds itself connected in this way to a number of mushrooms from which it draws the water and mineral salts it has collected form the soil. In return, a same mushroom can connect to several species of tree to draw sugars developed by plant life using photosynthesis. In North America, the mycelial network also serves as in intermediary between conifers and birches. When the birch sheds its leaves, it is still supplied with sugar. Networking, variety of sources: a new model to inspire territorial planning! (according to CSPNB, 2012).



Town and country planning

Pursuing the model of balance and complementary uses



Planning territories and using fewer resources

Whereas the aim of town and country planning is to organize the geographic area considered in the most harmonious way possible, the current spatial development of territories engender a phenomenon of urban spread which creates a number of sources of pollution. New buildings, transport infrastructures, new industrial parks are wearing away at natural, farming and forest areas all the time, setting off conflicts of use and consuming considerable quantities of resources. In the name of economic development (attractiveness, competitiveness, etc.), the environmental (and even social) dimensions are often impacted by planning projects. In addition to this, these projects are increasingly constrained by regulations and their not taking environmental stakes into consideration may be a threat to them.
These issues are very important in developing countries where the demand for more comfort is ever-increasing with growing urban population. In France, the equivalent of one department is artificialized every year. By 2030, artificialized surface areas will have doubled compared with the situation in 2000 (MEDDE, 2011).

But it is not only a question of the use of space and the destruction of ecosystems and farming land. This logic supports an economic and political system which places growth and consumption as a priority and does not take into account how fragile and finite natural resources are. Each parcel built and inhabited conditions an additional need for natural resources (soil, materials, energy, etc.) and represents additional cost for the local authorities (connection of networks, etc.), especially if the distances become longer between the habitat area and the employment and/or catchment area. At the same time, technological efforts on energy efficiency and the management of resources can create a "rebound effect" and slow down the decrease in consumption. On the other hand, emissions linked to heating and insulation performance only represent part of the global energy balance of a building and we also have to consider the emissions from building sites (materials, equipment, etc.) which are also high producers of CO_2. Life Cycle Analysis (LCA)* must therefore make it possible to consider the whole building and the constructive choices from manufacture to the end of the building's life.

Moreover, these infrastructures, once built, condition and lock landscapes and behaviour for decades. It is actually more difficult to subsequently modify networks and favour solutions which use less resources, which would necessitate transformations and different planning, than if they had been planned upstream. Because of this, and due to the specialization of territories (predominantly industrial, agricultural, urban, etc.), their capacity to face the stakes of access to resources is obstructed.

Reducing the vulnerability of territories and encouraging adaptation to climate change

Because town and country planning is an important factor in the regulation of our production and consumption modes, it can play a role in mitigation and adaptation to climate change. But the spreading of towns and the increase in peri-urbanisation amplify travelling time; intensify the individual use of cars. The type of transport infrastructure, and even the distance between workplaces and home influence the mobility of goods and people and thus transport-linked emissions. It is therefore easy to understand the interest of returning to dense urban forms connected to resource supplying territories.
The BPW* sector also represents an important share of emissions. Closely linked to planning policies, it represents 23.5% of France's GHG emissions (MEDDE, 2015). The use of raw materials engenders on the one hand the combustion of fossil resources (extraction, processing and transport) and draws on virgin natural resources. This use must therefore be reconsidered by privileging the use of deconstruction materials. The design of buildings and the planning of quarters and industrial parks also influence our energy consumption (more information in the URBAN MANAGEMENT section).

EXPERT'S WORD

Circular economy, trajectory, climate, planning

> **Jean-Claude LEVY**, Historian, geographer, journalist,
In charge of a mission of reflexion on circular economy, sustainable development and decentralized cooperation with the French Ministry of Foreign Affairs and qualified personality at ORÉE

Beyond the priority tools and procedures expected from COP21, we must consider examining the trajectory of circular economy as a public policy, integrative system which has been emerging over the last thirty or so years in local politics. These last belong mainly to local governments who are clients still relatively supreme in territorial planning.

