Potential of geothermal systems in Picardy

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Geothermal systems are not only about electrical plants or urban heating networks, but also concerned with geothermal energy assisted with a heat pump. In the former region of Picardy (North of France), 97% of the territory is suitable for very low temperature geothermal power. The French Agency for the Environment and Energy Management and the Picardy Region decided in 2016 to finance a facilitator to encourage geothermal use. To carry out this aim, it is important to consider the geothermal context in Picardy, its regulation and the potential, but also the local tools available, such as an inventory of geothermal installations or training sessions for architects. The objective is to help increase the number of geothermal projects in Picardy.

La géothermie ne concerne pas seulement les centrales électriques et les réseaux de chaleur urbains, mais également la géothermie assistée par pompe à chaleur. Dans l'ancienne région Picardie (dans le nord de la France), 97% du territoire est favorable à la géothermie très basse température. L'ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie) et la Région Picardie ont décidé de financer une mission d'animation en géothermie il y a un an. L'animateur connaît le contexte géothermique en Picardie, avec la réglementation et le potentiel, mais également les outils locaux comme le recensement des installations de géothermie ou la formation pour les architectes. La mission consiste ensuite à aider à l'augmentation du nombre de projets de géothermie en Picardie.

Los sistemas geotérmicos no sólo se refieren a plantas eléctricas o redes de calefacción urbana, sino también a la energía geotérmica asistida por una bomba de calor. En la antigua región de Picardía (Norte de Francia), el 97% del territorio es apropriado para la energía geotérmica a muy baja temperatura. La Agencia Francesa para el Medio Ambiente y la Gestión de la Energía y la Región Picardía decidieron, en 2016, financiar un sistemapara fomentar el uso de la energía geotérmica. Para llevar a cabo este objetivo, es importante considerar el contexto geotérmico en Picardía, su regulación y el potencial, así como las herramientas locales disponibles, tal como un inventario de instalaciones geotérmicas o sesiones de formación para arquitectos. El objetivo es ayudar a aumentar el número de proyectos geotérmicos en Picardía.

When we hear about geothermal systems, we usually picture electrical plants or urban heating networks. But high near-surface underground temperatures are not available everywhere. In the North of France, the former region of Picardy (now included in the new region called Hauts-de-France, gathering together the former Picardy and former Nord-Pas-de-Calais Regions) is a perfect example. Indeed, 97% of the territory is suitable for very low temperature geothermal power. This article describes the geothermal context in Picardy, the tools available, key actions already taken and the promotion of shallow geothermal use.

Geothermal context in Picardy

Environmental objectives and geothermal potential

Following the Grenelle Environment Forum in 2007 and the law "Grenelle II" in 2010, Picardy was given some ambitious objectives: to multiply by 21 times its actual geothermal heat production by 2020 (SRCAE, 2012). In Picardy, there is no possibility to create geothermal electrical plants and there are only a few cities suitable for a geothermal urban heat network, mainly in the south of the region (Analy, 2013). Indeed, only for 23 cities do all three major factors occur: high thermal consumption (linked to the population density), high enough temperatures, and sufficient flow rate of the Dogger (a geological formation whose aquifer can reach 70 °C and 160 m^3/h in southern Picardy).

As 23 cities creating an urban heat network by 2020 is not likely, the French Agency for the Environment and Energy Management (ADEME) and the former Picardy region turned their attention to very low temperature projects to enhance geothermal heat production. For that, they lead different programmes described further in this article and also propose different possibilities of funding for the projects.

Very low geothermal energy (Maton *et al.*, 2012, volume 2) is assisted with a heat pump, as the extracted temperatures are often below 25 °C. It can work with geothermal probes (also called a closed loop) or with a water table (open loop) and finally gives about 45 °C to a building's heat. It can cover heating or cooling needs of collectives (pools, schools, etc.) and private (office) buildings. According to the Geothermal Atlas of the French Bureau of Geological and Mining Research (BRGM), there is a real potential for this kind of geothermal project, with 97% of the territory suitable for very low temperature geothermal power (Maton *et al.*, 2012, volume 1).

