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Adaptation of Drinking Water Services to Climate Change in France

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SYNTHESIS

Adaptation of drinking Water Services to Climate Change in France

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Abstract

We are already being confronted with the impact of climate change. But this confrontation is only going to become more acute in the years ahead. Of that there is no doubt. However, there is an element of uncertainty about the precise extent and actual impact of these changes. On top of this we need to bear in mind that population growth will result in an increase in drinking water demand.

The objective of this technical synthesis is to assess the impact of climate change drinking water resources, to examine the vulnerability of drinking water networks. Then, it aims to analyze good practices, actions, innovations and adaptation strategies in order to relieve the quantitative and qualitative gap, of drinking water resources in France.

Key Words : Climate change, vulnerability, Drinking water, adaptation, water services

Résumé

Selon les dernières observations scientifiques, nous serons vraisemblablement confrontés dans le futur aux effets du changement climatique. Il n'y a aucun doute quant au sens de son évolution, bien que résident encore quelques incertitudes sur son ampleur et son réel impact avenir. Il faut ajouter à ce constat une augmentation de la population qui se traduira par une hausse de la demande en eau potable.

L'objectif de cette synthèse est d'identifier l'impact du changement climatique sur la ressource en eau potable, évaluer la vulnérabilité de cette dernière et de répertorier les bonnes pratiques, actions, innovations et stratégies d'adaptation mises en œuvre par les services d'eau potable afin de pallier à un éventuel déficit qualitatif et quantitatif de la ressource en France.

Mots clé : Changement climatique, vulnérabilité, eau potable, adaptation, services d'eau

Glossary:

CNRM : National Meteorological Research Centre

COP : Conference of the parties

IFEN : French Environment Institute

IPSL : Institut Pierre-Simon Laplace

ONEMA : National office for water and aquatic environment

PBACC : Adaptation basin plan on climate change

PNACC : National Adaptation Plan to Climate Change

QMNA5 : Annual minimum flow with the probability 1/5 of not being exceeded in a year

RMC : Rhône Mediterranean Corsica

SAGE : Land use planning and water management scheme

SUMMARY

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INTRODUCTION:

For the international community, there is no doubt about climate change. Its effects are irreversible but there remains some uncertainties about it real impacts. IPCC, Intergovernmental Panel on Climate Change, is a group of expert who collect the necessary data to assess what is at stake, the impacts and the geographical variability of climate change.

Water resource and drinking water in particular, is significantly affected by the effects of climate change, it's a consequence of the rise of temperatures and the temporal variability of rainfall. The adaptation of the drinking water services is very important in facing up to the decrease in resources quality and quantity.

In France, the first national adaptation plan to climate change was written in 2011. This plan indicates 5 actions aiming to attenuate the climate change effects on water resources. In 2015, The COP 21 conference took place in Paris but there wasn't any mention about water, nevertheless 2/3 of the 147 parties include that water issues are very important (Le Jeune, 2016). In the same year, the water agencies Adour-Garonne and RMC wrote a basin adaptation plan to climate change (PBACC), in November 2015. It's up to the Loire and Bretagne water agency to launch the process of PBACC. All these actions are proof of French actors' willingness to adapt to climate change.

In this synthesis, a focus is made on French drinking water services adaptation measures to climate change. For this, a bibliographic study has been realised to highlight the current situation of adaptation methods already carried out by the drinking water services to protect the resource and the drinking water supply in context of climate change. We will assess first of all the need of drinking water. Then, we will evaluate the impacts of climate change in France and the vulnerability of the drinking water resources. Finally, a typology is made to identify the methods of adaptation of French drinking water services to climate change

CONTEXT :

WATER ABSTRACTION IN FRANCE :

In France, the annual precipitation is 800 mm, part of which feeds the flow, the balance returns to the atmosphere as evaporation, evapotranspiration (Météo France). According to the IFEN water abstraction and consumption are respectively 20% and 3.5% of average annual inflows, renewable resources vary between 170 and 200 km^3. As a result, France has a volume of renewable water of 3200 m^3 / capita, which is close to the European average (Blum, 2005) In addition, several studies would assess the water needs for all uses to be globally 1000m3 / hab (La Jeunesse, 2015).