You don't have to go to China to see this, or Kalundborg in Denmark, or even for example to Quebec, to the Charlebois cheese house: but this can also be observed significantly in a likewise manner in France, on the eco-site of Vert-le-Grand[1], in the Essonne department, at the Bazancourt-Pomacle[2] bio-refinery, in the Champagne Region, or just next door to Revel in Belesta, and last but not least in its experimental stage at Salaise or Portes-du-Tarn (see insert below). We can see in these places how, on a scale of 3 or 4 generations, the accumulation of an industrial, or agro-industrial, scientific and technological capital, is likely to contribute to the construction of territories which may be shown as stages in this circular economy trajectory.

Therefore, it is natural for circular economy to come up against the issue of climate and global warming of anthropic origin (or not). It belongs on the one hand to tangible territories, in the biosphere, at the source, in the heart of moderate use and the optimal restitution of the natural flows of organic material (carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur) or inorganic material, and testifies on the other hand to a movement which would not be possible without mobilising energy, which is imposed at the heart of the use and processing of the material flows considered. Whether we are talking about industrial ecology, eco-design, bio-economy, product-service systems, etc., the trajectory of circular economy does not gather together these "pillars" but these dynamics, which are expected to modify the biochemistry of the energy/territory pair over time, in favour of using less energy, in such a way that the various economic, industrial, agricultural, etc. activities, and of course social ones, cannot harm the progress of life, at the very end of the leaves: as simple as photosynthesis!

Industry is an unquestionable dimension of this trajectory – shown by the examples mentioned above – but it is not specifically industrial, and scientists have a considerable role to play in it. Generally speaking, on a multilateral scale, as much as on the scale of local power, over more than a century, political representatives have occupied a significant place in it, especially as they are carried and controlled by a burdensome social demand. Local authorities have the skills and legitimacy to integrate these original solutions into territorial planning: local infrastructures, agricultural solutions, models of quarters and industrial areas, etc. must also reflect planning choices which are favourable to the construction of territories governed by the principles of circular economy.

[1] www.ordif.com/public/structure/groupe-semardel

[2] www.a-r-d.fr/ARD-filiales-et-partenaires-Bio-raffinerie-Recherches-et-Innnovation

Thinking circular economy in territorial planning

To enable regions to meet, as far upstream as possible, the resources, adaptation and resilience stakes, it is essential to set up planning logics which take circular economy into consideration. It is then a question of coherently integrating the different solutions already developed (presented in this document) and then integrating them upstream of the planning or requalification projects, in order to make it easier to balance the region's actors and activities. Anticipating circular economy in the planning of the built environment (pipelines, mutual logistics platforms, waste treatment plant, etc.) and of informative supports (information platform, etc.).
The aim is to work towards the complementarity of uses and the reduction of the regions' environmental impacts by systematically mobilising the solutions proposed by these new economic models in a life-cycle way of thinking:

- To optimise the use of energy resources: building design, energy recovery from waste (link with agriculture and the local authorities) and unavoidable energy, heat networks and renewable energy;
- To preserve water resources: plants for the treatment and recovery of grey, rain and industrial water;
- To optimise the consumption of materials: recovery of local materials, sustainable supply;
- To optimise waste management: organisation of the collection and mutualised treatment site, links between agriculture, town and industry, reclamation of industrial and agricultural coproducts;
- To optimise the use of space and reclaim the existing unexploited artificialized areas by allowing different uses to cohabit (economic activities, habitat, networks, agriculture, natural environments, etc.): densification, reclamation of industrial wasteland, deserted car parks, mutualisation of spaces (for example: logistics platforms);

- To reduce staff transport by encouraging access via local transport and developing “soft” modes: Plan de Déplacement Inter-Enterprises (PDIE - Inter-company travel Scheme), access to transport in periurban areas;
- To encourage local proximity by guaranteeing functional diversity (homes, services, shops, etc.) and short circuits (food, materials, local recycling, etc.).

