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D6.3 Heating and cooling strategies for pilot cities – City of Geneva

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Project Information

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Legal notice

The Hotmaps project

The EU-funded project **Hotmaps** aims at designing a toolbox to support public authorities, energy agencies and urban planners in strategic heating and cooling planning on local, regional and national levels, and in line with EU policies.

In addition to guidelines and handbooks on how to carry out strategic heating and cooling (H&C) planning, **Hotmaps** will provide the first H&C planning software that is

User-driven: developed in close collaboration with 7 European pilot areas

Open source: the developed tool and all related modules will run without requiring any other commercial tool or software. Use of and access to Source Code is subject to Open Source License.

EU-28 compatible: the tool will be applicable for cities in all 28 EU Member States and Switzerland.

The consortium behind

Scientific partners

TU Wien – Technische Universität Wien, Vienna | Austria; Aalborg Universitet; cem; energycities; Hes·so Haute Ecole Spécialisée de Suisse occidentale; EURAC research; Fraunhofer ISI; e-think Energy Research; PlanEnergi; energy center

Pilot areas for developing and testing the tool

Aalborg Kommune; Ville de Genève; Bistrita Municipality; Stadt Frankfurt am Main Energiereferat > Die kommunale Klimaschutzagentur; Milton Keynes Council; Kerry County Council; donostiasustapena fomentosansebastián

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1. Objectives and approach

1.1. Context

With 201,000 inhabitants, the city of Geneva is the most populated city in the Canton of Geneva, with one of the highest population densities in Europe.

Located in the heart of an urban area of more than one million inhabitants, it must structure its urban and political action as the central city, which offers infrastructures and services available to the inhabitants of the entire urban area.

In 2005, the City of Geneva adopted a vision entitled "100% renewable in 2050" to guide its action in the field of energy policy. The objective is to gradually make a transition from fossil fuels to renewable energies throughout the municipality. At the same time, the City of Geneva has also become involved at the European level and the definition of its medium-term objectives is part of the European Commission's Covenant of Mayors. It has endorsed the 3x20 targets for 2020, namely: a 20% reduction in greenhouse gas emissions, a 20% reduction in energy savings and a 20% reduction in renewable energy in total energy consumption.

To implement this vision, the City has developed an energy policy that focuses first and foremost on its own real estate assets.

To meet its commitments, the City must now develop a planning in line with its vision for 2050, on the scale of its entire territory, focusing its action on the existing urban fabric and large consumers. Indeed, while new buildings in development areas meet high energy performance standards, the existing building fabric, which today concentrates the majority of the population and energy consumption, is still highly dependent on fossil fuels.

1.2. Main objectives

The main challenge for the City of Geneva is to define the socio-economically appropriate energy supply strategy to achieve the energy objectives set (see Chapter 2).

While there are many technical solutions to exploit the available local energy resources, the overall strategy to achieve the objectives throughout the city is not defined. The main challenge of the future strategy will be to develop various technical solutions at a reasonable cost for society.

Part of these solutions now involves the development of new district heating and cooling networks under the responsibility of the Canton of Geneva and the Services Industriels de Genève (hereinafter referred to as SIG).

More generally, the Canton is responsible for drawing up a "master plan for energy networks" for the entire cantonal territory. The main objective of the master plan is to define the location of the major cantonal networks, known as "structuring networks", which will distribute energy in certain strategic areas.

The City of Geneva represents half of the canton's heat consumption, with very high urban and energy densities. The development of the master plan for energy networks must consider socio-economic conditions, heating and cooling needs, the use of renewable resources and excess heat, the extension of existing networks and the possibilities for creating new ones.

Today, the City of Geneva is ready to participate more actively in this planning work managed by SIG and supervised by the cantonal administration. The City must also develop its own energy planning to meet all the needs of the municipal territory, including areas that cannot be served by cantonal heating networks (structural networks). Currently, Geneva has the largest heat demand in the canton, but very few energy networks on its territory. In this context, the main objectives resulting from this can be expressed as follows:

1. Contribute with its territorial expertise during the development of the master plan for energy networks, in collaboration with SIG and the Canton, in order to confirm or challenge the planning of structural networks.
2. Define an energy supply strategy for areas not covered by renewable district heating and cooling networks (based on the inventory of available local resources).
3. Confirm the cost of the strategy and socio-economic feasibility. To ensure that renewable energies are made available and accessible to as many end users as possible.

1.3. Urban scales

Building scale:

Public buildings:
The City of Geneva is a major property owner. In addition to the public and administrative buildings, the City also owns and manages a stock of 5,400 social housing units.

Historically, the City of Geneva's energy policy has focused on the renovation and replacement of old heating and cooling systems in its own buildings.

The municipal territory also hosts many cantonal public buildings, such as secondary schools, universities and the Cantonal Hospital. Dialogue with the cantonal administration managing these buildings is established and regular.

To this list of buildings must also be added all buildings linked to the international organizations and to the public authorities, either through their pension funds or by public law foundations, which are large property owners in the territory, and which are subject to the same regulatory obligations as public authorities.

Private and corporate buildings:
Geneva's real estate network is essentially made up of multi-unit rental buildings, condominiums and housing cooperatives. The companies present on the municipal territory are essentially service companies, whose real estate stock is, in the vast majority, made up of office buildings.

Owners or their managers are bound by cantonal energy laws and regulations concerning building construction standards and energy supply and consumption.

District scale:

District-level thinking involves different parties. At this level, the canton encourages planning, through the establishment of territorial energy concepts (TECs), with a strong emphasis on the coherent development of networks and the promotion of renewable energies. The energy concept must also take into account the surrounding neighbourhoods, in order to balance the use of resources and share them, where appropriate.

Municipal territory:

Entitled "Geneva 2020, sustainable renewal of a city centre", the Municipal Master Plan (PDCom) serves as a reference for all development projects in the territory. It sets out a coherent set of medium- and long-term guidelines for spatial planning. It is also a contractual instrument between municipal and cantonal authorities that makes it possible to establish a shared reference base for current and future legislatures. This document was adopted on 16 September 2009 by the Municipal Council (municipal legislative body) and on 14 October 2009 by the State Council (cantonal legislative body).

Today, it is obvious that there is a lack of a planning tool to identify the potential for local energy supply in relation to urban development throughout the municipal territory in accordance with the objectives previously defined by municipal energy and spatial planning policies and to plan the necessary networks.

Therefore, the City, as early as 2016, committed itself to the European **Hotmaps** project, alongside European academic partners and seven pilot cities. This tool will contribute to the elaboration of the territorial energy diagnosis and to the testing of the different scenarios selected.

1.4. Hotmaps and the global approach

The **Hotmaps** toolbox plays a central role in the development of a coherent territorial energy strategy for the City of Geneva. **Hotmaps** allows the various actors of the territory to spatialize, visualize and scenario the energy issues of the territory in the medium (2035) and long term (2050) time horizon and to identify the portions of territories with the highest stakes. The **Hotmaps** tool is integrated with other mapped resources so that the Municipal Energy Master Plan can anticipate and guide future energy infrastructure developments in the region by encouraging the deployment of local renewable energies.

It must also form the basis for a dynamic exchange with the main stakeholders in the territory, such as SIG and the Canton of Geneva.

The **Hotmaps** toolbox should support the planning process, including:

- Consolidating know-how in terms of existing infrastructure, energy and urban planning, energy demand and local resources;
- Building energy scenarios and facilitating discussions between all stakeholders;
- Helping to define a long-term energy strategy that achieves the objectives and is affordable and integrated with other urban planning themes;
- Helping to define an evolutionary decision-making process (able to integrate changes and re-evaluate results);
- Helping to define the economic issues and financial planning elements for network deployment, as well as to evaluate the different scenarios according to the desired cost of final energy.

2. Targets and public policiesTargets

2.1.1. Local, regional and national targets

The objectives of the City of Geneva's energy policy are developed in close coordination with the qualitative objectives set at the level of the Swiss Confederation and the Canton of Geneva. At the same time, the City of Geneva has also been involved at the European level and in defining its medium-term objectives related to the European Commission's Covenant of Mayors.

The territorial approach to energy and climate policy has the following specific objectives:

- **Reduction of heat demand**
  - 50% in 2050, baseline 2005

- **Use of renewable energies**
  - 100% in 2050

- **Reduction of CO2 emissions**
  - 21% in 2020 (Covenant of Mayors), baseline 2005
  - 60% in 2030 (Cantonal Climate Plan) baseline 1990
  - 100% in 2050 (energy policy of the City of Geneva)

- **Reduction in the end-use of heating oil for heating (for municipal buildings only)**
  - 0% in 2022 (73% in 2006)

The objectives set by the City of Geneva will be modified as from 2020. After the declaration of the Municipal Council for Climate Emergency, reports were requested from the municipal administration, with a view to establishing a new climate action plan in 2021.

The Cantonal Climate Plan sets specific targets for CO_2 emissions at the cantonal level. It will be updated in 2020-2021 and the trajectories will probably be accelerated, with the aim of achieving carbon neutrality by 2050 and a 60% reduction in greenhouse gas emissions in 2030 (compared to 1990).

The objective of carbon neutrality means reducing GHG emissions to a value that corresponds to the natural absorption capacity of the territory. This capacity will be determined when the Cantonal Climate Plan is updated in 2020-2021.

Similarly, the national policy supported by the CO_2 Act is currently being reviewed by the Federal Chambers for its third review. The debates in October 2019 set a carbon neutrality target for 2050. The medium-term trajectory is still under discussion, as well as the share of offsetting emissions abroad. Parliamentary work will resume in 2020, with the hope of implementation in 2021.

2.1.2. Develop renewable energy infrastructure at the local level

Experience has shown that several energy resources are potentially usable in the territory. To move to an exploitation phase, the resource must be considered at its right territorial scale, in order to optimize implementation costs and make them competitive with fossil fuels. The rapid and massive deployment of renewable energy solutions requires the pooling of local resources and the establishment of collective infrastructures to distribute them, as well as the implementation of a multi-actor financing and investment strategy.

The City of Geneva must play its role as a planning authority on its own public domain, as well as its role as a facilitator in the development of projects, through coordination between local actors, but also through the energy transition of its own building stock.

2.1.3. Develop local electricity production

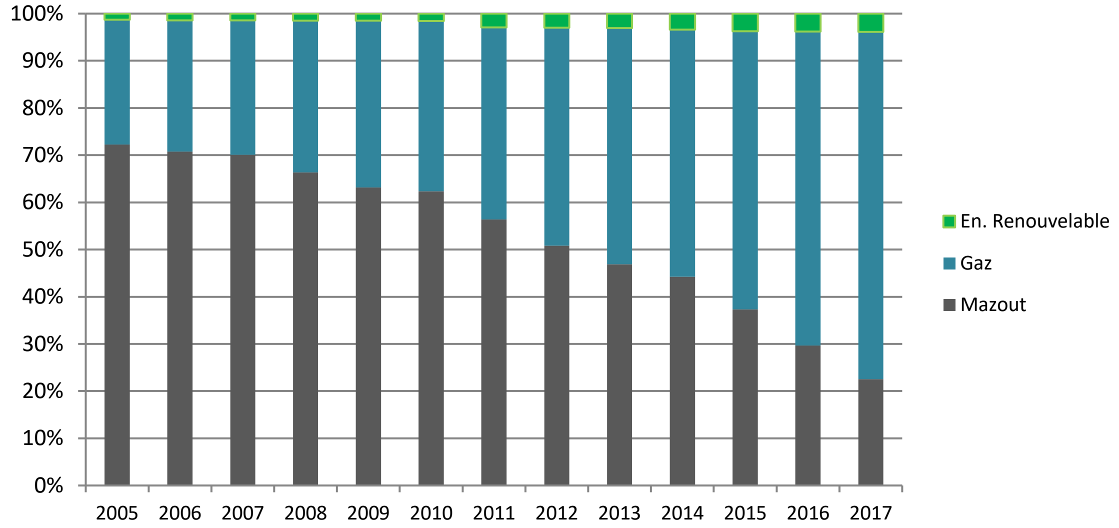
The City of Geneva's vision is in line with the Confederation's Energy Strategy 2050. The decision to disengage Switzerland from nuclear energy invites all local stakeholders to consider a more sober energy future and to develop solutions for electricity production.

