SOLAR ENERGY ROADMAP FOR 2050

Ville de Fourmies

Excerpts from the Document “Etude de Programmation Energétique »

Context

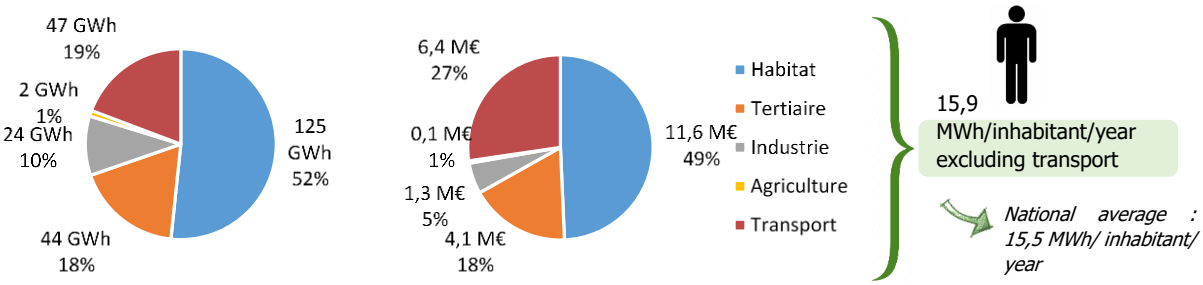
The city of Fourmies, in 2017, started to study the energy consumption patterns in the year 2018 order to fix the objectives and targets to be energy positive and carbon negative by the year 2050.

The baseline of the year 2015 was selected for the analysis of the energy consumption and the related energy expenditures to define the objectives of the year 2030 and 2050.

The data below is the simulation of the energy consumption data for the city divided into different activities and sectors for energy consumption. Excluding the transportation sector, the annual consumption is approximately 196 GWh which entails a total expenditure of approximately 17 million euros.

General vision

The annual consumption, in supply exclusively outside the territory (gas, electricity ...), reaches close to 241 GWh in final energy for an overall expenditure of approximately 23.5 million euros, half of which is spent by households.



Graphique 1 : Consommation du territoire par secteur (à gauche) et dépense en millions d'euros (à droite) en 2015

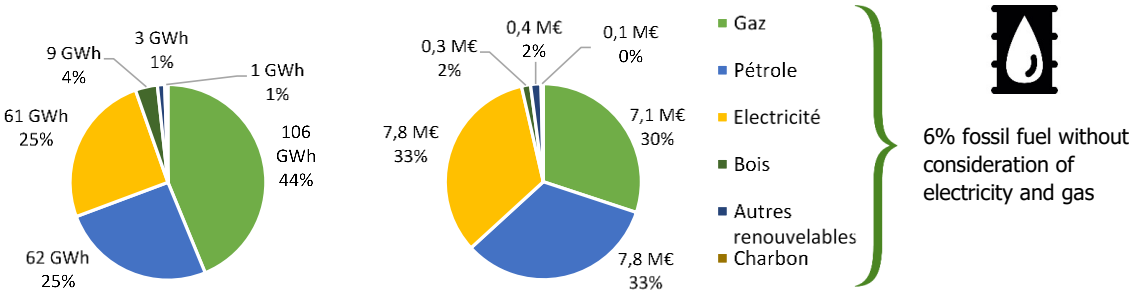
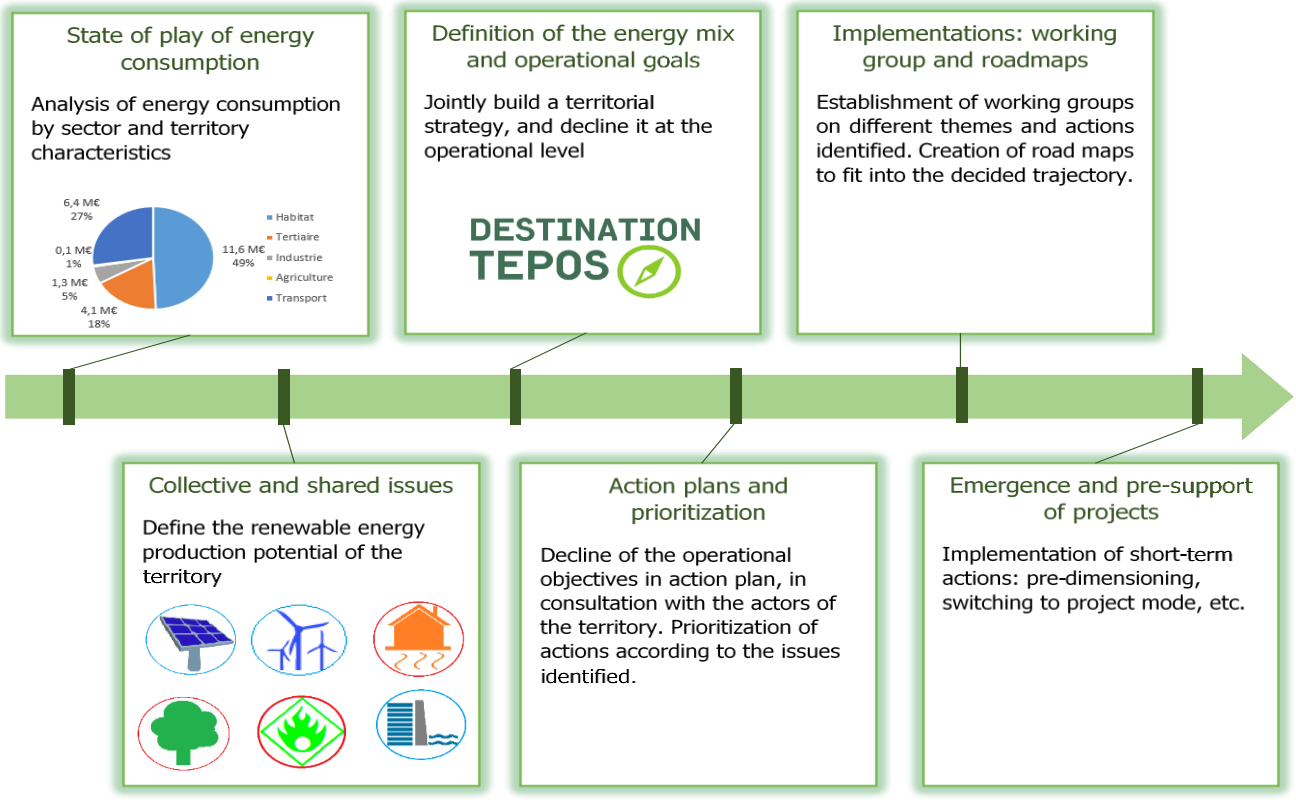