Industrial and territorial ecology (ITE), a major operational field of circular economy, intends to integrate these solutions on the territories by developing mutualisations and flow exchanges between economic activities. The IPCC strongly recommends exchanges of co-products, energy and industrial water flows, the sharing of infrastructures and the mutualisations of purchases (IPCC, 2014).
Nevertheless, the links between town and country planning and circular economy are as yet not highly dealt with and developed. A few still too rare examples, reveal an anticipation of these solutions upstream of the planning projects. The examples of Les Portes du Tarn and the Zone Industrialo Portuaire de Salaise-Sablons (see inserts opposite) are pioneers in this field.

Combining the tools and methodologies of circular economy and planning would make it possible to develop these initiatives. Town and country planning actually has all the structuring tools from the point of view of urban planning (PLU* (local town planning), SCoT* (municipal planning documents) etc.) and specific methodologies (eco-quarters, HEQ* standard, AEU®* (environmental approach to urban planning), etc.).

FEEDBACK

Designing a business park: industrial ecology for better integration into an environment

> La SPLA 81 “Les Portes du Tarn”

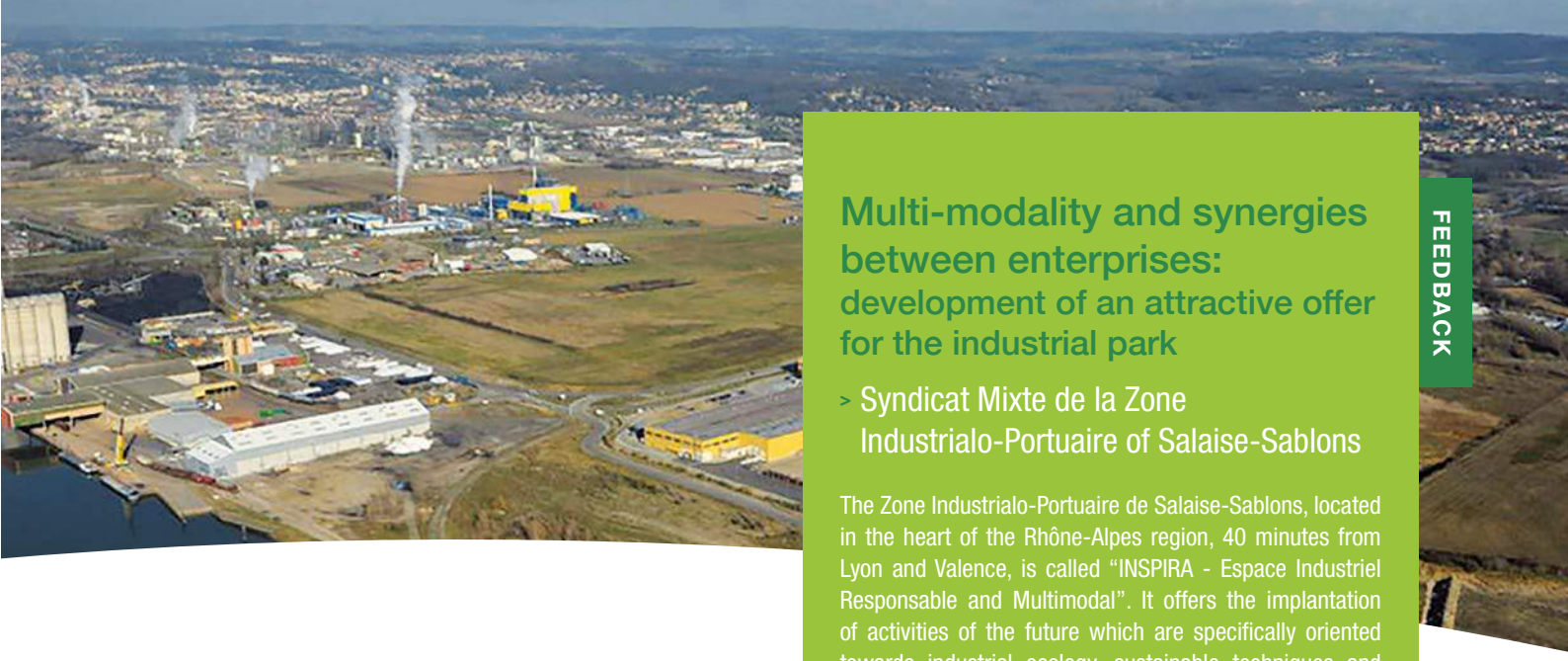
Straddling the Tarn (Saint-Sulpice) and the Haute-Garonne (Buzet sur Tarn), Les Portes du Tarn business park is spread over 198 hectares. Initiated in 2009 by the Communauté de communes Tarn-Agout and the Département du Tarn, the vocation of this project is to become one of the economic showcases of the department, just 20 km from the regional metropolis of Toulouse. The planning mission was entrusted in 2012 to SPLA 81 (Société Publique Locale d’Aménagement specially created for this purpose). Imagined as an urban quarter, Les Portes du Tarn will be made up of living areas and work areas, in order to meet the new expectations of the population, and offering to the targeted enterprises a quality offer of metropolitan scale.