French Mining Code reform

The French Mining Code was reformed in 2015 (Decree n°2015-15) concerning very low geothermal heat projects called Geothermal installations of Minimal Importance (GMI). If the geothermal installations meet some criteria, the project formalities are simplified.

For geothermal probes and water table, the criteria are:

- boreholes less than 200 m deep,
- power taken from underground amounting to less than 200 kW.

Extra criteria for water table systems are:

- water temperature below 25 °C,
- flow rate less than 80 m^3/h,
- water is returned to the same aquifer it was taken from.

Of course, there may be some additional local specific constraints such as protection

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zones of drinking water wells.

The last element to take into account is the administrative constraint map, drawn up by the BRGM with methodology described in Herbaux *et al.* (2013) and located on the website Geothermie-perspectives (ADEME BRGM, 2015). This map shows three different possibilities for both geothermal loops (closed or open): a green, orange or red square. If the square is green, there are no administrative constraints and the project is only subject to registration. If the square is orange, declaration is required, but a hydrogeological expert must approve it. For a red square, an authorisation request is necessary.

Tools available and keys actions already done

Inventory

In the frame of geothermal development in Picardy, ADEME Picardy, in partnership with the Regional Council, commissioned the Geother engineering consulting firm to carry out an inventory of geothermal installations in the former region. The goal was to know precisely the number of geothermal installations in Picardy, with their technical characteristics. It also aimed to update the geothermal figures of the Energy, Air and Climate Regional Scheme (SRCAE, 2012) of Picardy and change the environmental objectives concerning geothermal systems. The inventory consisted of a quantitative part for private individual installations and both a quantitative and qualitative part for public/private installations.

Based on the inventory results (Geother, 2016), the main conclusions are:

- The geothermal sector is less developed in Aisne, an area in the east part of Picardy, than in Oise, in the south-west, and Somme, in the north-west.
- There are 11 times more water table geothermal installations than geothermal-probe installations. This could be explained by the relatively recent appearance of probe technology (the first probe installation in Picardy took place in 2008).
- 77% of the installations belong to private individuals and 23% are run by public and private project managers.
- The number of public projects is roughly equal to the number of private projects.
- Private individuals aside, cold production reaches 54 TOE (0.6 GWh)[1].
- The whole geothermal heat production in Picardy is estimated at 1238 TOE (14.4 GWh), with 77% of it coming from public/private installations.

Architect training

Another action was the creation of a professional training course for architects about possible geothermal uses in construction and renovation. This training was proposed by Afapi (a local training organism for architects) and conducted by Ecome, an engineering consulting firm.

This training allows architects to become familiar with the administrative and regulatory aspects of geothermal projects, as well as the different actors of the sector. They are also taught some technical notions, and an economic scale to projects is given, along with possible sources of funding.

Two training sessions took place in 2016, in January in Soissons (Aisne) and in April in Amiens (Somme). Other regions of France have asked for the same training (Grand-Est in June 2017, for instance).

Audit of geothermal installations in progress in Hauts-de-France

ADEME Hauts-de-France (the new region including former Picardy and former Nord-Pas-de-Calais) commissioned the Ecome engineering office to audit 19 geothermal installations of the region (10 in Picardy and 9 in Nord-Pas-de-Calais). Beyond the 19 different analyses and advice for improvement, the aim of this study is to make a crossing analysis of installations and find the main defects that can occur in very low temperature geothermal installations. There is also a project to make 6 example sheets to expand the data catalogue of geothermal installations in Picardy.

Geothermal promotion in Picardy

Facilitator functions

In 2016 the former Picardy region and ADEME financed the position of facilitator for geothermal promotion thanks to FREME – the Regional Fund for Environment and Energy Management – and Fonds Chaleur funds.

The facilitator is in charge of promoting geothermal installations in former Picardy and is based in UniLaSalle, a post-graduate engineering school in geosciences in Beauvais. The objective is to increase the number of geothermal projects in Picardy. As the potential for geothermal heating networks is not so easy to exploit, the strategy is to create a number of little projects with very low temperature geothermal installations. The role of the facilitator is to boost and structure the sector, linked to the development of renewable energies in the region, by:

- improving and promoting communication about very low geothermal systems and associated technologies,
- improving communication among the different actors,
- offering free technical advice for project managers (not including private individuals) with pre-feasibility studies.