Using heat pump technology, the "100% renewable in 2050" strategy leads to an increase in electricity consumption. In order to ensure consistency between the thermal strategy and the need to secure electricity supply, the City of Geneva must invest in the development of local power generation solutions and consider exploiting the potential available locally. A specific strategy has been developed to compensate for new electricity consumption through savings and new renewable energy sources (solar and possibly wind).

SIG is also involved in the development of photovoltaic solar energy and offers various "products" to individuals and companies to realize the cantonal solar potential, which has been quantified and geolocated by the Cantonal Energy Office. The data are available on the Geneva Territorial Information System (SITG).

2.1.4. Municipal buildings

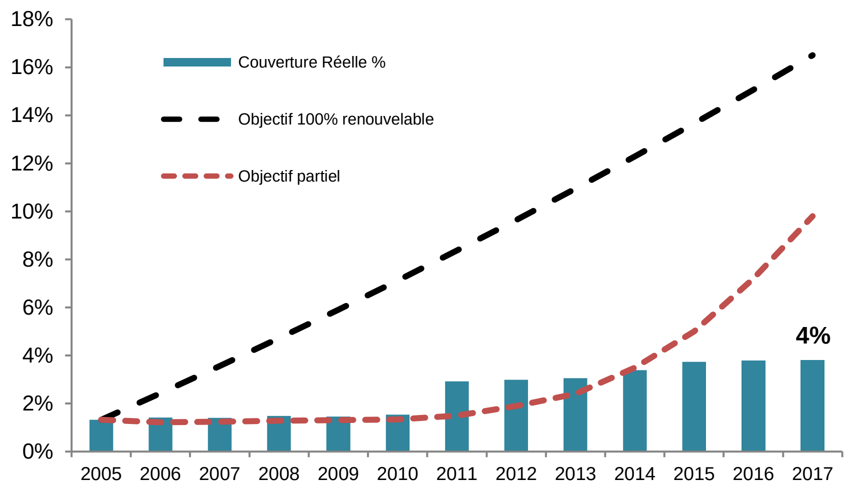
The "100% renewable in 2050" Strategy sets out the paths for the energy transition of the City of Geneva's buildings. In this process, gas acts as a transitional energy to replace heating oil, when renewable energies are not immediately available. This is particularly true in the case of planning the construction and connection to future heating networks that will be powered by renewable energies. Territorial planning is an integral part of the Strategy at the district level.



En. Renouvelable= Renewable Energies; Gaz= Natural Gas ; Mazout= Fuel Oil

For the moment, the target for renewable energies has not been reached. In 2017, the share of renewable energies for heating municipal buildings was only 4%.

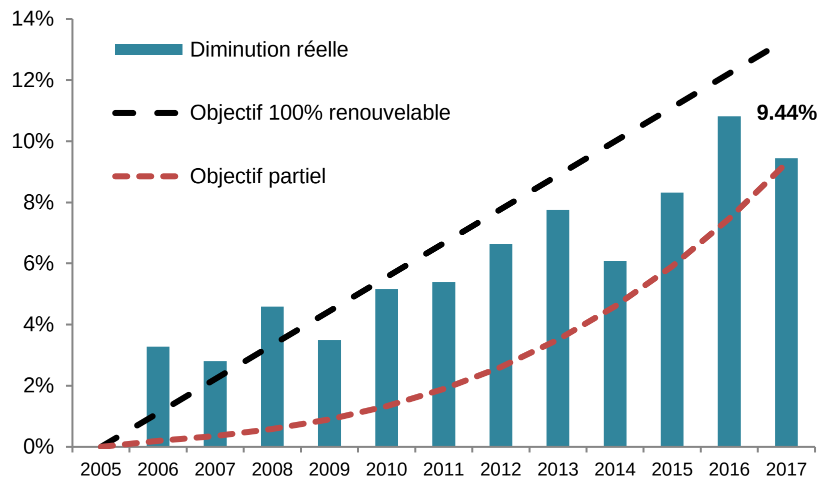
This proportion is expected to increase rapidly in the coming years, thanks to the construction of district heating networks and their connection to some of the largest consumers (e. g. large housing estates, municipal swimming pools or ice rinks).



Increase in the share of renewable energy in the supply of municipal real estate stock

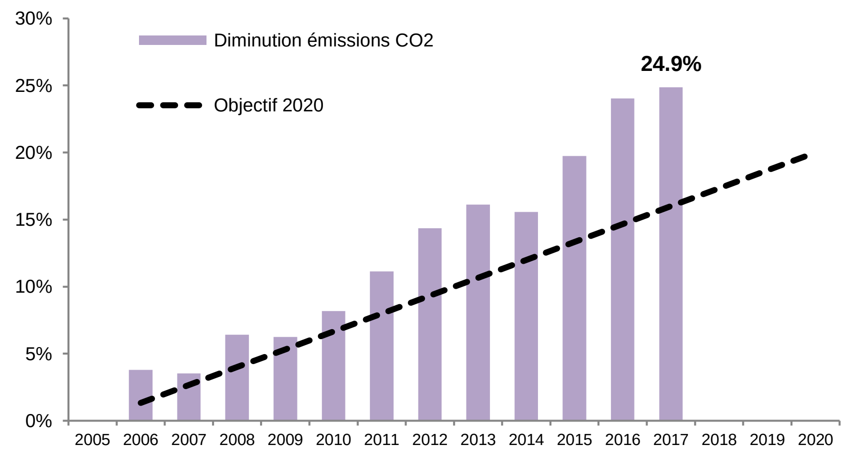
As well, the objective of reducing energy consumption for heating municipal buildings has not yet been achieved. The main reason is to be found in renovation interventions that have rather concerned small objects in recent years (renovation requirements linked to the age of buildings).

Projects concerning large consumers are currently being implemented and/or planned. These operations require very strong coordination, as investments are very large and must be spread over time. A strategy for the energetic and constructive remediation of large consumers is being developed, and the results will be visible in a few years' time. This process involves a long and complex process of reflection on the prioritization of investments and the timing of interventions, which can take several years.



Reduction in energy consumption for heating in the municipal building stock

The implementation of the "100% renewable" strategy and specific energy transition actions have made it possible to meet the objectives of reducing CO_2 emissions from the City of Geneva's real estate portfolio.



Reduction of CO_2 emissions from the municipal building stock

2.2. Policy instruments

2.2.1. National level

The objectives of the Swiss energy strategy 2050 are:

- Increase energy efficiency,
- Develop renewable energies,
- Gradually replace nuclear energy.

This strategy is implemented in the following legislative rules:

- Energy laws and strategies (Confederation and Canton of Geneva)
- Climate strategy with national CO2 law (the new version is currently being consulted - implementation expected in early 2021)

2.2.2. Cantonal level

- Climate plan
- General energy concept
- Energy Master Plan
- Networks energies master plan (district heating and cooling, electricity, gas and water)

2.2.3. Municipal level

- European Energy Award Gold
- Municipal energy and climate policy with Action Plan 2011-2014 and 2014-2018
- Strategy "100% renewable in 2050 for heating municipal buildings" (2006)
- Municipal electricity strategy: "Consuming less and producing better" (2011)

2.3. Stakeholders

Although it is necessary to consider the many stakeholders (see figure below), the main ones are undoubtedly the cantonal authority (Canton of Geneva) and the Services industriels de Genève (SIG), supplier of network energies (public utility company). As a public company, SIG's capital is held by the State of Geneva (55%), the City of Geneva (30%) and other municipalities (15%). The City of Geneva has one member who attends the Board of Directors.

The tables below summarize the roles and objectives of the various stakeholders identified:

WHO	WHAT IS STRATEGIC FOR THEM ?	WHAT IS THE PROCESS TO MAKE THE DECISION ?
SIG	Law, consumers, benefits	Internal decision Political agreement
Canton de genève	Law, political goals, terms, invests, exemplarity	Government decision Legislativ decision referendum
ACG	Law, political goals, terms, invests, exemplarity	Government decision Legislativ decision referendum
Régies	Law, disrepair, real estate value, minimize the costs	Internal decision Building owner's decision
Entreprises	Law, subsidies, minimize the costs, marketing, real estate value	Internal decision
Lobbies Politics, enterprises, NGO, etc.	influence	Democratic decision, vote
Consumers Tenants	Pay the final energy	Internal decision

3. Description of energy demand and supply

3.1. Data and mapping of demand, potential resources and existing production

3.1.1. Characterization of energy demand

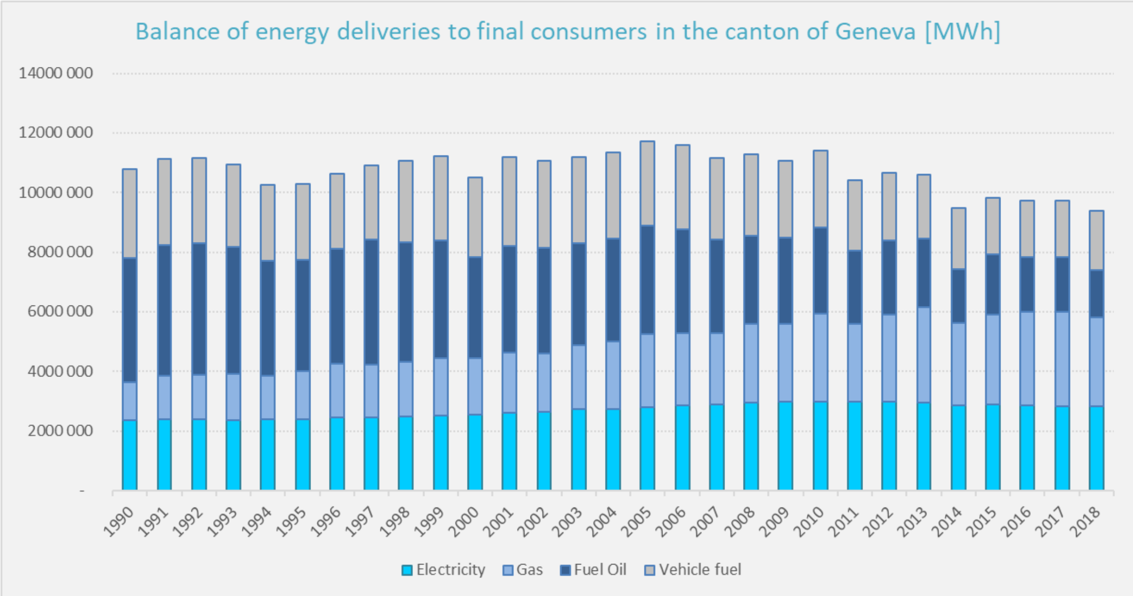
The following table presents the various data available, concerning the characterization of the building stock and its energy consumption.