In order to master the environmental impacts of the future park, SPLA 81 initiated the COPREI (COnception d’un parc d’activités sur les Principes de l’Ecologie Industrielle) project, which proposes to integrate the principles of industrial ecology from the design stage of the park and right through its future operation.
By choosing this mode of “integrated governance”, Les Portes du Tarn industrial park, optimises the management of the enterprises’ flow of materials and energy, reducing the impact of the activities on the environment at the same time.
“Les Portes du Tarn” is the only industrial park in France to integrate from design stage and right through its planning, a circularity logic, with a constant search for synergies between the various activities set up on the site (integrated management of waste, passenger transport network, optimised energy production and distribution system: geothermal energy, local biomass, solar energy, constant commitment to limiting noise pollution for the duration of the building work: regular measurement of the impact of the activity on its environment, installation planned according to the input-output balance).

Two firms have currently planned to set up in this industrial park : Vinovalie has created a premium oenological concept with a new bottling unit, a regional cluster and a museum area, leaving the field open for the three former sites to concentrate on the recovery of ecoproducts from the vine; the Compagnie Industrielle de la Matière Végétale (CIMV) will install its new bio-refinery.

Contact:
- Emilie GUIBERT, Communication
  e.guibert@spla81.fr – 05 31 81 98 06

More information:
- www.portesdutarn.fr



Circular economy also has a large fund of tools and methods: environmental analysis with ACV (Life Cycle Analysis), channel approaches to recycling around which regional actors come together, territorial approaches with industrial metabolism (quantification of the flows used in the framework of ITE), the implementation tools to accompany these (example of the COMETHE* platform - www.comethe.org), etc.

To **guarantee a policy and a governance** of the area to be planned which is coherent (industrial park, urban quarter, etc.) with the stakes specific to each region (local policies for transport, habitat, public service, economic development, etc.), dialogue between the different local economic and public actors is essential. Supported by methods for the coordination, evaluation, sharing of information, etc., the tools must be used coherently to enable regions to meet the many needs which coexist and are evolving:

- coordinating and integrating policies (planning, employment, culture, education, solidarity, etc.),
- synergizing actions led on the territory (Agenda 21*, PCET*, Eco-Quartiers, etc.),
- respecting the physical, sociological, and economic realities,
- developing regional rooting and national and international competitiveness,
- improving attractiveness,
- encouraging the social link,
- preserving agricultural, forest and natural areas, etc.

Planning-oriented decisions and choices largely condition our energy and resource management. Important environmental and climate problems and the cost represented by inaction make circular economy (and its associated benefits) an essential element for local policies in long-term management. These systemic and collaborative approaches represent thus a source of opportunities to plan regions to consume less and better and reduce global environmental impact.