Figure 1: Consumption per sector (at left) and the associated expenses (to the right) in 2015

ENERGY STRATEGY APPROACH



The pertinence of a solar energy roadmap for the year 2030 and 2050 are co-related to the energy consumption of the individual or collective buildings. The increase in the uptake of the energy efficiency activities is important for the increase in the part of local solar energy consumption in the energy-mix.

Energy Efficiency Objectives:

The city through its energy roadmap has co-designed with various stakeholders, various scenarios of energy efficiency measures in the residential and tertiary sector as described.

Some assumptions have been considered for the definition of the scenarios:

- Between 2020 and 2030, the reductions in energy consumption are linear as between 2030 and 2050
- The works are carried out with a goal of thermal performance type label BBC renovation (which could be revised as the building codes are revised)
- Between 2020 and 2030, the proportion of renovation of single-family homes and multi-family dwellings is 1: 2: 1 renovated house for 2 apartments (in 2030, 12% of individual houses will be renovated and 52% of apartments with a BBC objective renovation).
- Awareness regarding the uptake of eco-friendly gestures will have to be widely achieved
- The distribution of living space between single-family homeowners and single-family homes is not a given in the framework, this distribution exists in terms of the number of housing (and not living space). It has been estimated taking into account an average surface of single house rental of 90m ² and a floor area of the owner occupants average of 60m ²
- For the tertiary sector, by 2030, all energy savings are distributed in proportion to the initial consumption "municipal buildings and public lighting", "public buildings other than communal" and "other tertiary and services"

Three scenarios had been defined to give us the provisional understanding of the objectives:

- **Scenario 1:** It's a "let go" scenario wherein the heritage buildings are renewed with an urban renewal rate of 0.1% (about 2 buildings destroyed and 2 buildings built by 2050). A gain of 20% in comparison to the initial energy consumption (heating / programming work, ...) on 3% of the total built surface. There wouldn't be any renovations (energy, insulation etc..) for the other municipal buildings

- **Scenario 2:** it is a "voluntary" scenario wherein the heritage buildings are renewed with an urban renewal rate of 0.1% as for scenario 01. In addition, there are two types of renovation planned for the other municipal buildings:
    - global renovations (to reduce the initial consumption by around 50%)
    - high-performance renovations (to reduce initial consumption by around 70%).

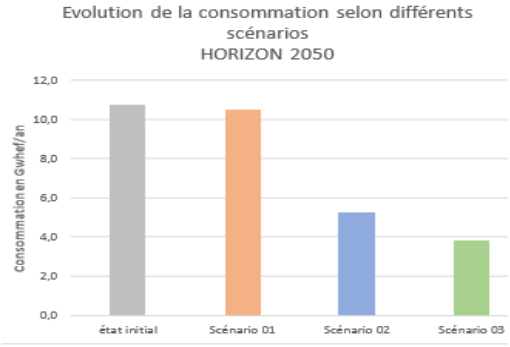
  By 2030, the two types of renovations are carried out on part of the heritage concerned (about 40% of communal built areas are concerned). By 2050, renovations are all planned with a high-performance objective on part of the heritage (76% of built-up area was considered renovated).

- **Scenario 3:** it is an "ambitious" scenario. The heritage is renewed with an urban renewal rate of 0.1% as for scenario 01. In addition, all the building renovations are all planned with a goal of very high energy performance[1]. By 2050, all the buildings will be renovated.

Important: The "Loi Elan" is a law in France which is obliging all the tertiary buildings with the superficies superior to 1000m² to attain 40% energy economy by 2030 and 50% energy economy by 2050. The reference years for these consumptions will have to be at least 2010.