Available data (Building stock)	Yes/No	Unit / Data format (excel, tab, GIS etc.)
1. Georeferenced (geographic coordinates)	YES	Building Cadastre with ID number for each building (EGID)
2. Gross floor area	YES	- Heat surface available at 1 ha grid - Number of floors and footprint area
3. Construction year	YES	- Construction period always available - Construction year not fully available
4. Refurbished year	YES	Transformation year available
5. Building type / use	YES	As per Geneva's classification
6. Heat demand (MWh and/or MW)	YES	- Installed power by heating system at building level - Heat demand, consumption, heat power at 1 ha grid
7. Existing heat supply: natural gas, district heating, individual oil boiler etc.	YES	Type of heating system available at building level

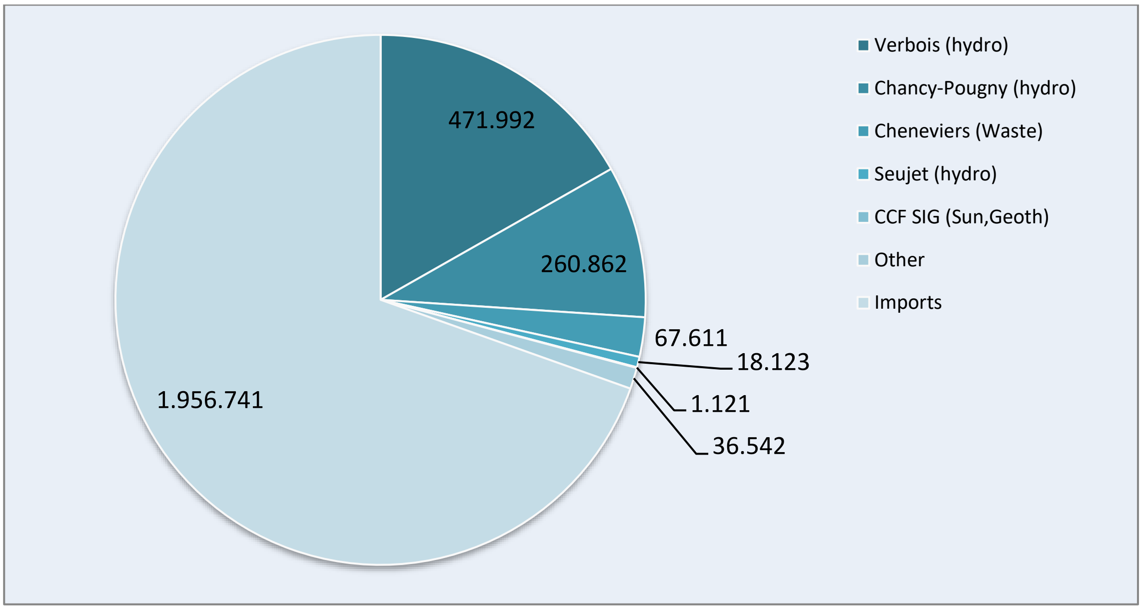
A lot of data is available on this website: https://www.etat.ge.ch/geoportail/pro/

The heat demand is available at the building level. The historical data are saved so that at the building level, it is possible to know the average consumption of the building over 2 or 3 years. An infrared thermography of the entire Canton of Geneva is also available on the site.

3.1.2. Balance of energy deliveries to final consumers in the canton of Geneva [MWh]

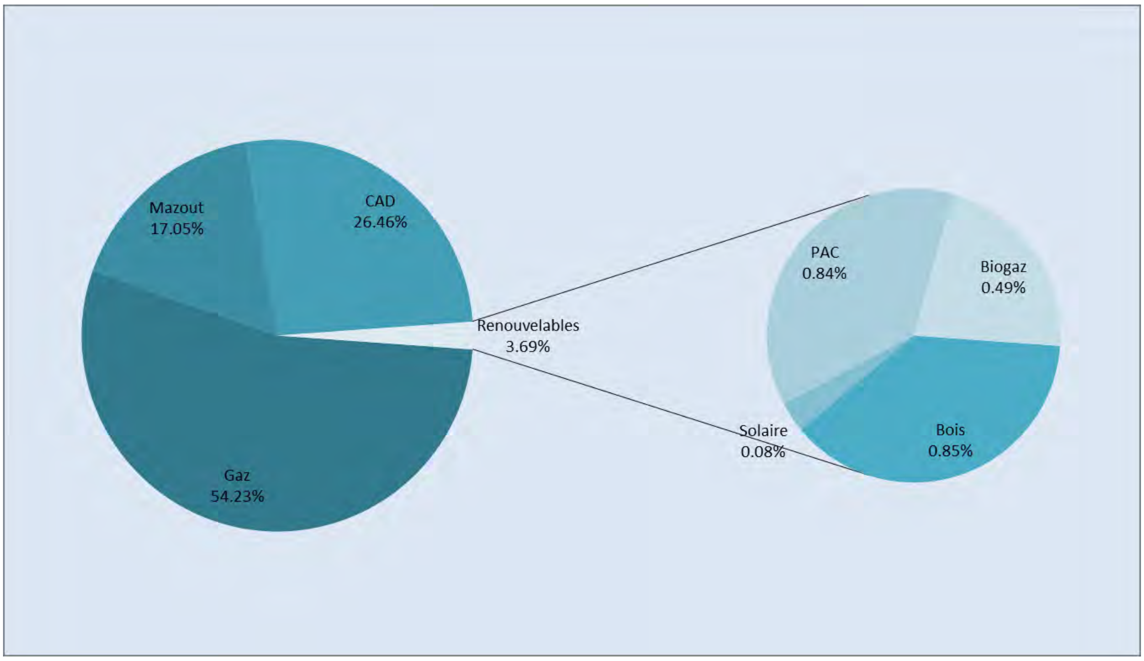


3.1.3. Production and supply of electricity to the Geneva cantonal grid [MWh]



Total electricity network consumption (without CERN) : 2’812’992 [MWh]
CERN: 759 [MWh]

3.1.4. Heat distribution in municipal buildings



Heat supply to municipal buildings, 2017
CAD = District heating ; PAC = heat pumps

The district heating part has a renewable part, which varies according to the networks. By default, we can consider a share of 20% renewable and 80% gas.

4. Risks and opportunities

The current legal framework does not ensure a clear division of roles and responsibilities: The Canton of Geneva requires the municipalities to develop their energy plans; on the other hand, the canton has designated SIG to develop the Network Energy Master Plan.

The resulting lack of coordination requires the involvement of more stakeholders, such as the City of Geneva, in the various planning processes. In this respect, the **Hotmaps** toolbox can play an important role in providing a common understanding of situations and opportunities.

4.1. Use and deployment of Hotmaps

4.1.1. Risks regarding data availability in Switzerland

The Hotmaps project has created data, based on available data from European organisations or previous European research projects. As Switzerland is not part of the European Union, some Swiss territorial data may not be included in these different data sources. Particularly in terms of energy resources (agricultural and forest residues).

Currently, the default database therefore has two incomplete datasets for the Swiss territory, including Geneva. In fact, the calculation modules, who need those two specific data sources, may not work if the required data is missing. Users have the possibility to fill these gaps personally. It should be noted that the verification process carried out during the **Hotmaps** project, particularly for Swiss cities, allowed a calibration of the default dataset.

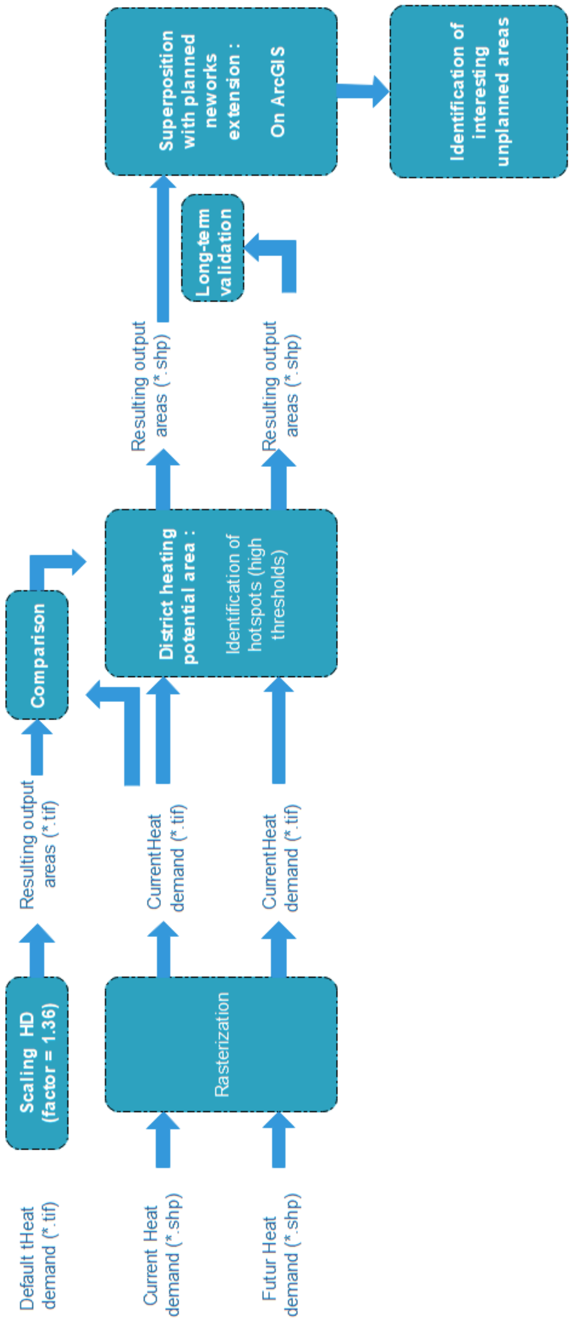
In addition, many territories, such as the City of Geneva, have more precise data (based on real data) than those offered by default on the **Hotmaps** platform (obtained by modelling the territory). Therefore the local data is often preferred– also for the calculations.

One of the main challenges for the deployment of **Hotmaps** in Swiss cities will therefore be related to the ease of importing their own data.

4.1.2. Analysis of the potential of grid energy developments

The following figure represents an overview of the methodology used in the framework of the municipal grid energy strategy. The main steps are as follows:

- Integration of OCEN data into the **Hotmaps** platform.
- Use of **Hotmaps** calculation modules (CM - District heating potential: economic assessment and CM - District heating potential areas: user-defined thresholds) to identify areas with very high development potential.
- Overlay of results obtained with SITG maps, such as planning of structural networks.
- Analysis of the adequacy of network planning and territorial demand.



4.1.3. Data processing

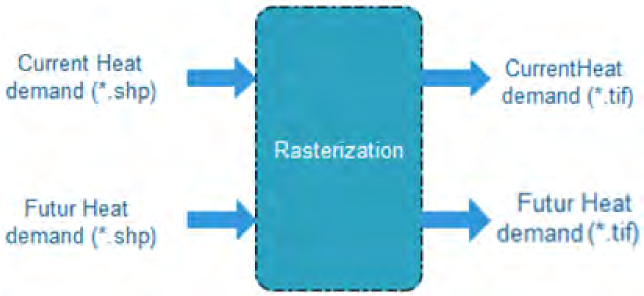
The Canton of Geneva benefits from a very rich geographical information system (GIS), which includes a great deal of energy or energy-related data (as descripted in chapter 3).