FEEDBACK

Multi-modality and synergies between enterprises: development of an attractive offer for the industrial park

> Syndicat Mixte de la Zone Industrialo-Portuaire of Salaise-Sablons

The Zone Industrialo-Portuaire de Salaise-Sablons, located in the heart of the Rhône-Alpes region, 40 minutes from Lyon and Valence, is called “INSPIRA - Espace Industriel Responsable and Multimodal”. It offers the implantation of activities of the future which are specifically oriented towards industrial ecology, sustainable techniques and energy, renewable materials and smart distribution. This project is initiated by a Syndicat mixte in which the Region, the Department and the Communauté de Communes are associated in close collaboration with the Compagnie National du Rhône. Its aim is to welcome new industrial activities and services, to develop, for industrial materials, the use of inland waterway and rail modes and to install environmental management for the planning of the area and accompanying future enterprises and salaried workers.

The principle of cooperation, from which industrial economy stems, finds its origins and its reality thanks to its positioning in close proximity to one of France’s first chemical platforms and the presence of dynamic industrialists in its region. Exchanges of materials, energy, services and waste have formed an industrial system for over 20 years on the Plateforme chimique de Roussillon and in connection with the enterprises set up on INSPIRA. So here it is what already exists and needs to be considered and mobilized.

Where the planning of the region is concerned, the elected representatives worked first on land economics with a reflexion on the density of industrial parks, the conversion of wasteland and the long-term tools of land management. In view of the many partners mobilised, a strategic steering committee chaired by the Sous-Préfet and the Président du Syndicat Mixte are careful to respect common aims and the necessary reactivity to respond to industrial projects.

A public/private consortium on innovation and applied research must make it possible to have a model which allows both the implantation of services and enterprises according to existing, potential or created synergies. Approximately 700 000 euros are engaged for 24 months work.

Contact:

- Vincent DAÖN – Director
  vincent.daon@zone-industrialo-portuaire.fr
  04 74 86 83 80

More information:

- www.zipsalaisesablons.fr

Interweaving dynamics

to work towards a territorial ecosystem

The exemplary region should integrate, transversally and systemically, most of the solutions involving all the flows and channels solutions presented in this document.
The Green Valley cluster (the SEM* for economic development of Epinal Golbey and enterprises including Norske Skog and Pavatex) located on the territory of the Communauté d'Agglomération of Epinal, in the Vosges Region, shows the capacity of a region to integrate circular economy through different operational fields. A wide synergy is deployed around the papermaking firm of Norske Skog Golbey and contributes to the creation of a real ecosystem which is not limited to the industrial world.

The different actors have grasped the potential value of processing scrap and rejects. A maximum of waste is reclaimed as resources. As an example, Norske Skog is working on a project for reclaiming its paper ashes so that they can be used in the plastics industry. The enterprise has also identified the potential of the molecules contained in wood thanks to a partnership set up with Harmonic Pharma, a pharmaceutical start-up in Nancy for the development of new therapeutic and nutritional substances for human and veterinary use.
The majority of virgin fibres used by Norske Skog is made up of connex products from sawmills in the East of France which enables them to commercially reclaim the coproducts of their process (50% of losses); at the same time the wood resource is preserved as the sustainable supply of recycled paper is privileged for a yearly tonnage of 500 000 tonnes, the equivalent of the selective collection of around 26 million French consumers.
Cooperation between actors is also effective in the field of energy. The steam (unavoidable energy) from Norske Skog's thermomechanical pulp making process finds new applications in its internal process and is reclaimed commercially with the neighbouring enterprise, Pavatex (manufacture of wood fibre panels). Energy consumption is thus reduced and costs optimized, associating environmental respect and competitiveness. Beyond the cluster, the municipality of Golbey is planning to have its heat network supplied by Green Valley Energy's project of mutualising a boiler on the site.
Moreover, the reduction in consumption and water discharge is a major stake for Norske Skog, whose production depends heavily on this resource. Thus the enterprise has its own water treatment plant through which it treats both its own waste water and that of Pavatex.
Where transport is concerned, Green Valley offers a multimodal service enabling the reduction of all road transport and approaching 50% of its deliveries by rail. In addition to this, in order to find answers to the logistic stakes, Norske Skog mutualises the purchase of wood with Pavatex allowing it to make economies of scale, secure access to the resource and avoid conflicts of use between wood for industry and wood for energy.
The Green Valley cluster is fashioning the region's landscape and the local authorities are also mobilising on this territory as they have planned future implantations on the 60-hectares eco-park opposite Norske Skog's site. This area will be the object of planning to facilitate the perfect balance between the actors and activities of the territory.