The scenario 2 (red dotted line), represents the scenario chosen as an objective for the year 2030 while the scenario 3 (purple dotted line) has been marked as a target for the year 2050. These objectives help us to globally reduce the energy consumption and display an exemplarity in the process and create a ripple effect for the other actors in the region/territory.[1]

		Scénario 01	Scénario 02		Scénario 03	
	Initial[2]	2050	2030	2050	2030	2050
Consommation totale annuelle (GWhef/an)	10,8	10,5	7,2	5,3	5	3,8
Gain énergétique par rapport à la situation initiale de 2015		2,8%	33,10%	51,20%	53,20%	64,80%
Montant global d'investissement pour le renouvellement urbain[3] et la rénovation (depuis 2015) (surface concernée en m²)		2 100 k€HT (2 818 m²)	18 900 k€HT (21 207 m²)	38 300 k€HT (37 394 m²)	39 200 k€HT (36 959 m²)	50 600 k€HT (47 667 m²)



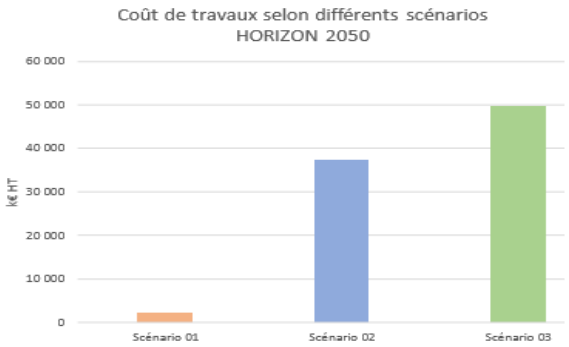


Figure 2: Synthesis of the scenarios for the heritage buildings

[1] "In this context, a very high energy performance" means a total renovation that can achieve energy savings of 40 to 55% depending on the use and type of occupancy of the building concerned (ie an energy label C or D depending on the performance of the initial building).

[2] The initial consumption was evaluated through recent energy bills (- 3 years, for 40% of buildings), Energy diagnostics (for about ¼ of buildings), ratios relative to heated surfaces (about ¼ buildings), other miscellaneous sources (10%).

[3] The cost includes both the demolition, construction of new buildings and the completion of renovations. For the record, the heritage is supposed to be renewed with an urban renewal rate of 0.1% (ie about 2 buildings destroyed and 2 buildings built by 2050).

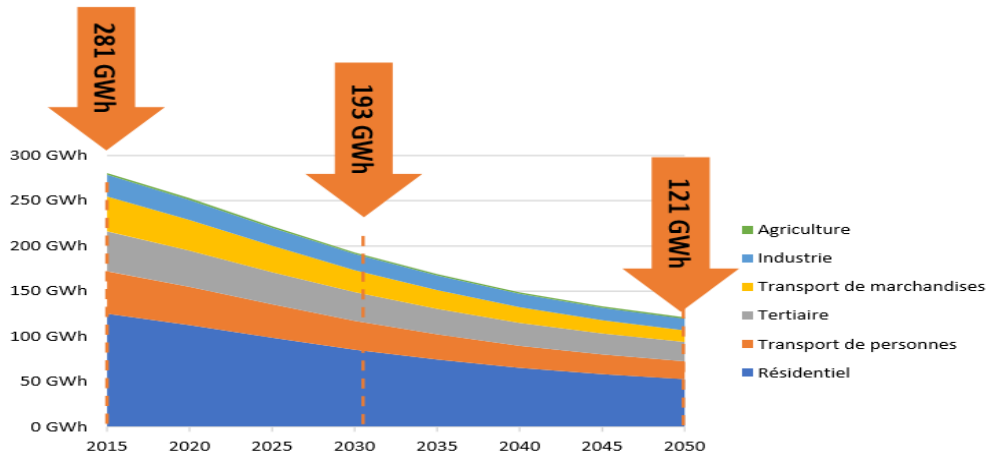


Figure 3: Evolution of Energy Consumption 2015 - 2050 (TEPOS)

The **"2030 target"** (in red & green cross lines) corresponds the necessary targets to the achieve the goals towards a TEPOS (Territoire Energie Positive) territory in 2050.

The "2030 VF target for Fourmies" corresponds to the averages of the choices made by the 5 public groups during a workshop. The graphs below show the results:

- As far as the optimisation is concerned, it concerns the projected consumption by 2030 according to the sectors,
- in the case of renewable energies, these are projected productions by 2030 depending on the types of energy.