The intensity of resource exploitation in France is estimated at 19% by IFEN, which is less than its European neighbours, Belgium (46%), Italy (32%), Spain (23%), Germany (22%) (Baker, 2007). Therefore, France seems well resourced by water, except that a regional disparity has been observed (Baker, 2007). Indeed, between 1997 and 2007 twenty departments each year reached the limits of consumption, this number can triple during the driest years (2003 2005 2006) (Paumier et al., 2007).

Drinking water for its part represents 3.4% of the annual abstraction and 1% of net consumption. They are estimated at 6 billion m^3 divided into 2.5 billion m^3 of surface water and 3.5 billion m^3 of groundwater (Haffner, 2007).

DRINKING WATER NEEDS :

Between 1980 and the 2000s, the volumes taken to the ASP remained relatively steady (Blum, 2005). Since 2005, a new trend has been observed, withdrawals for drinking water production decreased by 6% between 2005 and 2009 (Chazot et al., 2012), while the population increased by 7% between 1999 and 2009. However, climatic conditions have an influence, such as during the drought of 2003 where an increase in consumption of 3.4% was observed for up to 6.2 billion m^3.

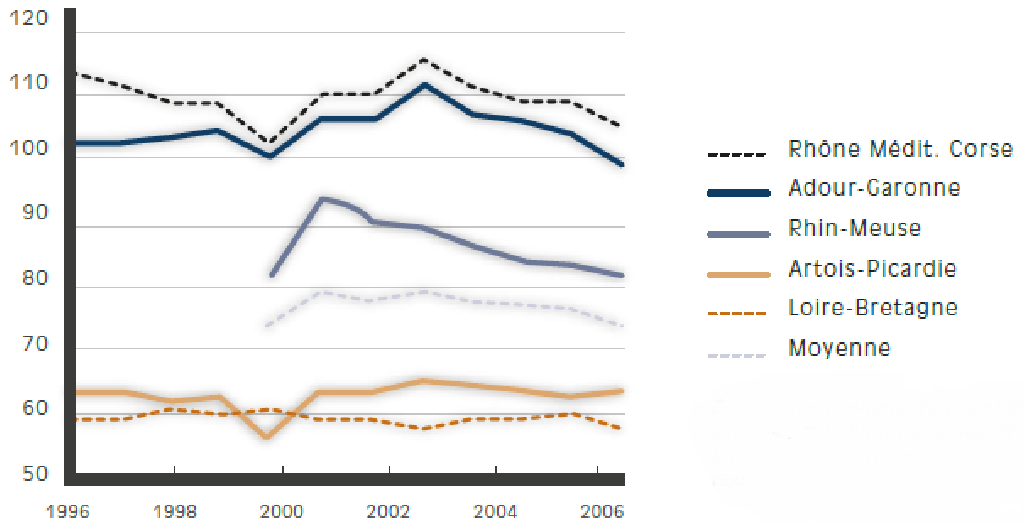

Figure 1 : Evolution of the volume of drinking water taken per capita for different basins. (Agence de l'eau Adour-Garonne, 2014)

IMPACT OF CLIMATE CHANGE ON WATER RESOURCES:

CLIMATIC PREDICTION IN FRANCE IN 2030-2050

Future climate change in the case of France is simulated from two French regional climate models ARPEGE-Climat and LMDZ respectively developed by CNRM-Météo France and IPSL, within the framework of the national adaptation plan to climate change. Selected simulations are based on two scenarios: the first optimistic (B2) and a second pessimistic (A2) of the Intergovernmental Panel on Climate Change (GIEC) (PNACC, 2011).

Increases in average temperatures measured at 2 ° to 3 ° C will be observed in the 2030-2050. Change in the mean precipitation is relatively uncertain for winter and autumn where it varies among backgrounds, regions or scenarios. However, both scenarios show a decreasing trend in rainfall in spring and summer. Nevertheless some uncertainties remain: the natural variability of the climate, the ability of computer models to reproduce the functioning of climate and the quantities of greenhouse gas emissions during the period targeted for modelling (PNACC, 2011).