This example, one of the most successful and innovative in France, demonstrates the capacity and opportunities for deploying circular economy. Fruit of collective intelligence, the actors have synergized the territorial ecosystem by encouraging local development and cooperation.

Conclusion

Cyril ADOUE

Consultant expert in Industrial Ecology at Inddigo,
Researcher at ENSIACET and Chairman of the ORÉE
Circular economy Working Group

Since 2012, the notion of circular economy, which was erstwhile more confidential, has been largely disseminated in French and European societies… to the point of entering into the law in the strictest sense in 2015. As a macroscopic view of a regional economy, it is supported, as has been illustrated in this book, by tools which have been tried and tested and which demand, faced with environmental and socio-economic stakes, the rapid materialisation of efficient actions. This global approach, which is necessarily rooted in experimentation and development, is systemic by definition. A good understanding of the potential offered by a multiscale approach and of the levers enabling implementation, means a clear perception of its many economic, environmental, local and geostrategic implications, both in the short and in the long term. As we have shown, it interacts directly with the issues of agricultural production and town planning, it involves the efficiency of the use of water, energy, non-renewable materials, the transport of goods and people, waste produced by our activities, etc.

For around 20 months, the Circular economy / Territory Working Group has thus questioned these interactions thanks to testimonials from a number of members, enterprises and regions. It has enabled, for each of these channels, to identify what these interactions could be from a practical point of view. Those taking part in these sessions were able to meet each other, share their experience and how they see the practical form that this transition could take towards circularity, the performances it is possible to reach, the difficulties and levers which can be mobilized or which have yet to be created. This publication is the fruit of the work accomplished. It highlights these developments and focuses, at this stage of the maturity of the concept of circular economy, on the importance of sharing experience and good practices so that they can be assimilated and duplicated.

The progression of knowledge however always goes with the emergence of new questions. This work has also enabled new fields of reflexion to appear. Biodiversity anecdotes highlight the numerous interactions between the examples brought to light by members and the sphere of life. Present in certain approaches and definitions of circular economy, the link with the living world is often reduced to the circulation of the organically-sourced materials in the technosphere. Wider reflexion on these circular economy/biodiversity interactions would make it possible to clearly reposition circular economy within the Biosphere.

Lastly and whether the examples are relative to town planning, agriculture, transport, waste, water or energy, etc., a number of the experiments or developments studied in this book highlight the importance of choices and decisions relative to “planning” in its widest meaning. These questions need to be asked on the scale of the design of the building, the quarter, of the town or more widely its area of influence. In the era of metropolisation, the importance of planning choices and the way in which they will condition the transition to circularity in years to come impose deeper examination of levers which can be activated or which need to be created in this field. ORÉE will work on continuing these reflexions in the months to come through its working group…

Postface

Geneviève BOUCHÉ

Doctor in the science of organisations, futurologist specializing in the recomposition of entrepreneurial fabric, member of the Société Française de Prospective and vice-chair of Club Jade

All these projects are a homage to the men and women who let their intuition guide them. Some wanted to walk in history's footsteps and imagine desirable futures, to think about solutions which were either handy or purely adventurous! Others decided to share their inspirations, at the risk of losing credibility. And others oriented their research work, sometimes with very precarious means. And lastly others decided to act with the resources they had managed to make available…
Little by little, this movement is gaining strength and becoming stronger than the tide: we are changing civilisations. We are leaving a mode of operation based on the law of the strongest and moving towards the law of the most adaptable. This model is not an innovation, we are simply adopting that of other species living on this earth.

On the other hand, to rise to action means that we have to innovate more than ever! Actually, innovating is something we like doing. Those who opened the way and who meet at ORÉE are beaming, even if there are still many fundamentals to hinder their work. But, because they are radiant, they are inviting us to go forward… And moreover, the world is toppling around us. Day after day, people are speaking out and common sense is gaining ground on dogmatism.
We are managing to broach real questions, and specifically, how can we lead the multiple transitions that we need to lead. Adapting our financial model is going to take time (50 years). The investments designed for the current model are far from being amortized but nevertheless, our collective will encourage us towards new investments without which the migrations cannot take place.