In one year, the facilitator was requested to carry out 18 potential or pre-feasibility studies; 2 of these led to more complete feasibility studies and 8 are still on-going due to a lack of information on the project or their recent start.

Maps from the inventory

Based on the inventory of geothermal installations in Picardy, maps were created (***Figure 1***) (Dourlat, 2017), showing different things:

Geothermal installations exploited on 31 December 2015 in Picardy (public/private institutions).

Most of the geothermal projects running were carried out in Somme and Oise and there is an overwhelming majority of open loop geothermal projects. As mentioned above, this could be explained by the relatively recent appearance of probe technology. Concerning the geological context, the chalk water table, which is known to be favourable to geothermal energy, covers Somme, three quarters of Oise and the northern Aisne territories. Thus, projects were created where geothermal energy could be easily accessed. Even though Picardy is in the North of France, there is an increasing need for cooling alone or in parallel with heating. The total geothermal heat production then reaches 982 TOE/year (11.4 GWh) and the total cold production reaches 54 TOE/year (0.6 GWh). There is a difference of 3 GWh between the heat production announced from the inventory (14.4 GWh) and that calculated for this map because the inventory takes into account the installations that are not running (which could run again if restored).

1 1 TOE= 1 Ton Oil Equivalent = 11,630 kilowatt per hour (KWh) = 11.6 gigawatt per hour (GWh)