VULNERABILITY OF DRINKING WATER RESOURCES:

Surface water :

The results in France show a decline in annual average flows across the territory between 10% to 40% according to the simulations of the project Explore 2070, except the right bank tributaries of the Lower Rhône river. All models project more severe low flows on the outlets of large watersheds, the QMNA5 could fall up to 70% on the Garonne River. Concerning flood flows, it can't detect a trend taking account of the divergence between the projections. On the other hand, according to the 5th IPCC report, the risk of floods and flooding will increase in the coming years.

The quality of surface waters will be impacted by flood events that are expected to amplify in the coming years. Pollutants in the soil will be transported by leaching, 90% of contaminants would be carried during these events (Laperche, 2012). The increase in temperature and the decrease in river flows will affect the dissolved oxygen concentration of the water that will fall, and this will lead to a decrease in self-purifying capacity of surface water (Guiraudie, 2016).

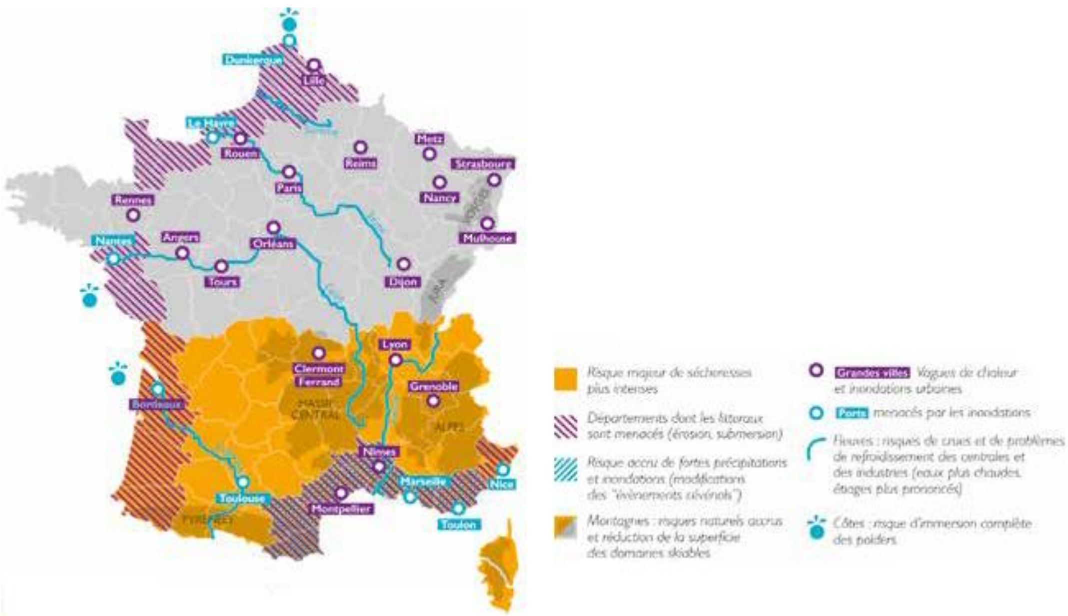

Figure 2 : Predictable impact of climate change on surface water in France in the 21st century (Ademe, 2015)

Groundwater :

The results of Explore 2070 show a general decline in piezometry associated with a decrease of the groundwater recharge between 10 and 25%, with areas that will be most severely affected, particularly the Loire basin and the South West France, where the decrease in the groundwater level will go up to 50%.

In addition to changes in recharge, coastal aquifers will be impacted by changes in sea level. The elevation of the sea level may lead to saltwater intrusion in the aquifer which will deteriorate water quality. On metropolitan aquifers, saline intrusion due to changes in sea level should have a limited impact. A bigger impact could be related to a decrease in the groundwater level associated with the decrease in recharge or increase in groundwater abstraction (EXPLORE 2070, 2012a).