But sometimes dramatic events are beginning to play a leading role: we are beginning to see the signs induced both by global warming and a model of society which respects humans very little, and urges populations to act urgently. The period of time allotted to our changes of models, even though it is only at discussion stage, is growing shorter. We have to be crafty and not let the old world crumble while the new one is trying to find its rightful place.

We are lucky to have a digital world! It makes objects intelligent and humans collaborate. It makes it possible to miniaturize production locations and distribution processes. It frees men from fastidious and dangerous tasks, and gives us time for thought and discussion.

And in this way, man sees his fellow human beings in a different light: they are no longer just neighbours and colleagues. He is no longer a producer on weekdays and a consumer at the weekend. He wants to be involved in a fair way, he can become the actor of his social and financial environment at each stage in his life. Local authorities have understood this and are positioning themselves more and more as facilitators in relation to fellow citizens initiating potential progress. Other waves of innovations, to come, will make it possible to increase this change in social climate.

This document is a homage to all the pioneers who are leading us towards a utopia, which of course needs to be discussed beyond COP21, as it is a model of a mature society that we have the extraordinary opportunity of building.

Latest publication :
"*Changeons de civilisation*" – Kawa editions

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Definitions / acronyms

AEU: Approche Environmentale de l'Urbanisme - environmental approach to urban planning

Agenda 21: Strategic action plan presenting a project for the sustainable development of a territory (town, inter-municipality, region, etc.) and the setting up of short, medium and long term actions.

BioNGV: Bio Natural Gas Vehicles

Biosourced materials: Materials from plant or animal biomass. These products are used mostly in construction work and the building industry (insulation materials, panels, glues, etc.).

BPW: Buildings and Public Works

Carbon sink: Natural or artificial reservoir which captures and stores atmospheric carbon: oceans, forests, etc.

Cascading water: Maximising the use of water thanks to diversified and successive uses (hot, cold, for rinsing, etc.).

CH_4: Methane

Clinker: Solid residue from the combustion of urban waste in incineration plants.

COMETHE: Conception d'Outils Méthodologiques et d'Evaluation pour l'Ecologie Industrielle – Design of Methodological and Assessment Tools for Industrial Ecology

ELV: End-of-Life Vehicles

Grey energy: Quantity of energy needed to produce a material or product

HEQ: High Environmental Quality

Heating or cooling network: All the public or private pipes transporting heat or cold to several delivery points for heating, air-conditioning and industrial processes. The fluids can be of different types: hot, iced, overheated or steam heat.

Life cycle analysis (LCA): Systemic approach enabling an assessment of the environmental impacts of products, services of a company or process for extracting raw materials to the end-of-life of waste.

Methanisation: Technology whereby organic material is broken down by the action of micro-organisms in an anaerobic environment. It produces a digestate which is rich in organic materials and biogas.

Mycelium insemination: Providing the soil with fragments of mushrooms or other organic substrates to intensify the production of nutritional elements.

N_2O: Nitrous oxygen

PCET: Plan Climat Energie Territorial - Territorial Climate and Energy Scheme

PLU: Plan Local d'Urbanisme - local town planning

Rebound effect: Increase in consumption that compensates the resource saving initially planned for a technological innovation. Most often occurs as for monetary reasons, but can also be social or organisational.

Resilience: Capacity of an organism, organisation or system to readapt and resist external disturbances.

SCoT: Schéma de Cohérence Territoriale - Territorial Cohesion Scheme

SEM: Société d'Économie Mixte – MEC Mixed Economy Company

SME: Small and Medium-sized Enterprises

STP: Sewage Treatment Plant

Unavoidable heat or energy: The unavoidable part of the energy used for an industrial process and released in the form of heat. It can be recovered for thermal reclamation or for producing electricity.

WEEE: Electrical and Electronic Equipment Waste

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