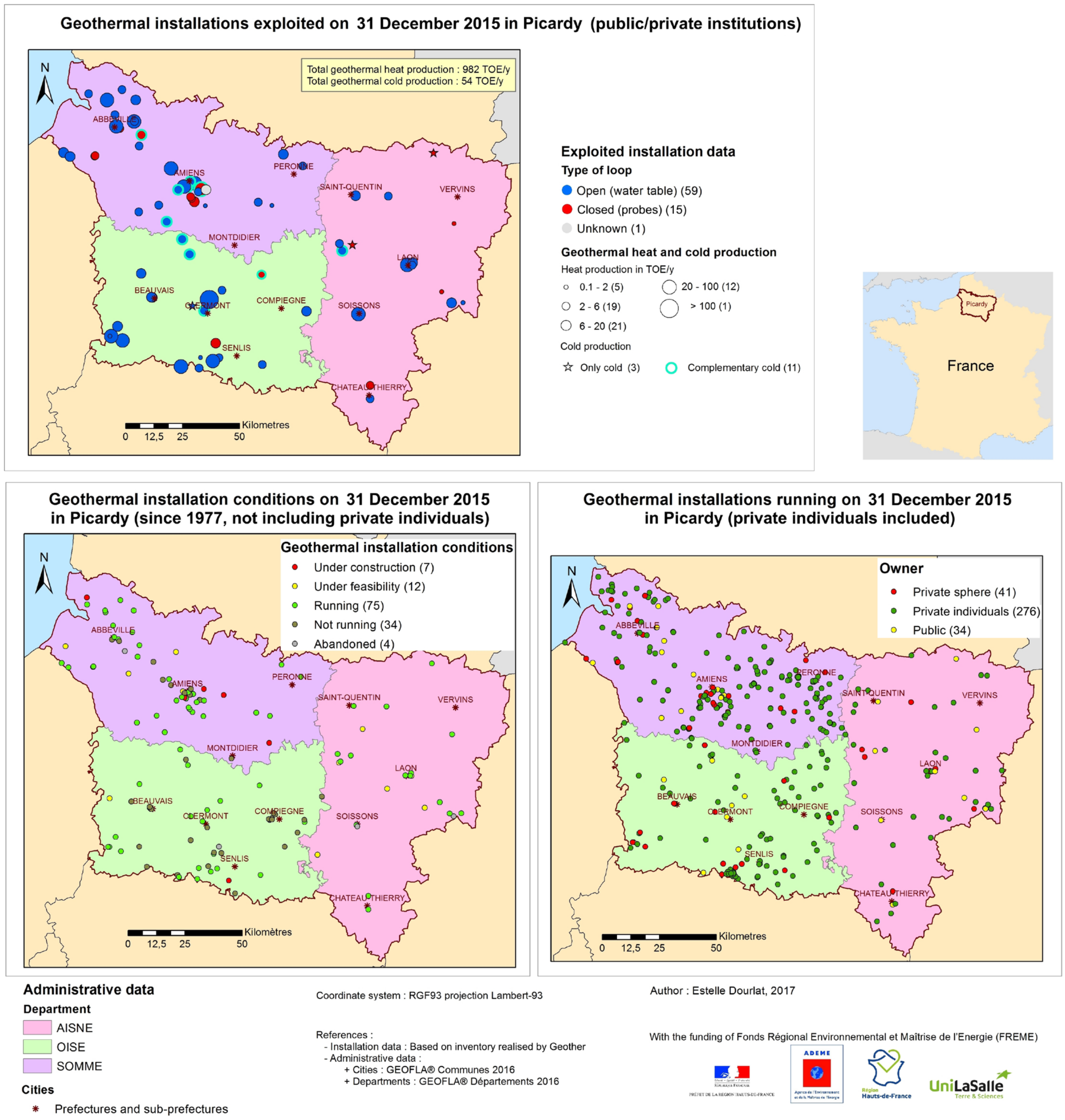

Figure 1: Three maps showing different characteristics of geothermal installations in Picardy, France.

Geothermal installation conditions on 31 December 2015 in Picardy (since 1977, not including private individuals).

This map shows that most of the geothermal installations are running or in the feasibility study stage, a reflection of the ongoing development of the technology since 1977. Still, 75 running installations 40 years after the first geothermal project in Picardy shows that the sector needs help in its development. Another point is that most of the abandoned or not running installations are located in the southern Picardy, in the department of Oise. Many of the geothermal installations in this department were constructed before the 1990s and suffered from the aftermath of the second oil price shock and from the lack of knowledge of the importance of maintenance.

Geothermal installations running on 31 December 2015 in Picardy (private individuals included).

The majority of geothermal installations belong to private individuals. The number of installations owned by public structures and the private sphere (companies) is almost the same. But these installations added together do not reach even half of the number of private individual installations. That means that both public and private sector are wary about geothermal energy, and a great deal of work is needed to increase these figures.

An update is planned once a year, since new geothermal projects should be declared online.

Construction site coverage

One project of the facilitator assignment is to create a database of photographs and videos about geothermal installations in Picardy.

For that, the first video – subtitled in English – was produced (Dourlat, 2016) at the probe field construction site of Sir John Monash Centre in Villers-Bretonneux (Somme). This geothermal project mainly aims to cool the centre and to do this, 41 probes of 185 m deep were carried out.

Entitled "Geothermal in the Service of History", the video introduces drilling images, with the explanations provided by Geoforage. The project is also put in context by a Project Manager (Australian Government, Department of Veteran Affairs) and

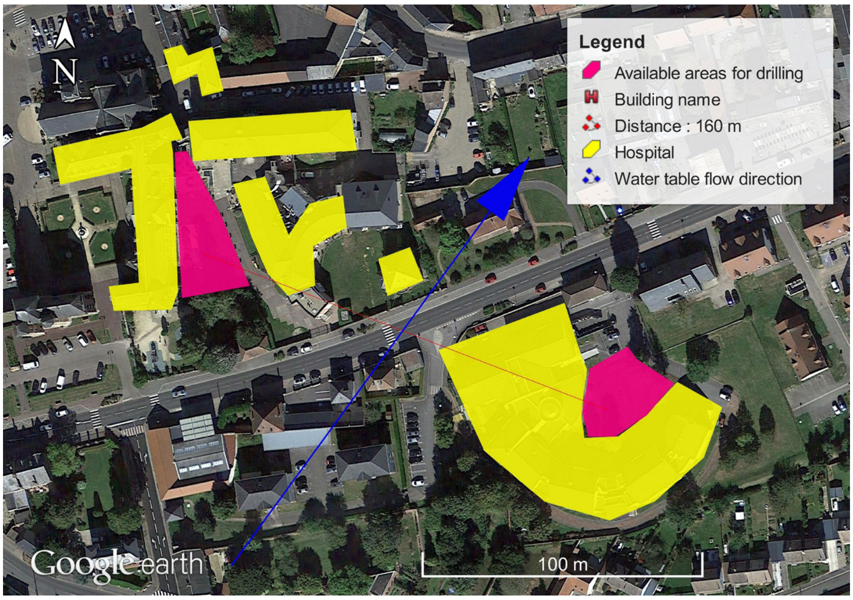

Figure 2: Land and building constraints for the geothermal project of Crèvecoeur-le-Grand Hospital.

an architect (from COX). They present why the Australian Government decided to use geothermal energy and some motivations (governmental constraints, producing both heat and cooling, renewable energy, long lasting, invisible).