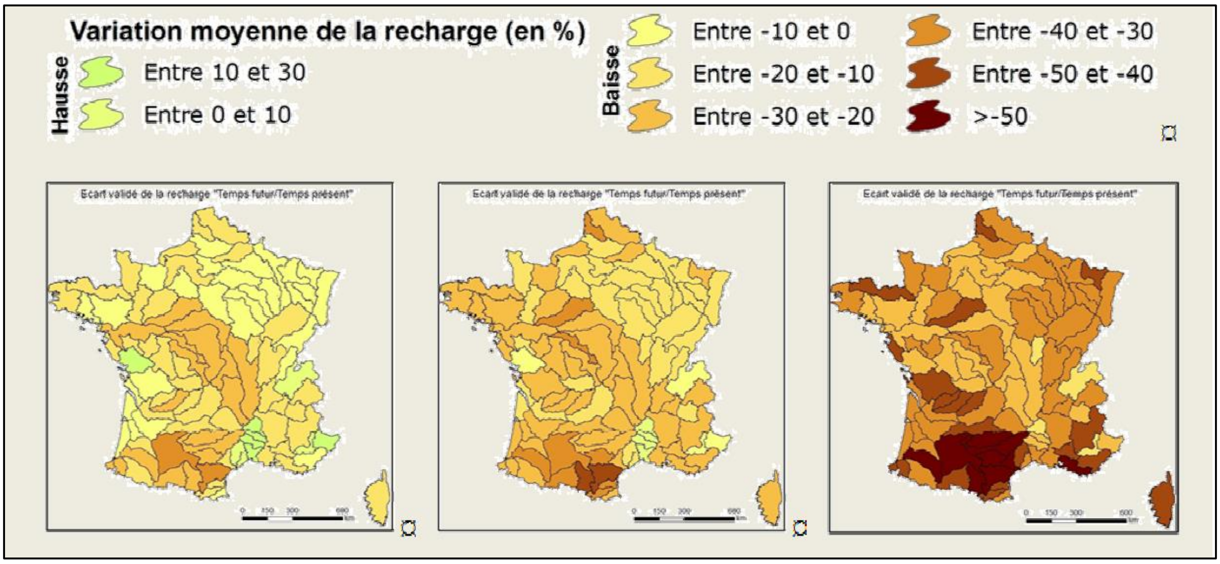

Figure 3 : Minimum, medium and maximum of the groundwater recharge future / present (Explore 2070, 2012a)

TYPOLOGY OF DRINKING WATER SERVICES ADAPTATION TO CLIMATE CHANGE:

According to IPCC the adaptation is « an adjustment of human or natural systems in response to climate stimuli or their effect, in order to attenuate harmful effects or take advantage of beneficial opportunities ».

Adaptation refers to all the political, technical, institutional, societal and behavioural actions that drinking water supply must do to limit the negative impacts or take advantage of opportunities created by climate change.

MANAGEMENT OF LEAKS AND CONSUMPTIONS:

Reduction of leaks:

According ONEMA, water losses by leaks are estimated at nearly 22% of the water collected and transported but can reach 40% in some areas. Water losses are an additional abstraction on the resource, but also have other impacts such as energy required for pumping and production, the use of chemicals to treat drinking water.

Therefore, it is important to initiate a process to manage optimally the water loss and this by implementing actions that will aim at:

- a better knowledge of the networks and its functions ;
- the establishment of monitoring and research tools of network losses.

The knowledge of the networks consists of harvesting structural data of pipes and their environment such as diameter, the material, the year of laying the pipeline. Historical data contribute to understand the facility conditions including interventions related to breakage and leakage of pipes and connections. The evolution of knowledge about heritage can be evaluated by using key performance indicators. In France, five basic indicators are used:

- the performance of the distribution network,
- the linear index of network losses,
- the linear index of uncounted volumes,
- the index of knowledge and patrimonial management of drinking water systems,
- the average turnover of drinking water systems,

The tools used to limit water loss and the conservation of network performance are :

- sectorization which is the decomposition of the network into several levels of sub-networks for which the volumes are measured continuously.
- pre-location acoustic leakage is to estimate the sound levels comparing to a reference level.
- modulation of pressure: it consists of reducing the pressure on the network without disturbing the continuity of service. Thus, the corresponding rate of leakage is reduced and afterwards the calibration allows monitoring of network operation.
- remote reading of consumption can detect abnormal consumption during hours when water demand is lowest, in order to detect leaks.

Thus we can determine the operations to be carried out (restoration of pipelines, renewal of network, and establishment of an interconnection). Nonetheless, such facilities are very expensive, between 545 and € 680 million over 15 years in Languedoc Roussillon (Bullet, 2008) in addition to the disruption caused sources (service continuity disruption, traffic).