Integration of the heat demand of the Canton of Geneva

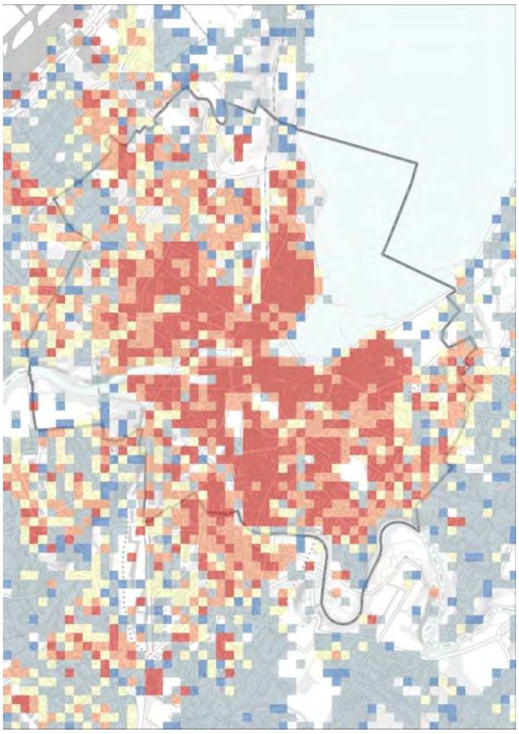
The Office de l'énergie du Canton de Genève (OCEN) has vector data on current and future heat demand (2030) - in the form of a heat density map.

In order to refine the results of the calculation modules, we have created two "raster" layers (Geneva current and Geneva 2030), compatible with the **Hotmaps** platform and its calculation modules, based on OCEN data.

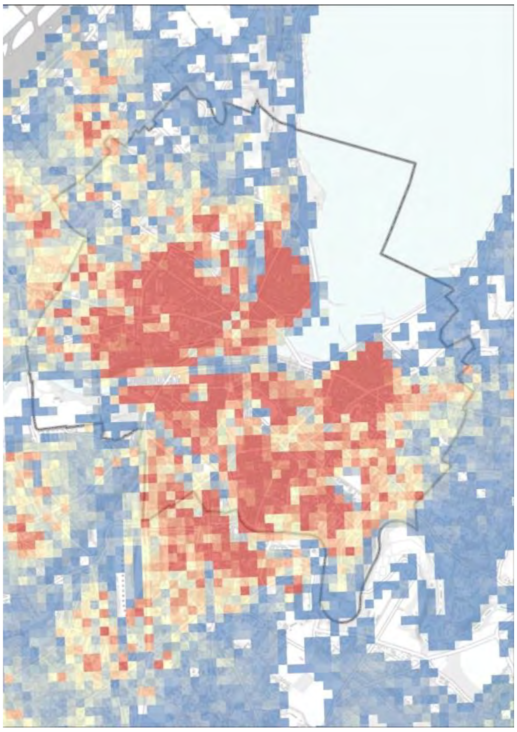
In order to guarantee a perfect superposition of data on the **Hotmaps** platform, the OCEN data were rasterized on a **Hotmaps** data extraction, on the territory of the City of Geneva.



Process of rasterization of vector data

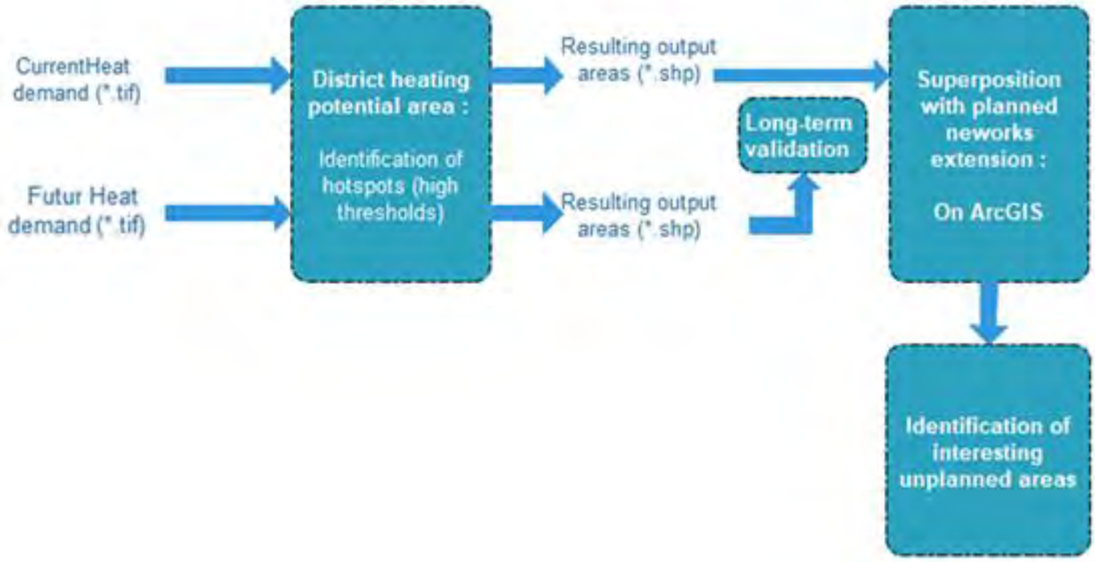


Personal Layer « Geneva current »

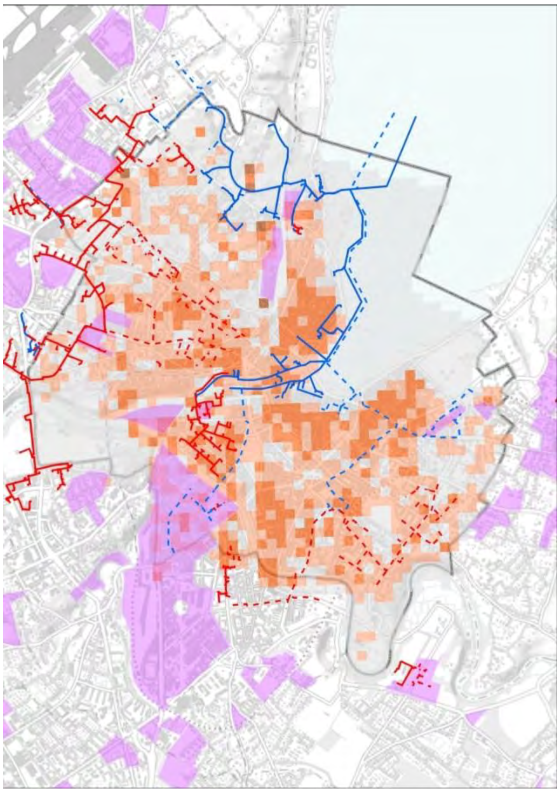


Heat density Default data set

4.1.4. "District heating potential area" Calculation module

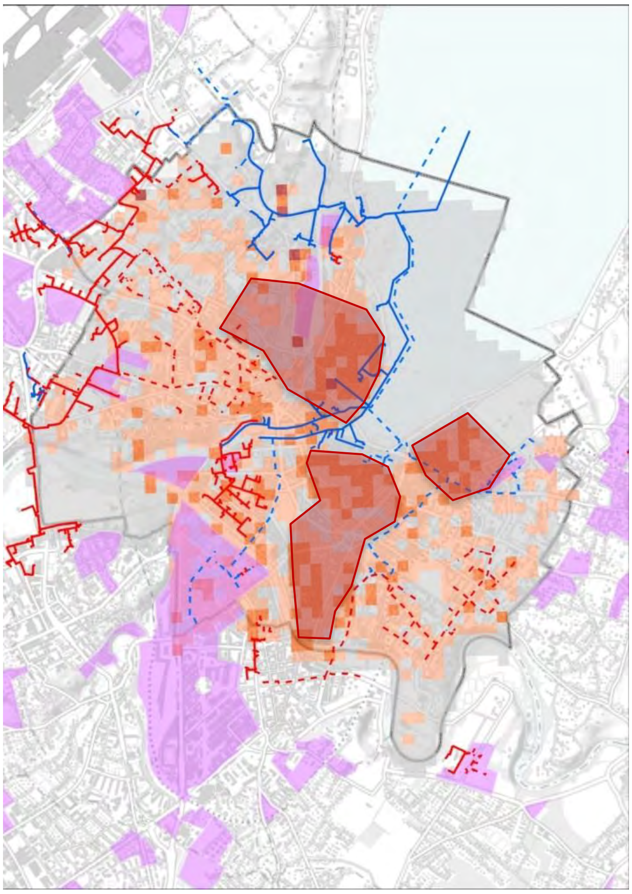


By importing these layers into **Hotmaps**, we can begin to develop a planning vision of the territory. For example, by integrating the results of the ***CM-District heating potential areas: user-defined thresholds***. This vision can also be enhanced by reimporting these results into dedicated mapping software and superimposing existing and planned heating and cooling networks, as well as areas of the territory in transition (development projects).



These results can be transposed to a 2030 vision, using the "Geneva 2030" map and applying the same treatment.

From this basis, specific scenarios can be developed for areas that are outside the influence areas of the structural networks, but which represent a strong potential for the development of heating networks (example in red on the map).

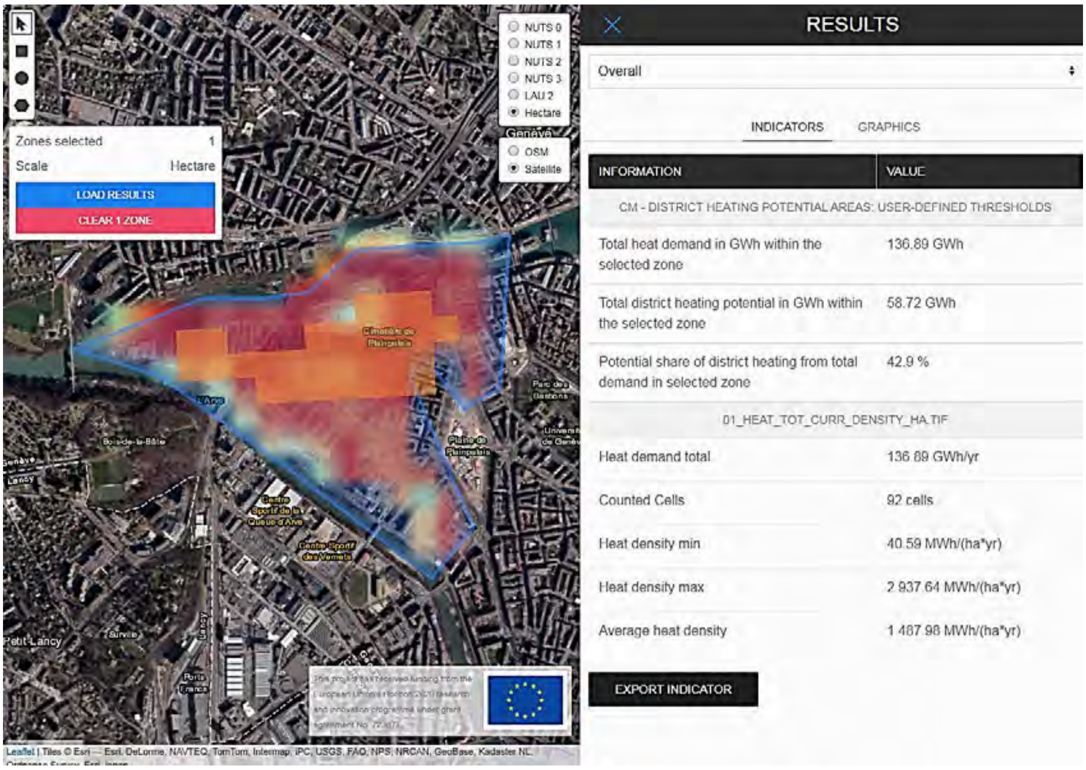


4.1.5. Extraction of Toolbox results and contextual linking

The results obtained by processing one calculation module must be usable and reprocessed in another calculation module.