This video (Dourlat, 2016) brings a practical view of a geothermal project to people who wish to learn more, but cannot visit a work site. In fact, once the work is finished, only the machine room will be visible. So geothermal energy will simply be invisible to unaware visitors.

This first coverage from Picardy allows those who are curious to discover more about probe-type shallow geothermal energy. It also shows with images that geothermal projects are a reality in the northern part of France.

Example of a pre-feasibility study

Crèvecoeur-le-Grand Hospital wished to switch from oil-fired boilers to a renewable source of energy. As it is partly classified as an historic site, they decided to study geothermal energy, since it is much less visible than wind turbines or solar panels. They asked for a pre-feasibility study from the facilitator to gather arguments to decide the relevance of geothermal installations for their project. They wished if possible to stay in the frame of Geothermal installations of Minor Importance (GMI) to avoid administrative procedures.

The first step of this study was to explain the different types of geothermal installations that could possibly exist for the project. The necessary steps to follow in a project were also detailed (feasibility, drilling, heat pump, maintenance), as well as the possible subsidies for such a project.

The second step was to present the study context (size of the field, siting of the buildings, expected heat consumption).

Then comes the underground potential. According to the map (ADEME BRGM, 2015), there is no administrative constraint for closed or open geothermal loops for GMI. The database of boreholes shows that chalk is from 9 to 125 meters deep. As the thermal conductivity of chalk may be from 0.92 to 3.8 W/(m.K) and as the use of probes is possible as of 1.5 W/(m.K), there is a potential for geothermal probe implantation.

For water table geothermal energy, the Geothermal Atlas puts the water table's depth at 38 m underground. The flow rate is supposed to be from 10 to 50 m^3/h, for a temperature between 10 and 15 °C. The crossing of the data from the hydrogeological map, the boreholes around the project site and the measures taken from a piezometer located 500 m southwest of the project site, shows that the water table chalk is indeed found between 32 and 41 m deep. Unfortunately, there is no flow rate registered in the sector. That means that there is a potential for water table geothermal energy, provided the flow rate values are high enough.

Then, there is a reminder about heat consumption: the geothermal heat should be dimensioned so that 50% of the needed power can cover about 75% of the consumption. The 25% of consumption needs left should be covered by a non-renewable complementary energy source. Indeed, this residual need for heat is experienced only a few weeks a year (about 3 weeks), when the weather is the coolest. Dimensioning for 100% of the needed power is less efficient (economically and energetically) than using a complement.

For an approximate heat consumption of 2 GWh, and with different underground hypothesis, a pre-dimensioning gives between 9,750 and 15,200 linear meters of probes. For the water table geothermal energy, with a flow rate of 10 m^3/h and a borehole doublet, only 8% of the needs would be covered by the geothermal energy. With a flow rate of 50 m^3/h, about 50% of the needs would be covered by the geothermal heat.

The different scenarios are compared to the site map (***Figure 2***). It seems very difficult to place more than 50 probes in the available space. The best choice seems to be water-table geothermal energy. If granted, the AQUAPAC warranty is advised in this case, as the flow rate is not precisely known.

Thanks to this pre-feasibility study, the hospital obtained enough information to decide to go further with a feasibility study and is currently choosing the office to commission for the study.

Conclusion

The purpose of this article was to show that geothermal potential can exist where it is not possible to create geothermal power plants or urban heating networks. Picardy led some key actions to promote shallow geothermal systems and encourage new projects in its territory. There will be a real challenge with the merger of the former regions of Picardy and Nord-Pas-de-Calais, now a single region called Hauts-de-France. Indeed, some actions such as the inventory of geothermal facilities, architect training or establishing a facilitator of geothermal energy do not yet exist in the northern part of the new region, so this gap needs to be filled in order to homogenise the actions on the scale of the new region and to better promote the use of shallow geothermal resources and geothermal heating networks.