Hydro-economic kits:

The objective of using water-saving equipment is to reduce drinking water consumption for the current uses (kitchen, shower, sanitary). The water-economic kits allow water savings up to 30% (Rinaudo et al., 2011). These measures concerning the installation of reducing flow / pressure on taps, shower heads and low consumption flush toilets.

Awareness campaign:

The awareness campaigns are primarily focused on improving the knowledge and not as a direct incentive to adopt efficient actions. Awareness campaigns have objectives related to scarcity issues, rationalization of consumption and make people aware of vectors in their entourage.

The MAC Eau program (Master of Water Consumption) was carried out by the Gironde local authority (Département) within the SAGE for deep aquifers. This project aims to preserve water resources in the deep aquifers linked to drinking water supply. To do this, local authorities have distributed 80,000 hydro-economic kits and have installed 70 rain water collectors and pressure modulators on the Syndicat Intercommunal d’Alimentation en Eau Potable de Blayais network which is a community group responsible for providing drinking water locally. These operations allow water saving of up to 1.9 million m^3 / year. (jeconomiseleau, 2016)

Pricing :

In France, the law on water and aquatic environments (LEMA) encourages water services to implement incentive pricing, which will encourage users to reduce their consumption. Several fee-paying structures can be considered (binomial pricing, pricing offset by gradual, seasonal pricing). The use of decision support tools informs policy makers on the economic interests of a pricing change.

The hydro economic models are exploratory tools for decision support that enable stakeholders to consider a wide range of water management strategies by providing information on the technical impacts, physical, environmental, climate and socio -economic various scenarios measures or water management policies that might be implemented. A hydro economic model was developed in a research framework to design a program that would alleviate the deficit cheaply across the Orb river watershed (Hérault) in 2030. A set of actions "without regret» were identified such as the improvement of drinking water networks efficiency, regardless of the chosen climate scenario (Grémont et al., 2015).

INCREASE WATER STOCKS FOR THE FUTURE:

With the decrease of water reserves due to increased demand and climate change, actions are to be taken to maintain the balance between demand and resource availability.

Artificial groundwater recharging:

Artificial groundwater recharging consists of introducing into an aquifer a quantity of water from surplus surface water to increase the amount of groundwater available. Treatment can be done depending on the quality of water charged, the type of injection and the quality of groundwater. The injection of the water is generally carried out through high surface infiltration basins or injection wells (Haffner, 2007). In addition to controlling the level of groundwater, aquifer recharge would be to:

- Stock water cheaply.
- Enhance the groundwater quality by reinjection of surface water with better quality.
- Limit the intrusion of salt water in coastal areas.

In France, there are 49 artificial groundwater recharge sites for drinking water supply. The most commonly used method is the injection of large surface infiltration basins. It's important to manage the surrounding river system rigorously because water for aquifer reloading should not be lacking for other uses of the resource. Artificial recharge of groundwater should be considered as an instrument of global management of the watershed (Weuilleumier et al., 2008).

Water transfers:

Besides the construction of dams and reservoirs which remains the easiest solution for securing drinking water supply which has large impacts on the environment, water systems and water quality (trapping sediments, pollution concentration, interruption of ecological continuity). A new type of water security is water transport which has sprang up in France like the Aquadomitia project. This project consists of extending networks provided by the Rhone and the interconnection with those provided by Orb, Herault, the Canal du Midi and l'Aude, in partnership with the Departments of Aude and the l'Hérault (Région Languedoc-Roussillon, 2013). The project objective is to carry 15 million m^3 with a capacity of 2.5 m^3 / s. Moreover, the project has an impact on the Rhone River particularly during times of tension when the question of abstraction volumes arises. Add to that other Departments and Regions suffering from water stress during drought that wish to have a similar project : the North of the Gard and the Vaucluse (Conseil scientifique du comité de bassin Rhône Méditerranée, 2014).

Soils unsealing:

Soil unsealing is a technique of infiltration by rainwater infiltration basins, rain gardens and valleys. This solution reduces river pollution, and will capture as much rainwater during extreme events and recharge the groundwater by infiltration

Several projects have been developed with the support of the water agency. The city of Agde has created retention basins / infiltration with a capacity of 13,200 m3. The city of Voreppe in Isère, has set up a reclaimed marsh soil and a retention basin of 2900 m3. Unsealing of banks of the Rhone was undertaken by the city of Laveyron by putting a permeable green grassed amphitheatre and car park that will facilitate the infiltration of storm water (Agence de l'Eau Rhône Méditerranée Corse, 2014).