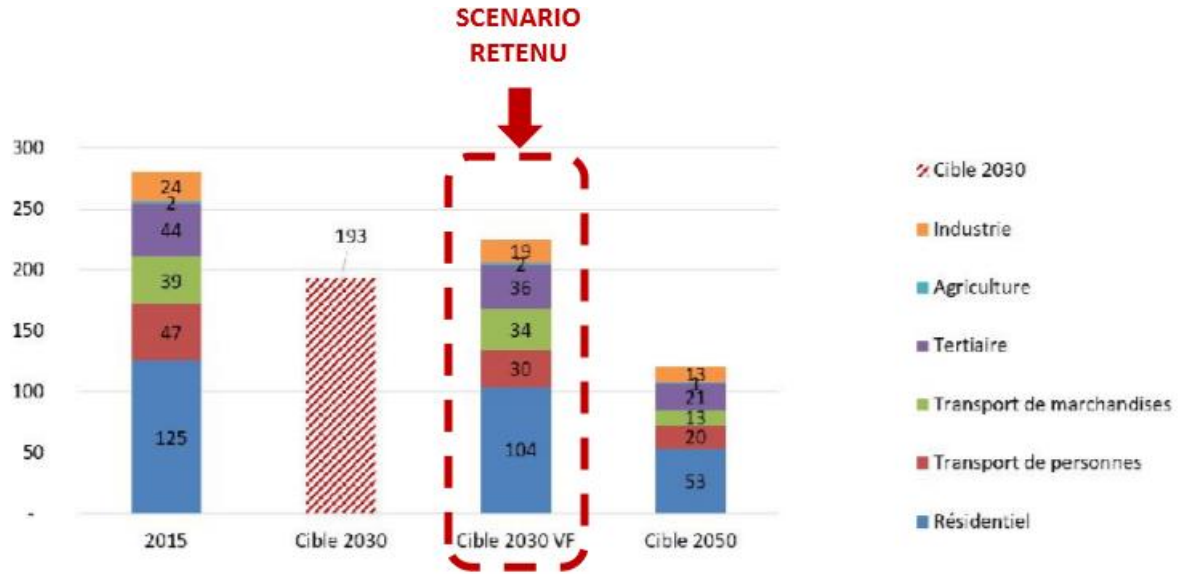


Figure 4: Energy consumption of the region in GWh/year

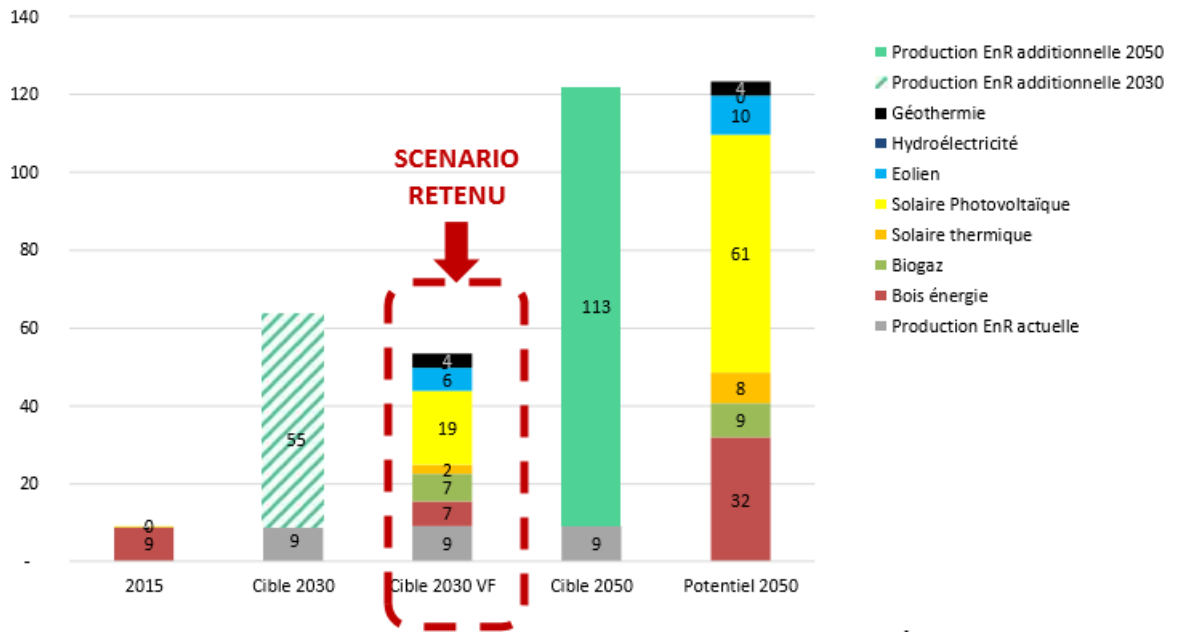


Figure 5: Prospective of renewable energy production en GWh/year

By 2030 and 2050, the energy consumption by sectors and their energy mix will be heavily modified. For example, the energy used for mobility is currently 94% of fossil origin (petroleum fuels). Gradually, with the ban on thermal engines from 2030, the oil consumption will heavily decrease and that of electricity will proportionally increase with the increase in biogas (CNG/LNG). There is a possibility of gas and electricity of renewable origins becoming the majority, eventually replacing oil completely.

The fixing of objectives regarding the reduction/optimisation of energy consumption permits us to accelerate the growth of renewable energy which could be integrated with the renovations and could cover up to 100% of the energy consumption needs by 2050.

Development strategy for Solar Energy

Through the co-creation activity and collective decision to define the target for the year 2030, the ambition for the production of 19 GWh/year through solar PV technology and 2 GWh/year through solar thermal technology was approved and selected.

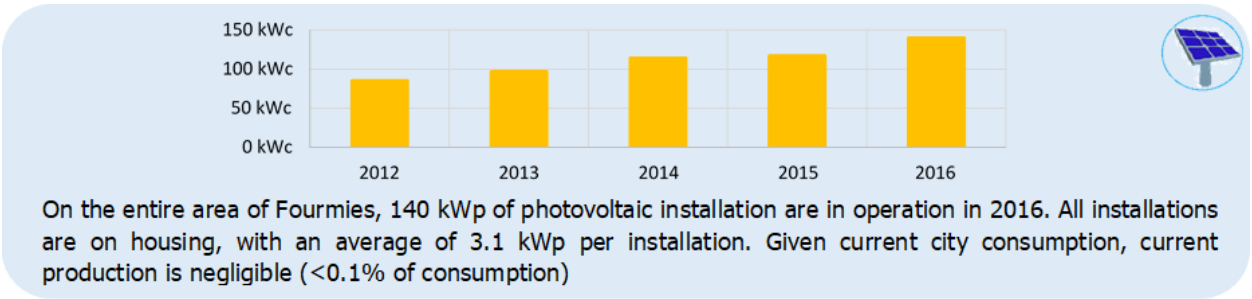


Figure 6: the installations of solar PV in 2016

The potential of the following renewable sources were studied carefully:

- photovoltaic

- Solar Thermal
- wind
- geothermal
- Wood energy

Potential for biogas has not been assessed under the previous deliverable, while another study is ongoing

EnR	Total Potentiel (GWh)	Part of production in the overall consumption in 2015 (%)	Regional Landmark (GWh)	
			2020	2050
Photovoltaic	61	31 %	1,1	6
Solaire Thermal	7,5	3,8 %	1,3	4
Wind	10	5,1 %	6,5	14
Hydro	0	0 %	0	0
Geothermal	1,7	0,8 %	3,9	7
Wood-Biomass	33	16,8 %	7	9
Heat recovery	6,5	3,3 %	2,7	3
Heat Network	10,6	-	4,3	10
Biogas	ND	ND	2,1	20

This detailed study has allowed us to highlight a gross potential of the order of **121 GWh** all renewable energies combined of which **68 GWh/year** will be originating from solar energy.

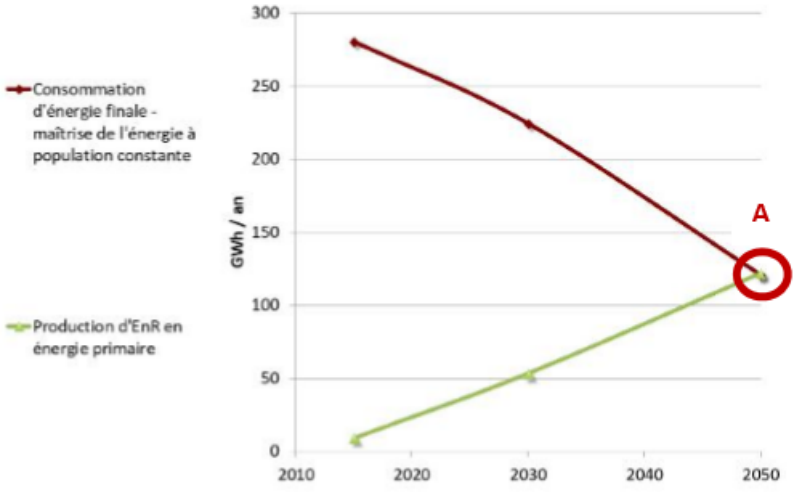


Figure 7: Horizon 2050

These technologies can contribute to increase the part of renewable energy of the city through individual and collective installations and contribute to respond to the energy needs of Fourmies through the establishment of a heat network. The heating network is not mentioned explicitly but is concerned by the implementation of the renewable energies mentioned above.

For the record, the table below shows the renewable energies production of the territory:

• The initial diagnosis was based on the 2015 baseline year

• The 2030 production comes from the choices made by the city of Fourmies during the Destination TEPOS workshop in January 2018.

• The 2050 production corresponds to the objective set for the achievement of the "Positive Energy Territory" performance.

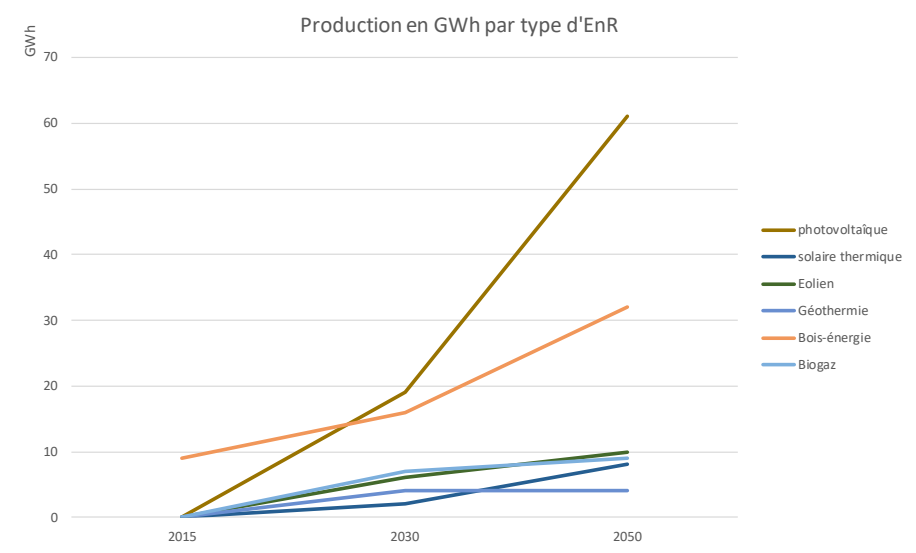


Figure 8: Production of ENR by sources (in GWh)

It is necessary to analyse the opportunities and obstacles before defining the definite strategy.

Solar PV- A detailed inspection gave us the understanding that:

- Housing and the small tertiary sector have the highest production potential in the city. However, in view of the socio-economic characteristics of households (and commercial partners), a strong need for awareness-raising, support and third-party investment appears necessary to tap into this potential,
- The significant potential requires considering a so-called massification / change of scale approach which involves maximizing the power installed on potential surfaces. One of the routes to be favoured consists the making the most of the electricity produced by total injection or collective auto-consumption with the prospect of combining private and citizen funding or even the establishment of a territorial operator,
- There are few areas greater than 1500 m² (42 buildings, including 5 municipal buildings) and present a major stake in production,
- The city manages 41 municipal buildings representing 7% of the potential in terms of surface. 27 buildings have a surface area of more than 600 m², which corresponds to PV plants greater than 100 kWp. The municipal buildings thus present an important lever to stimulate local demand and create the conditions of attractiveness for a photovoltaic deployment plan.