For example, if the ***CM - District heating potential areas: user-defined thresholds*** gives a result identifying two areas with high potential for developing a heating network, the data from these two areas should be used to apply the ***CM - District heating potential: economic assessment***.

This successive analysis of the same result contributes to the construction of different scenarios, if the data can be saved and reused in the tool.



Similarly, the user must be able to enter "exclusion" fields in the calculation modules. For example, if in an area of the city there is already a heating network, which provides all its heat potential, then the user must be able to exclude this area from future calculations, in order not to distort his scenario with false results.

4.1.6. Interpretation of the Toolbox results

In the case of Geneva, which has a very high density (heat and buildings) and very high construction costs, the results with the values proposed in the various default scenarios are not sufficiently contrasted to allow a remarkable variation to be distinguished. With the CREM, we tested values closer to the Geneva reality. The Toolbox allow you to enter custom values that are more in line with the reality of each city.

Similarly, the results of the various calculation modules must be able to be interpreted unambiguously. The inputs must therefore be clear and based on a local reality.

Example 1: CM - District heating potential: economic assessment

This CM is one of the most important in **Hotmaps**. It must be very easy for the user to understand and the results obtained must also be very clear and easily interpretable. Because these results will constitute the main elements of the development of scenarios and strategies of user cities.

The explanations of this CM are not very clear and can create confusion for the user. The WIKI chapter does not clarify this situation. We suggest including examples and clarifying user support, especially in the titles and definitions of inputs and outputs.

Examples have been constructed to show the different results obtained by varying key parameters (see annex).

Example 2: CM - District heating potential areas: user-defined thresholds

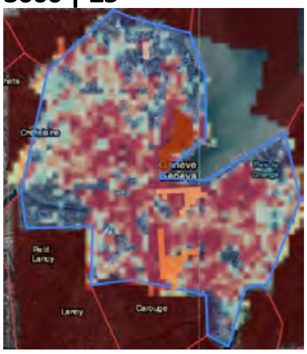
This calculation module is particularly useful for quickly identifying areas of potential for the development of heating networks based on the energy demand characteristics of the territory.

As the energy densities of the Geneva area are particularly high, the default values do not provide sufficiently detailed information. A sensitivity matrix was therefore developed, based on OCEN data, to identify the city's consumption hotspots.

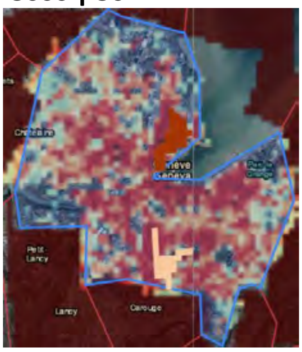
The following table gives the values of the inputs of the calculation module, and the results obtained in terms of coverage of needs by the heating networks and the number of associated zones.

Geneva current		Min. heat demand in hectare				
		500	1000	2000	3000	4000
Min. heat demand in a DH area	25	97.96% | 1	94.59% | 2	65.84% | 4	15.51% | 4	2.48% | 1
	50	97.96% | 1	92.02% | 1	59.26% | 1	9.98% | 2	--
	100	97.96% | 1	92.02% | 1	59.26% | 1	--	--
	200	97.96% | 1	92.02% | 1	59.26% | 1	--	--
	400	97.96% | 1	92.02% | 1	59.26% | 1	--	--
	800	97.96% | 1	92.02% | 1	59.26% | 1	--	--

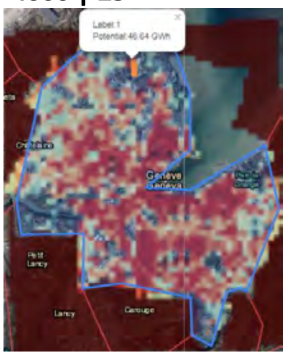
3000 | 25



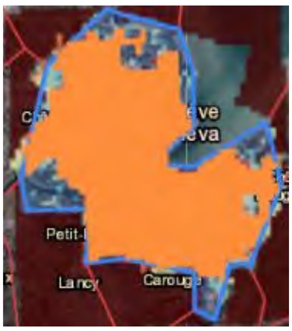
3000 | 50



4000 | 25

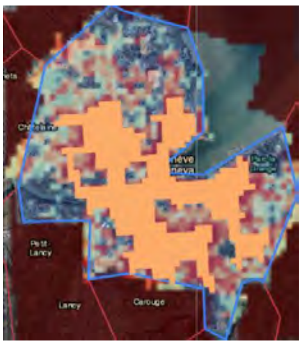


500



1000

2000



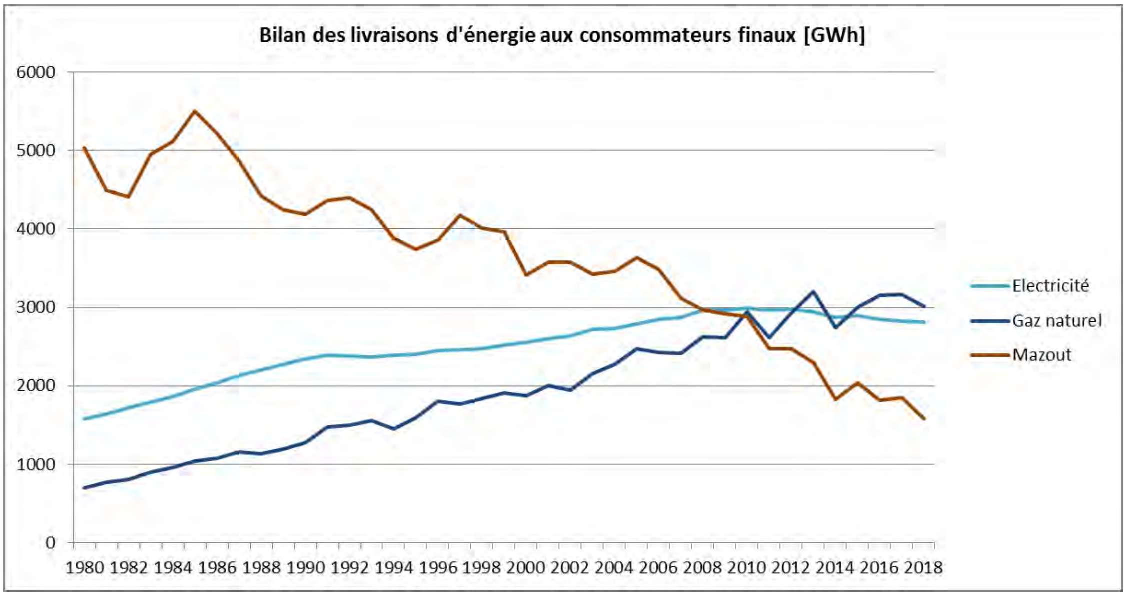
The variation of the results according to the evolution of the input variables clearly shows that the potential for the development of thermal networks in Geneva is high. However, it is still difficult to assess the risk or "conservatism" of some scenarios. To do this, documentation and user support must reflect the different scenarios that would better "qualify" the results.

5. Strategy for heat and cold

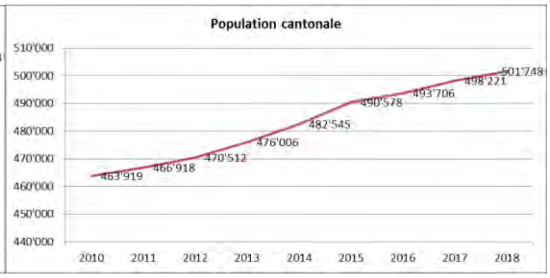
5.1. Elements for scenarios construction

5.1.1. Current trends (source: Cantonal EDP project)

A quick overview of energy deliveries to end consumers in the canton of Geneva since 2000 expressed in GWh (see graph below) reveals various trends: the reduction of fuel oil in the cantonal energy mix in favour of an increase in natural gas deliveries, a drop in fuel deliveries, and a slight change in electricity deliveries.

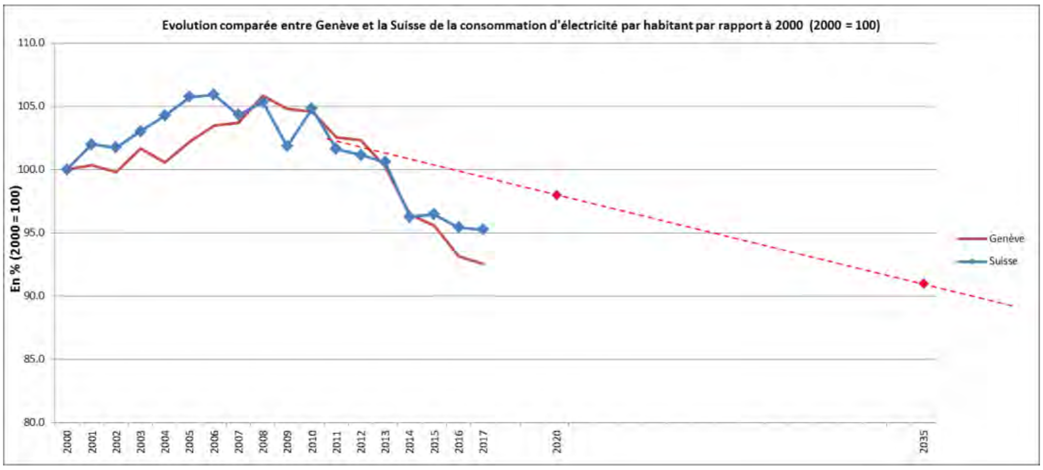


In 2017, a view of the development of fossil thermal energy consumption per capita in Geneva compared to the year 2000 shows a downward trend that must be continued, as shown in the graph below. The indicator is, however, strongly influenced by the canton's constant population growth.



In view of the comparative development between Geneva and Switzerland in terms of per capita electricity consumption compared to the year 2000, it is once again possible to observe a downward trend, as shown in the graph below.