Abstracts protection:

Since the water law of 16 December 1964 water services had to set up protection areas in their abstractions, this stops the spread of pollutants. Moreover, in context of climate change, flooding will increase which leads to the transportation of pollutants. Local authorities need to develop surface water abstraction protection systems. The Intermunicipal Association of Water and Sanitation of Ganges which draws its drinking water from the Hérault, installed a trout-meter on its water abstraction. The trout-meter consists of a tray containing young trout, through which the abstracted water transits. Trout being highly sensitive to polluted water, if an abnormal excitation of the trout is observed, an alarm is signalled to block the water pumping. However a backup solution (drilling or interconnection to a neighbouring network) is expected in this case to ensure continuity of service (Molières, 2016).

Tools for decision making support:

The organisation, called (use the French name)union of the waters of Viviers which manages the production and drinking water supply of the town of Niort, undertook an assessment of future needs through a modelling program resource-needs since 2004. The study is divided into several stages. First data collection was carried out of drinking water measurements over recent decades. Next modelling of the resource associated with a modelling of consumer behaviour is done by taking into account several parameters: linking the daily maximum temperature / consumption of the day, price elasticity effect on water, demographic and urban evolution, seasonal effects, and crisis scenarios on a historical basis (drought). In the end, the organisation says if it's necessary to add new resources, taking into account the hypothesis of increased frequency of climatic events (severe low water levels or heavy rainfall event) (Lambert, 2016).

ALTERNATIVE SYSTEMS FOR DRINKING WATER SUPPLY:

Waste water reuse:

The reuse of wastewater is often used for irrigation or watering of green spaces. However, the households' water can be reused for the drinking water supply. Indeed, Singapore appears to be the world leader in this technology, where the city-state has some difficulties for its drinking water supply. In 2003, NEWater project was developed. It extended the wastewater treatment by coupling several processes (ultrafiltration, reverse osmosis and UV disinfection), and this allowed Singapore to provide 30% of its drinking water from this alternative resource (Martine, 2015). However the process uses a huge amount of energy power and chemicals.

Desalinisation:

Desalination is a technique for producing drinking water by separating water and salt from sea water and brackish water. Distillation and reverse osmosis are the two most common techniques for this process. However, desalination has a significant impact on the environment, such as habitat destruction due to large water withdrawals, discharge condensation, discharge treatment products (anti-scaling products, de-foamers and chlorine derivatives) and greenhouse gas emissions (Dunglas, 2014). On the other hand, there are other solutions for reducing desalination energy consumption and thus reduce its environmental impact and its cost (choice of powerful and energy-saving equipment, optimizing the design of the station, Research on membranes) (Baker, 2007). The new processes for reverse osmosis have an energy consumption of from 2.5 to 3.5 kWh / m^3, while the distillation processes can reach 19 kWh / m^3 (Dunglas, 2014). The coupling of desalination with renewable energy is timely. In Morocco a first pilot project of a water desalination plant was recently inaugurated in the Benguérir city that runs on solar energy, producing 5 m^3 / h (Savage, 2016).

Desalination of sea water in France is not highly developed. Most units are small and concern Islands, e.g. Belle-Ile-en-Mer (Morbihan), Ile d'Yeu (Vendée) or near Sables d'Olonne (Vendée). The Sables d'Olonne project, carried out by the Department, the union and the Vendée water department of energy and the Sydev (a maintenance organisation), will have to provide for a short fall, an estimated 4 million m^3 for 2025. This could lead to the construction of a plant with a capacity of 10 to 20,000 m^3 per day by 2020 coupled to renewable energy to offset the energy problems. A technical feasibility, legal, financial, environmental and energy study was funded by the Region Pays de la Loire and the Water Agency Loire-Bretagne at the end of 2011 (Collet, 2012).

Appr’eau a support tool by Veolia:

This is a support tool that gathers information about drinking water supply, it provides diagnostic support to:

- assess the situation of water supply in the area studied,
- study the local context and determine the possibility of practical implementation of alternative methods (desalination, wastewater).