References

ADEME BRGM. 2015. Geothermie-perspectives, carte des contraintes réglementaires pour la Géothermie de Minime Importance (Interactive map of geothermal constraints for Geothermal installations of Minimal Importance). French Agency for the Environment and Energy Management (ADEME) and French Bureau of Geological and Mining Research (BRGM). ***http://www.geothermie-perspectives.fr/cartographie?mapid=40***

Analy, M. 2013. Atlas du potentiel géothermique des aquifères de la région Picardie. Tome 3 : Étude du potentiel de développement de la géothermie en région Picardie (Atlas of geothermal potential of aquifers in region of Picardy. Volume 3 : Study of the development potential of geothermal energy in region of Picardy). French Bureau of Geological and Mining Research (BRGM), Rivery. BRGM/RP-62381-FR.

Decree 2015-15. Décret n° 2015-15 du 8 janvier 2015 modifiant le décret n° 78-498 du 28 mars 1978 modifié relatif aux titres de recherches et d'exploitation de géothermie, le décret n° 2006-649 du 2 juin 2006 modifié relatif aux travaux miniers, aux travaux de stockage souterrain et à la police des mines et des stockages souterrains, l'annexe de l'article R. 122-2 et l'article R. 414-27 du code de l'environnement (Decree 2015-15 of 8th January 2015 on shallow geothermal energy). ***https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000030073515&dateTexte=20170314***

Dourlat, E. 2016. La géothermie au service de l'Histoire [VOST.En] / Geothermal in the service of History. Video, UniLaSalle, Beauvais. ***https://www.youtube.com/watch?v=BYAHJ4vLBlI***

Dourlat, E. 2017. Cartes des installations de géothermie en ex-Picardie (Map of geothermal installations in the former region of Picardy). UniLaSalle, Beauvais. ***http://www.geothermie-perspectives.fr/article/cartes-installations-geothermie-en-ex-Picardy***

Geother. 2016. Présentation du recensement des installations géothermiques de minimes importances en Picardie (results from the inventory of geothermal installation in Picardy). Geother, Nanterre. ***http://www.geothermie-perspectives.fr/sites/default/files/presentation_recensement_geothermie_Picardy.pdf***

Herbaux, M., Kreziak, C., Durst, P., Martin, J.-C., Cochery, C., Midot, C. 2013. Méthodologie d'une cartographie des contraintes et des risques géologiques liés aux forages géothermiques de minime importance (Methodology of a mapping of constraints and geological risk linked to geothermal drillings for Geothermal installations of Minimal Importance). French Bureau of Geological and Mining Research (BRGM), Orléans. BRGM/RP-61768-FR

Maton, D., Analy, M., Drust, P., Goyénèche, O., Herniot, P., Zammit, C. 2012. Atlas du potentiel géothermique des aquifères de la région Picardie. Tome 1 : Méthodologie et conception de l'Atlas (Atlas of geothermal potential of aquifers in region of Picardy. Volume 1 : Methodology and conception of the Atlas). French Bureau of Geological and Mining Research (BRGM), Rivery. BRGM/RP-61365-FR

Maton, D., Analy, M., Drust, P., Goyénèche, O., Zammit, C. 2012. Atlas du potentiel géothermique des aquifères de la région Picardie. Tome 2 : État des lieux et perspectives de développement de la filière géothermie (Atlas of geothermal potential of aquifers in region of Picardy. Volume 2 : State of play and development opportunities of the geothermal). French Bureau of Geological and Mining Research (BRGM), Rivery. BRGM/RP-61365-FR.

SRCAE, 2012. Schéma Régional du Climat, de l'Air et de l'Energie Picardie : Volet énergies renouvelables. (Energy, Air and Climate Regional Scheme of Picardy : renewable energies section). Picardy Prefecture and Picardy Region. ***http://webissimo.developpement-durable.gouv.fr/IMG/pdf/SRCAE_Volet_Energies_renouvelables_cle5fd311.pdf***