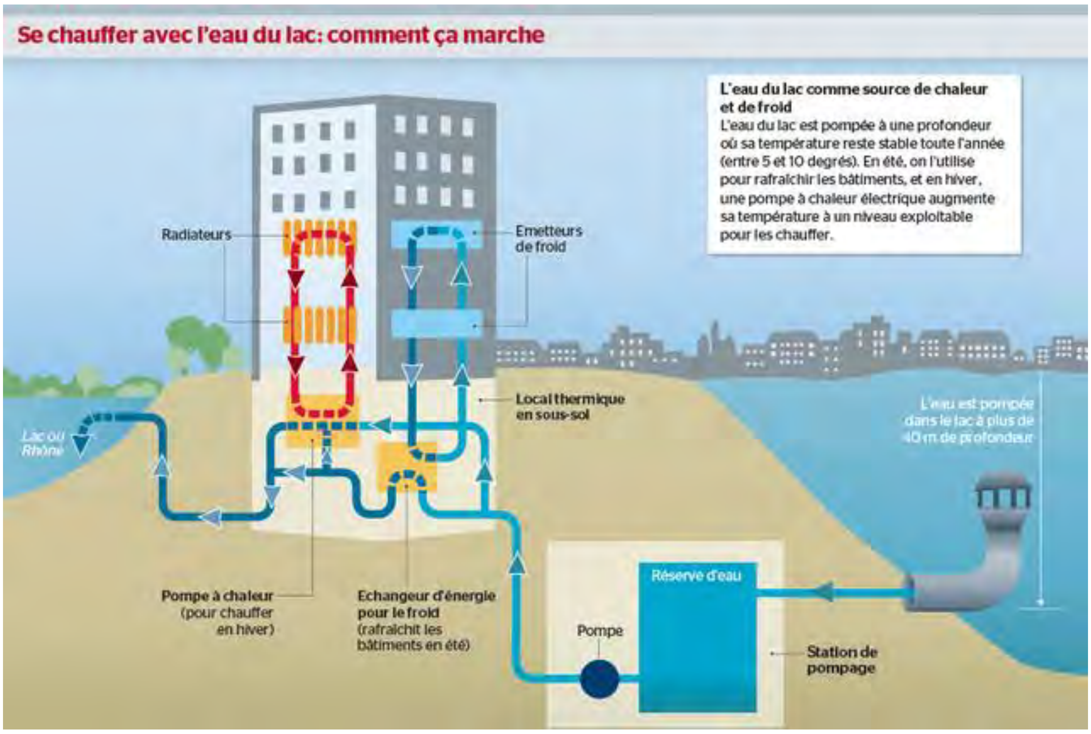
Just over 60% of electricity is consumed by economic activities. Private households and collective uses (general building services and public lighting) account for 23% and 13% respectively.



The canton's goal of a nuclear-free 2000-watt society confirms its determination not to rely on nuclear power plants in Switzerland or abroad.

5.1.2. GéniLac

The canton and SIG are currently building a scenario based on the use of the lake for heating and cooling buildings. This network is called "GeniLac". It was developed in the UN and international organisations sector almost 10 years ago. It is primarily used to meet cooling needs. It will provide the connected buildings with a water flow at a temperature of 10 to 12°C. This water can also be used as a cold source for decentralised heat pumps (as shown in the diagram below). The development of heat networks based on a central heat pump is also possible with this type of infrastructure.

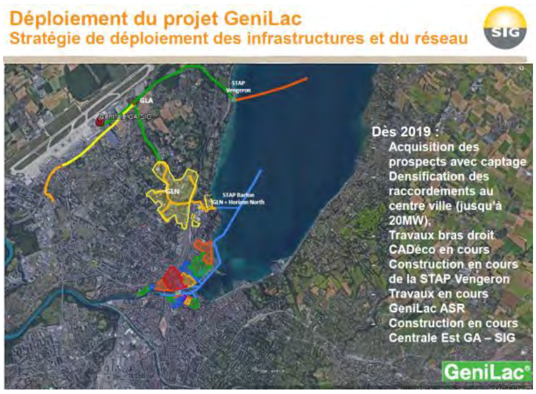


The canton and SIG are planning to expand the network in various parts of the city, after the pumping and distribution systems for Lake Geneva water have been extended. A roadmap has been established for the development of GeniLac. The main challenge is to create networks on the City's territory where heat demand is highest, but implementation is more difficult than in less dense areas. The city centre is close to the lake and the Rhône, so GeniLac seems to be an interesting solution.

Roadmap - GeniLac

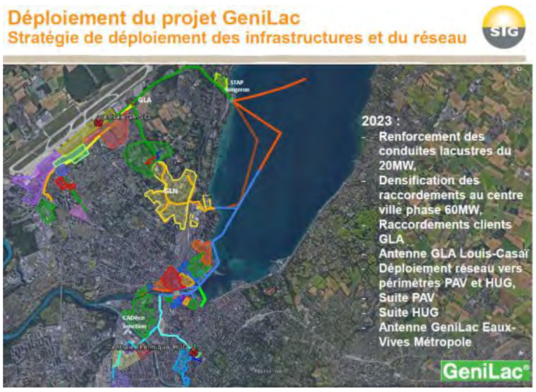
2017

2019



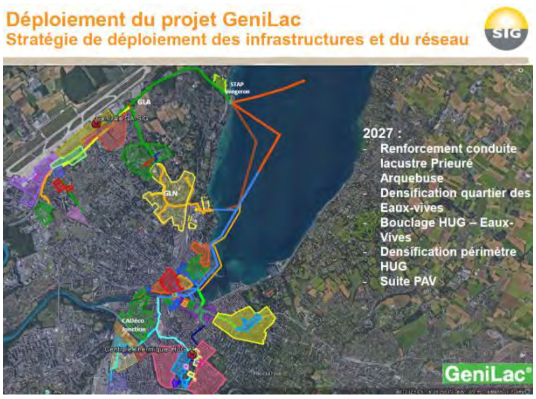
2021

2023



2025

2027



5.1.3. Planned developments

In addition, the canton and the SIG encourage other scenarios:

- Interconnection and connection of existing district heating networks;
- the use of excess heat and biogas from wastewater treatment plants;
- explore the geothermal potential at different depths.

These strategies are being developed and discussed with stakeholders as part of the Energy Master Plan and the Network Energy Master Plan. The new versions will come into application in 2020.

On the other hand, other stakeholders are developing their own heating and cooling networks based on the excess heat from large companies close to them. For example, CERN's excess heat will provide heating and cooling for a new area near Geneva that will include 2,500 new homes.

5.1.4. Geothermal energy

The potential of geothermal energy is currently under study. After two years of exploration of the Geneva subsoil as part of the 2020 geothermal programme, SIG and the Canton of Geneva are unveiling their first results.

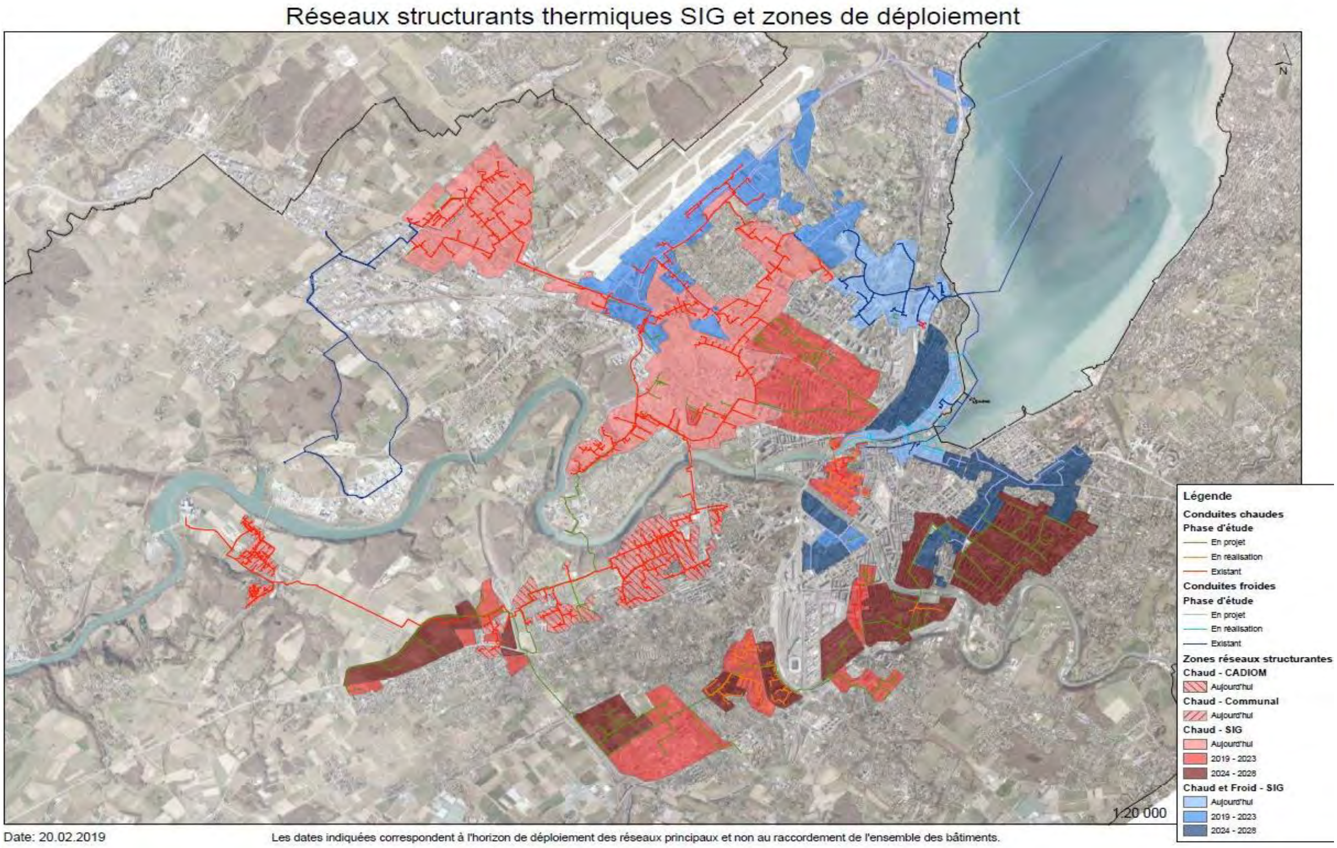
Five areas of the canton meet the geological requirements for medium-depth geothermal energy and some shallow groundwater. The City of Geneva is not concerned for many reasons at the moment: the "Geneva groundwater" is partly located on the territory of the City, explorations are complex in urban areas due to traffic, noise, etc.

The five zones have the ideal geological characteristics for geothermal energy exploitation: limestone, porous and permeable rock, rocks with faults in which water flows easily (high permeability). These resources are located at depths between 500m and 3,000 m, for temperatures in the range of 25 to 120 °C.

The program begins the detailed exploration phase in 2019. Drilling of a deep well is expected to begin in 2020.

5.1.5. Development of heating and cooling networks - Planning elements

The Network Energy Master Plan is currently being validated. It provides a guiding image of future network deployments or interconnections in the canton of Geneva (time scale 2030). This image is not definitive, but it allows the development of different scenarios on the scale of the City of Geneva.



The guiding principles of this image are that the zones delimited around each network route are established on the assumption that 100% of the buildings will be connected (available capacity and verified economic efficiency). The areas in shades of red are heating networks, the areas in shades of blue are the GeniLac network.

These zones are defined in the scenarios below as structuring network zones. The development of these networks is ensured by SIG.