The tool is adapted for diagnostic support for areas with little data. Moreover, it provides access to a documented database that contains technical, regulatory and economic information (Pagotto et al., 2007).

REDUCTION OF GREENHOUSE GASES:

The reduction of greenhouse gas emissions is very important for water services, like any industrial activity, the Drinking water supply and treatment generates greenhouse gases that are largely responsible for climate change.

Energy optimization:

Emissions are generally due to the energy consumption for water transportation (removal, drainage outlet) and the inputs used for water treatment processes (activated carbon powder or grain, coagulant flocculants, oxygen for ozone production). However changing the amounts of greenhouse gases emitted depends on several parameters:

- the resource (surface water, groundwater) ;
- types of energy and fuels ;
- nature and quantity of chemicals used ;
- topographic situation of production and distribution systems.

An example, in the case of drinking water supply for Paris, groundwater abstraction would generate between 21.4 and 26.2 g CO_2 / m^3 while surface water will have an emission level between 78.8 and 84.2 g CO_2 / m^3 (Duguet et al., 2007).

To reduce greenhouse gas emissions, it is important to replace electrical equipment by efficient ones, the establishment of renewable energy sources (turbines, wind, solar). Regarding chemicals, studies have shown that it is possible to optimize the frequency of regeneration / change activated carbon which constitutes 75% of greenhouse gas emissions (Duguet et al., 2007).

Install micro turbines on networks:

The use of turbines on rivers for electricity generation is a common practice in France. In fact, 1.5% of national energy production comes from hydropower. However, the establishment of turbines on AEP Networks is less common. The turbines convert the potential energy of the water into electrical energy, which makes them more effective in mountainous regions where water height plays a part. In France, in 2008 the water service "Nice Cote d'Azur" was the first to generate electricity from its drinking water system especially with the micro turbine at Cape Cross, located upstream of the Nice treatment plant. Three other micro turbines will follow with a capacity of 1.9 MW, which represents 60% of the electricity required to operate the Nice tram transportation system (Enerzine, 2010).

In Tahiti, « Vaimarama » is a project, resulting from cooperation between the city of Papeete Polynesian Waters, that introduced a micro turbine system in 2014. This system produces 95,000 kWh, equivalent to the annual consumption of 35 Polynesian households (Tixier, 2015).

Other projects have emerged especially with Suez Environment using two micro turbines on the drinking water networks, in Vallauris and in Monestier, each with a capacity equivalent to the annual consumption of 23 and 38 households.

Cogeneration:

Cogeneration consists of producing electricity and heat from a single energy source. MICROSOL is a new innovative project by Schneider Electric based on this principle. It enables to produce electricity, drinking water and heat for isolated rural communities. A pilot project was launched in 2013 in Cadarache, its principle is based on using solar power with photovoltaic panels that generate electrical energy and thermal energy. The heat will be used to accelerate the evaporation-condensation of the water cycle that will produce 2 m^3 / day of drinking water. MICROSOL is capable of powering a village of 500 inhabitants 24h/24 into electricity, heat and water (Souquet, 2013).

CONCLUSION:

The study of the impact of climate change on drinking water resources allowed assessing the vulnerability of French regions to this phenomenon, which will vary according to the regional context. Add to this, several questions remain linked to the real evolution of climate change because of many uncertainties of its impact.

The water services have developed strategies of adaptation to face up to these vulnerabilities. Many projects have been undertaken at different levels to ensure continuity and quality of drinking water supply to the effects of climate change. These operations involve different levels: Management of consumption and losses, securing the drinking water resources, evaluation of the application of alternative drinking water supply systems, reduction of greenhouse gas emissions.

Furthermore, new opportunities for development are expected for the drinking water services to ensure better adaptation strategies for climate change. This concerns the possible optimization of the drinking water treatment in areas where water abstraction suffers from the decline in their assimilative capacity. The implementation of a potential carbon footprint indicator for the drinking water supply in order to optimize the energy consumption looks unlikely. It would be difficult to implement because it requires a good knowledge of the network (Bolognesi, 2016), this « carbon footprint » can also results in the integration of the climate challenge in drinking water schemas plans.

It is thanks to these developments associated with the will of the services of potable water to develop and look for effective ways to have the best adaptation policy to ensure a good transition to the evolution of the climate change.

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