- The territory lends itself, in particular, to the prospect of evolution (cf. grid of the electricity network) towards collective auto-consumption and therefore the sharing of energy in a district. The economic model is still complex, but Fourmies can help prefigure this trend by aggregating private and public consumers and producers on pilot projects.

Solar Thermal- A detailed inspection gave us the understanding that:

- The use of thermal solar, alone, does not seem relevant in the town of Fourmies. Indeed, the municipality has an extremely developed gas network, as well as an interesting potential on heating networks. It is therefore important to rely on this solar thermal / gas coupling for the first few years.
- The municipality has many large buildings on its territory (either private or public), a sign of past or current industrial activities. Hence the solar thermal, for air preheating (opaque walls, etc.), could be favoured, making it possible to reduce the heat requirements to be produced by so-called "active" systems.
- With a view to deploying one or more heating networks, solar thermal energy could find its place with, in particular, existing ground surfaces in urban areas or outskirts (wasteland, etc.). The characteristics of the City are favourable to an opportunity assessment.
- Pool or eco-neighbourhood type projects are of particular interest for the use of thermal solar and access to supports (heat funds, etc.): heat network with solar thermal, solar carpets, etc.

To start with the uptake of renewable technologies, the following steps are being taken:

- Prioritisation of public buildings as a demonstrator and increase the solar uptake
- Feasibility studies of the potential buildings are undertaken with the following criteria:
    - Surface for solar installation
    - Adaptability of the building (age of building, structure, etc)
    - Production kWh/kWp
    - Orientation of the building
    - Potential for awareness
    - Model of consumption
- The projects with lower Rate of Return on Investments are preferred as demonstrators which also have innovative and collaborative aspects
- The public uptake of solar energy is mainly through the inclusion of social housing corporations in our projects (ex: the inclusion of 3 solar housing corporations for the installation of ~1700m² of solar thermal by 2024)

Presentation of Investments:

The Global Investments:

The initial investment required to produce 124 GWh of renewable energy over one year is estimated at 87 million euros.

The most significant investment concerns photovoltaics (66% of investment), this sector representing the main opportunity on the territory and will cover half of the energy needs of the territory by 2050 according to the TEPOS scenario.

The second investment is to a lesser extent (12%) on solar thermal, while wind, geothermal, wood energy and biogas have a similar investment of 5 to 6%.

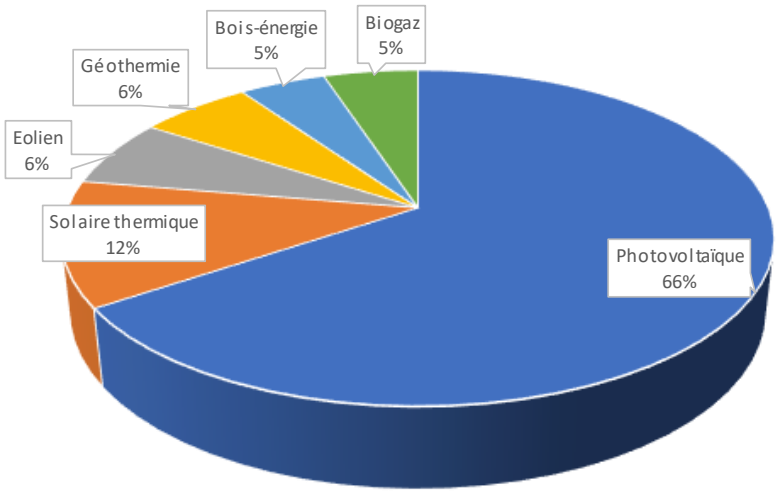


Figure 9: The investment for each source of EnR

For wind power, geothermal energy, wood energy and biogas, a large part of the investments are made between 2020 and 2030. For the two most involved renewable energies (photovoltaics and solar thermal) deployment and investment are continue between 2030 and 2050.

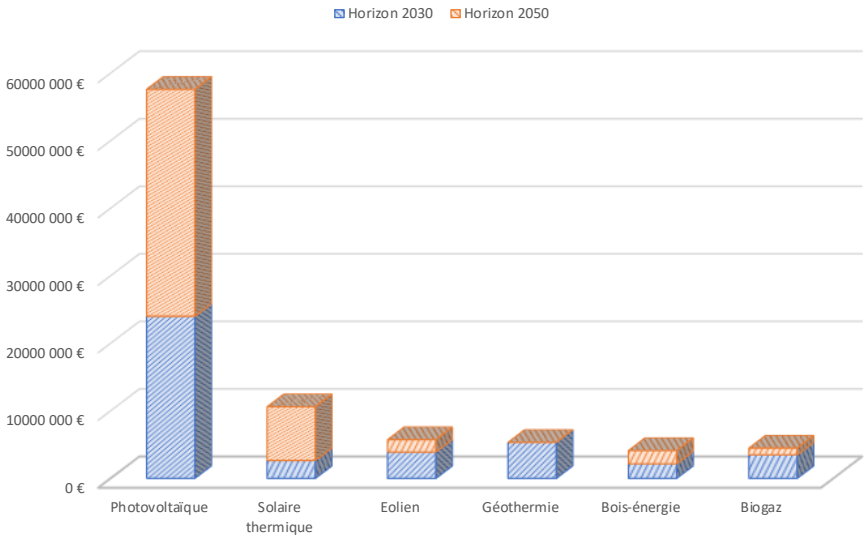


Figure 10: Investments by EnR, horizon 2030 and 2050 - Source Coherence Energies

The table below summarizes the main economic assumptions and the deployment of works by sector:

ETUDE DE PROGRAMMATION ENERGETIQUE - VILLE DE FOURMIES

SCENARIO DE REFERENCE : CIBLE 2030 Démarche Destination TEPOS

		Hypothèses technico-économique		TEMPORALITE			INVESTISSEMENT CUMULE
		Horizon 2030	Horizon 2050	2015	2030	2050	2015-2050
Photovoltaïque	**Potentiel production (GWh) TEPOS**			**0**	**19**	**61**	
	productivité par an en kWh/kWc	950	1000				
	investissement en euros par kWc	1200	800		24 000 000 €	33 600 000 €	**57 600 000 €**
	investissement par MWh produit chaque année	1263	800				
Solaire thermique	**Potentiel production (GWh) TEPOS**			**0**	**2**	**8**	
	productivité par an en kWh/m²	300	400				
	investissement en euros de m²	1050	530		2 650 000 €	7 950 000 €	**10 600 000 €**
	investissement par MWh produit chaque année	3500	1325				
Eolien	**Potentiel production (GWh) TEPOS**			**0**	**6**	**10**	
	production en MWh par MW installé/an	2000	2200				
	investissement en euros / MW	1300	1000		3 900 000 €	1 818 182 €	**5 718 182 €**
	investissement par MWh produit chaque année	650	455				
Géothermie	**Potentiel production (GWh) TEPOS**			**0**	**4**	**4**	
	production en MWh par kW installé	1,4	1,8				
	investissement en euros par kW installé	1900	575		5 320 000 €		**5 320 000 €**
	investissement par MWh produit chaque année	1330	319				
Bois-énergie	**Potentiel production (GWh) TEPOS**			**9**	**16**	**32**	
	énergie produite en MWh par an	52	15000				
	investissement en euros	16000	1830000		2 153 846 €	1 952 000 €	**4 105 846 €**
	investissement par MWh produit chaque année	308	122				
Récupération de chaleur	**Potentiel production (GWh) TEPOS**			**0**	**0**	**0**	
					ND	**ND**	
Réseaux de chaleur	**Potentiel production (GWh) TEPOS**			**0**	**0**	**0**	
					ND	**ND**	
Biogaz	**Potentiel production (GWh) TEPOS**			**0**	**7**	**9**	
	Biométhane injectable en MWhPCS	8366					
	investissement en euros	4159156			3 480 049 €	994 300 €	**4 474 349 €**
	investissement par MWhPCS de biométhane produit chaque année	497,15					
					montant d'investissement global		**87 818 377 €**
				9	***54***	***124***	

Presentation of projects and the strategy going forward:

The city with the help of various financers has already installed 3 solar PV plants:

- Rooftop solar PV plant on the “Gymnase Marie-José Pérec” with an installed capacity of 36kWp

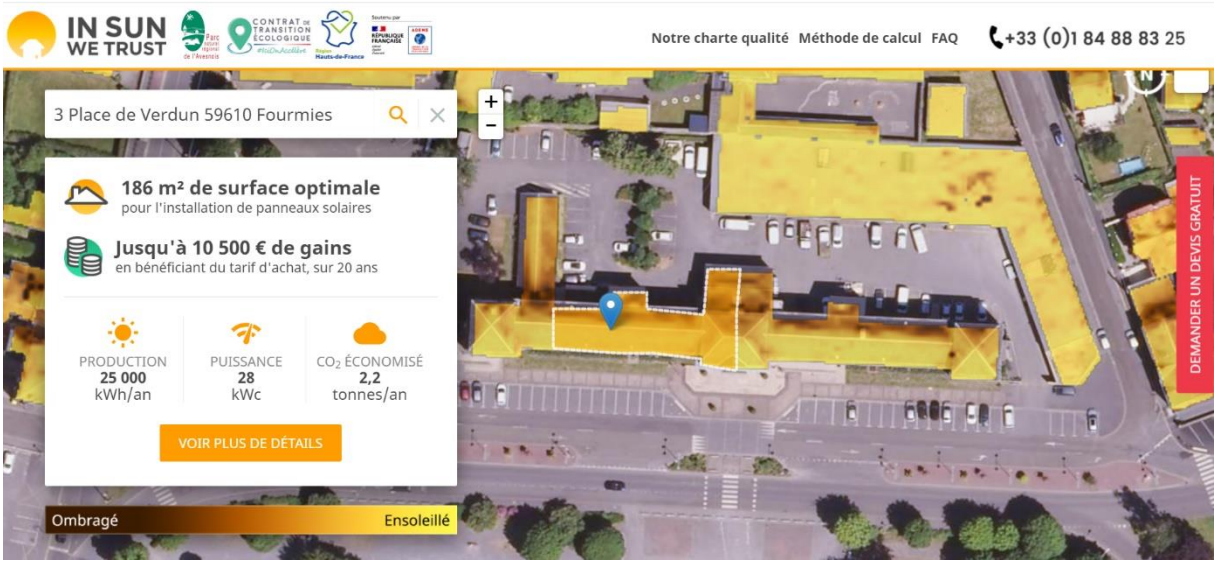
- Rooftop solar PV plant on the “Gymnase Léo Lagrange” with an installed capacity of 67kWp