5.1.6. New regulatory elements

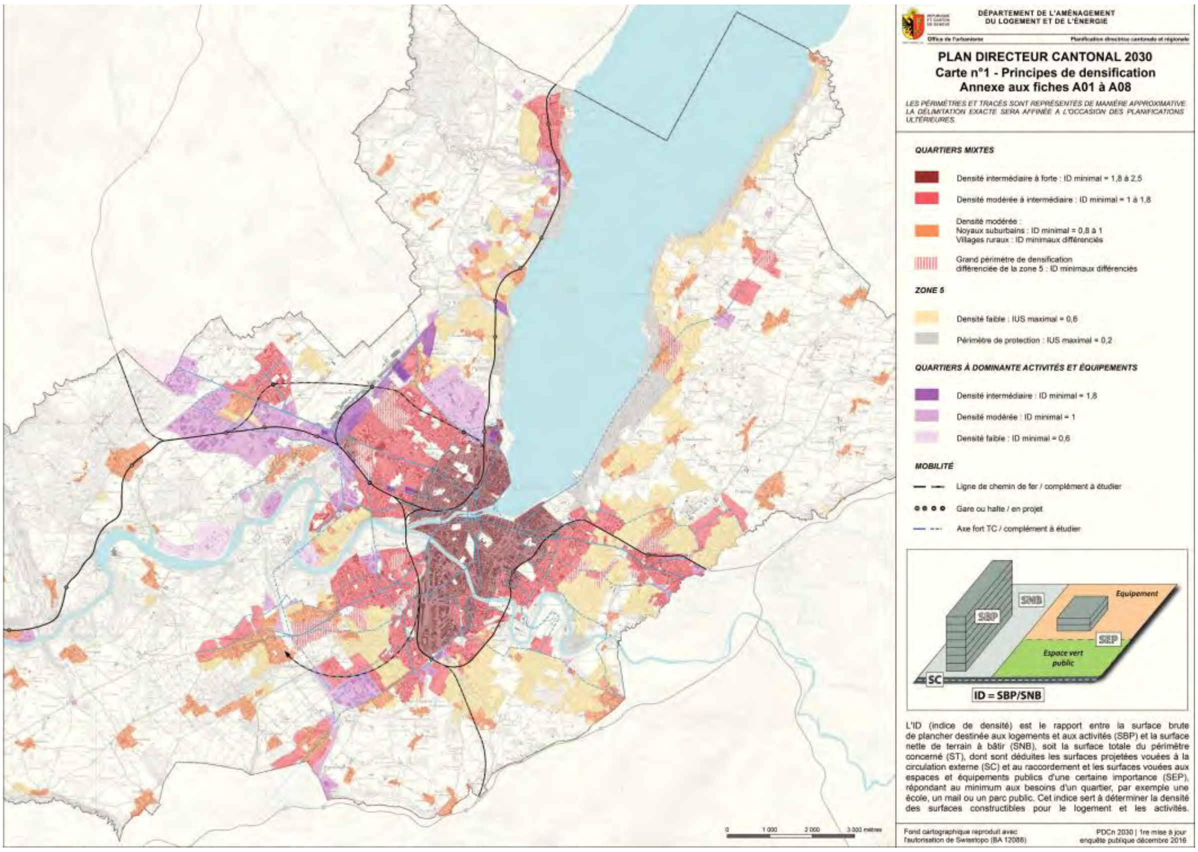
The draft Energy Master Plan (canton) also provides for regulatory changes. Among these, the most important are the tightening of energy requirements for renovations and new buildings, the obligation to connect to a grid if there is a structural network nearby, the ban on the use of fossil fuels in new buildings, and the obligation to cover a certain proportion of heat and electricity consumptions with rooftop solar energy.

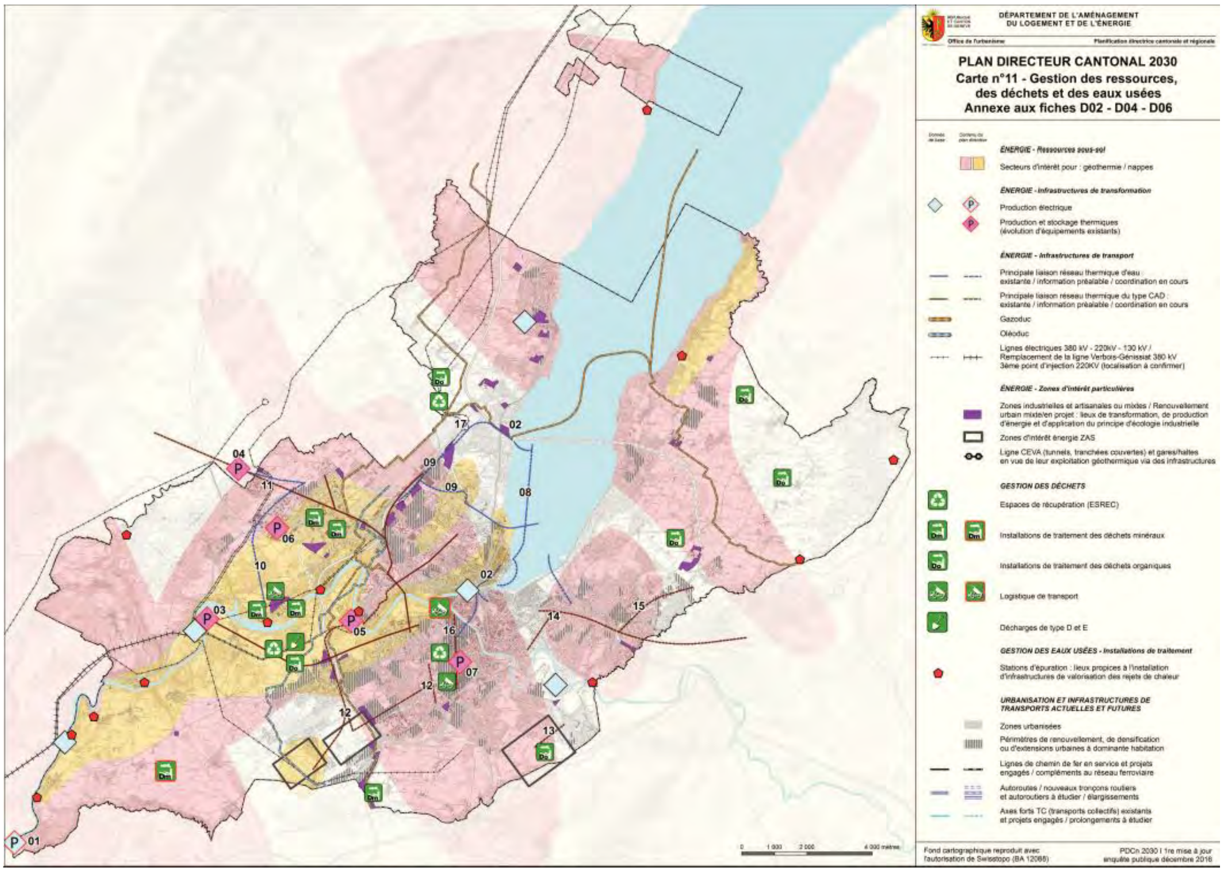
These regulatory changes should be validated during 2020, for entry into force between 2021 and 2025.

5.1.7. Urbanism – cantonal strategy 2030

The canton plans to accommodate an additional 100,000 inhabitants in 2030, including 25,000 in the City of Geneva. The current city is becoming more and more dense with taller buildings. The city extends into industrial areas or the surrounding countryside, which host or plan many construction projects.

In line with this development, the canton is reviewing the waste and wastewater treatment network and some parts of the energy networks by 2030. As can be seen on the map, the City of Geneva is not very concerned, with the exception of an area to the south called Praille-Acacias-Vernets (PAV).




DÉPARTEMENT DE L'AMÉNAGEMENT
DU LOGEMENT ET DE L'ÉNERGIE
PLAN DIRECTEUR CANTONAL 2030
Carte n°11 - Gestion des ressources,
des déchets et des eaux usées
Annexe aux fiches D02 - D04 - D06
ÉNERGIE - Ressources sous-sol
Secteurs d'intérêt pour : géothermie / nappes
ÉNERGIE - Infrastructures de transformation
Production électrique
Production et stockage thermiques
(évolution d'équipements existants)
ÉNERGIE - Infrastructures de transport
Principale liaison réseau thermique d'eau :
existante / information préalable / coordination en cours
Principale liaison réseau thermique du type CAD :
existante / information préalable / coordination en cours
Gazoduc
Oléoduc
Lignes électriques 380 kV - 220kV - 130 kV /
Remplacement de la ligne Verbois-Génissiat 380 kV
3ème point d'injection 220KV (localisation à confirmer)
ÉNERGIE - Zones d'intérêt particulières
Zones industrielles et artisanales ou mixtes / Renouvellement
urbain mixte/en projet : lieux de transformation, de production
d'énergie et d'application du principe d'écologie industrielle
Zones d'intérêt énergie ZAS
Ligne CEVA (tunnels, tranchées couvertes) et gares/haltes
en vue de leur exploitation géothermique via des infrastructures
GESTION DES DÉCHETS
Espaces de récupération (ESREC)
Installations de traitement des déchets minéraux
Installations de traitement des déchets organiques
Logistique de transport
Décharges de type D et E
GESTION DES EAUX USÉES - Installations de traitement
Stations d'épuration : lieux propices à l'installation
d'infrastructures de valorisation des rejets de chaleur
URBANISATION ET INFRASTRUCTURES DE
TRANSPORTS ACTUELLES ET FUTURES
Zones urbanisées
Périmètres de renouvellement, de densification
ou d'extensions urbaines à dominante habitation
Lignes de chemin de fer en service et projets
engagés / compléments au réseau ferroviaire
Autoroutes / nouveaux tronçons routiers
et autoroutiers à étudier / élargissements
Axes forts TC (transports collectifs) existants
et projets engagés / prolongements à étudier
Fond cartographique reproduit avec
l'autorisation de Swisstopo (BA 12088)
PDCn 2030 I 1re mise à jour
enquête publique décembre 2016

5.2. Definition of three scenarios

5.2.1. Four types of heat supply

The calculation module ***CM - District heating potential: economic assessment*** is used to define economically coherent areas for the development of heating networks. These areas overlap with the areas defined in the Network Energy Master Plan, which defines the development areas of the structuring networks, driven by SIG. Thus, three types of zones appear that are likely to receive urban networks in Geneva: high-temperature structuring network zones, low-temperature structuring network zones (GeniLac) and economically coherent zones, but not included in the SIG planning.

Finally, areas that do not have sufficient heat demand density to allow the development of heat networks, and where decentralised and renewable solutions will have to be found.

The methodology for defining the four zones is detailed in Section 6.1.

5.2.2. Three levels of intervention

Within these different planning areas, three types of public intervention are possible. Each type of intervention determines a scenario:

5.2.3. Scenario 1: Business as usual - BAU

- Over the next 10 years the progression will continue based on the trends of today and the past few years.
- Regulatory requirements are the same as in 2019.
- Subsidies are available and linked to the revenues from the CO_2 tax. In Geneva, a total of CHF 35 million is available for private individuals within the framework of the building programme and for energy renovation projects. This availability is assumed to remain constant until 2030.
- The rate of renovation is identical, i.e. 1% per year. (In terms of the number of renovated buildings - objects, out of the entire cantonal building stock).
- The standards for renovation and construction are identical.
- The final cost of energy is indexed to inflation.
- SIG structuring networks are built.
- By 2030, the connection rate will reach 70% for the structural networks.
- Air conditioners remain on sale
- The law for the cooling of industrial sites does not change.

5.2.4. Scenario 2: Implementation of PDE + PDER projects

- The cantonal Energy Master Plan (PDE) and Networks Energies Master Plan (PDER) are implemented. The objectives set out in the PDE are well on the way to being achieved by 2035.
- Structured network developed at 100% with a 100% connection rate.
- Regulatory requirements are adapted to the objectives of the PDE.
- The renovation rate is 2.5% per year.
- Renovation and construction standards are improved. The average IDC (heat consumption index) after renovation is 250 MJ/m2. (Minergie-Rénovation standard).
- New buildings must comply with the Minergie-P standard (assumption to be specified in the amendments to the legislation in 2021)
- The tax on CO_2 increases to CHF 210 per ton instead of CHF 120 which impacts the cost of energy. Energy cost = inflation + CO_2 tax
- Subsidies increase in line with the revenue from the CO_2 Act. According to the terms of the CO_2 Act 2021.
- Obligation to cover 30% of domestic hot water requirements with solar thermal energy for new construction projects or renovated buildings.
- Obligation to supply 30 Wp per m^2 of new or renovated SRE (energy reference area) with solar photovoltaic energy.
- Enhancing natural cooling in renovations and in the design of new buildings.
- Promotion of air-water heat pumps in areas outside the structuring networks.