- Rooftop solar PV plant on the “Ecole Louis Aragon & Mendès France” with the total installed capacity of 98kWp

The regional national park along with the national and regional energy authorities have designed a solar prospection map which helps all the potential developers to identify the potential of their rooftops. This is known as “Cadastre Solaire”. The tool can be found: https://parc-naturel-avesnois.insunwetrust.solar/

Using this online tool, the public-private entities or the citizens could simulate their solar installations and have a pre-feasibility and obtain the following estimated data:

- Mapping the solar potential of a specific rooftop
- Surface of the available rooftop
- Estimated cost of the installations (over a period of 20 years)
    - Total reselling of electrical production
    - Auto consumption of the electrical production
    - Heating through solar thermal installations
- Revenue to be perceived
- Total financial gains over a period of 20 years
- A financial simulation with following factors:
    - Time for return on investments
    - Rate of return on the project
- The “qualified” installers near the address of the building



There are various upcoming projects and various ongoing studies which would help us to further accelerate the uptake of the renewable energy for the future:

- Feasibility study of rooftop installation on 10 municipal Buildings (2 of the installations were realised for the INTERREG 2 Seas projet)
- Commissioning of a 35kWp solar installation on the city cinema hall for January 2022
- Commissioning of a 51kWp solar installation on the rooftop of the upcoming “tiers-lieu smartlab” for the summer of 2022
- Installation of 6000m² to 9000m² of rooftop solar PV power plants to provide atleast 50% of the electricity of the “Future Eco Neighbourhood” of the city which will serve the collective residences, primary school, collective kitchen, vehicle charging stations and the swimming pool
- The installation of various small solar thermal installations for the sanitary heating needs of the collective housing for the “Future Eco Neighbourhood”
- A legal study for the formation of an “entity” which would help the city to delegate the investments and reduce public risks while accelerating the uptake of the solar energy,
- Feasibility study for the installation of solar PV on the rooftop of private buildings (companies and private supermarkets)
- Mapping of public buildings with the potential of solar installations:

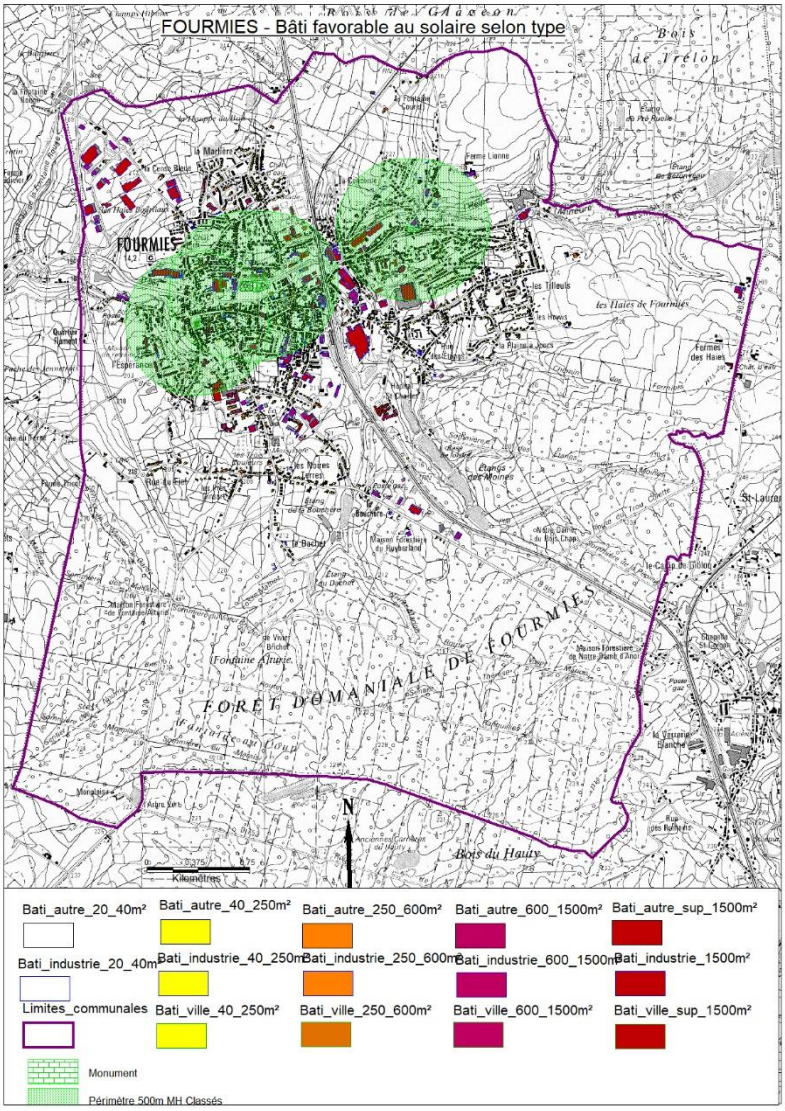


Figure 11: Map of potential solar installations