5.2.5. Scenario 3: Intervention +

Same as scenario 2 and more:

- The municipality encourages the development of secondary DH networks (outside the structuring network) with a 100% connection rate.
- Outside the DH zone, a decentralised strategy based on the promotion of air-water heat pumps or the use of local resources is set up.

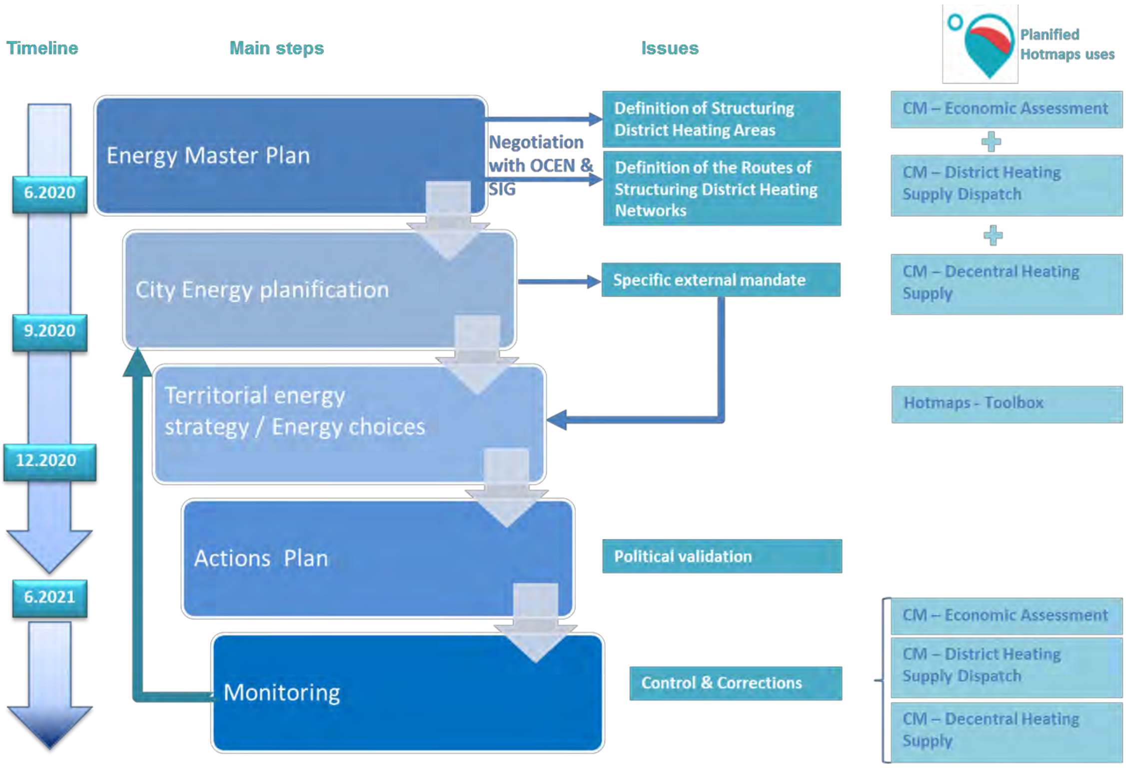
5.2.6. Scenarios - basic values for comparison

Scenarios 100% renewable - zero CO2 emissions in 2050

Variables	2030 Scenarios								
	1. Business as usual			2. PDE/R			3. City support		
	Structuring Networks Areas	City DH Areas	Areas without DH	Structuring Networks Areas	City DH Areas	Areas without DH	Structuring Networks Areas	City DH Areas	Areas without DH
Regulatory Requirements	No connection requirements	Renewable energy requirement for new buildings or refurbishments as of 2023	Renewable energy requirement for new buildings or refurbishments as of 2023	Requirement for connection	Renewable energy requirement for new buildings or refurbishments	Renewable energy requirement for new buildings or refurbishments	Requirement for connection	Requirement for connection	Obligation renewable energy on new building or refurbishment. Fuel oil ban from 2023. Obligatory biogas share.
SIG structuring networks	between 50 and 70% connection			100% connection in 2030			100% connection in 2030	100% connection in 2030	
Refurbishment rate	1%	1%	1%	2%	2%	2%	2%	2%	2%
Refurbishment Energy standard	20% of Minergie	20% of Minergie	20% of Minergie	Minergie	Minergie	Minergie	Minergie	Minergie	Minergie
New Building Energy standard	Minergie	Minergie	Minergie	Minergie P	Minergie P	Minergie P	Minergie P	Minergie P	Minergie P
Final Enery cost	15 ct/kWh	10 ct/kWh	10 ct/kWh	15 ct/kWh	10 ct/kWh	10 ct/kWh	15 ct/kWh	15 ct/kWh	15 ct/kWh
Grants	CH Building Program	CH Building Program	CH Building Program	CH Building Program + cantonal program	CH Building Program + cantonal program	CH Building Program + cantonal program	CH Building Program + cantonal program	CH Building Program + cantonal program + municipal support	CH Building Program + cantonal program
Cooling requirements	according to Data set Hotmaps	according to Data set Hotmaps	according to Data set Hotmaps	according to Data set Hotmaps	according to Data set Hotmaps	according to Data set Hotmaps	Taking into account the needs related to adaptation to climate change: cold on GéniLac, on heat pumps with subsoil recharging		

Fixed Variables
New Gross Floor Area
Construction costs
Interest rates

5.3. Geneva planning roadmaps



- We want to use **Hotmaps** to develop and track the entire energy planning process (including monitoring).
- The data available at the municipal level will be adapted to make it compatible with the processing of **Hotmaps**.
- Scenarios will be developed based on the results of the CMs. They will be compared with each other with the **Hotmaps Toolbox**.
- The scenarios will be confronted with OCEN and SIG expertise in order to find a consensus for planning and implementation.
- Negotiations with the OCEN and SIG have already begun.
- We need to share the tool with our partners. For this, it is imperative that the descriptions of the inputs and results are clearly and quickly defined in the **WIKI**.

6. Methodology for using the Hotmaps Toolkit

6.1. Definition of heat supply areas

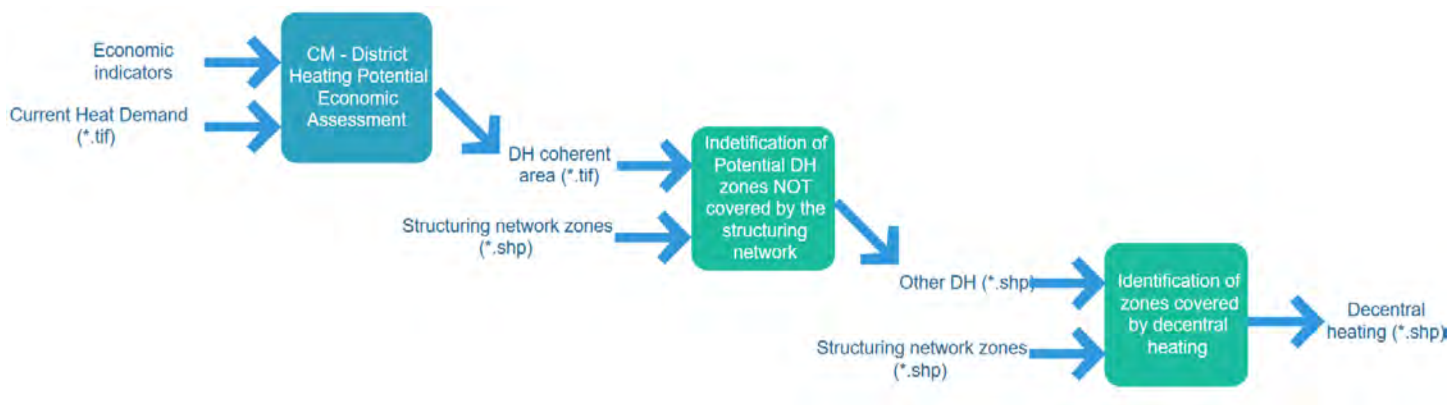
6.1.1. Use of the CM-Economic Assessment:

- Definition of an economically consistent area for district heating with the following user data :
  - Ceiling cost for the construction of the DH network [EUR/MWh].
  - Average construction cost [EUR/m].
  - Construction cost index [EUR/m2].
  - Interest rate (%)

- With the result (shapefile) of the economically coherent zone, determine the 4 zones with different heat supply:

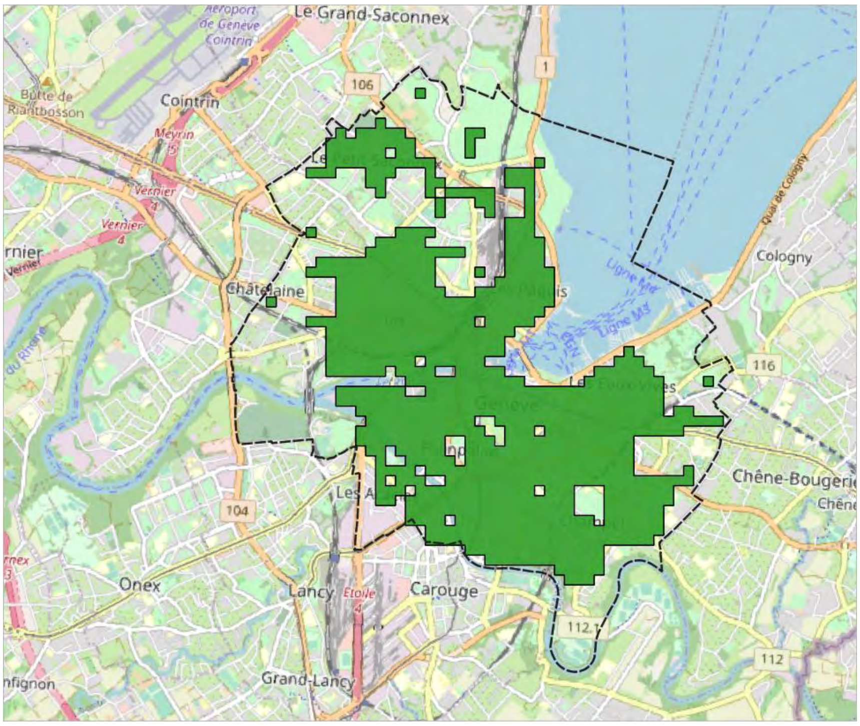
1. High-temperature structuring networks : fixed input (in red in the illustrations)
2. Low-temperature structuring networks (GéniLac): fixed input (in blue in the illustrations)
3. Other district heating (in green in the illustrations): obtained on QGis by subtracting from the economically coherent zone (Resulting from the CM) the 2 fixed zones of structuring networks
4. Decentralized heating (in grey in the illustrations): obtained from QGis, areas not covered by zones 1, 2 or 3.

6.1.2. Process implemented:

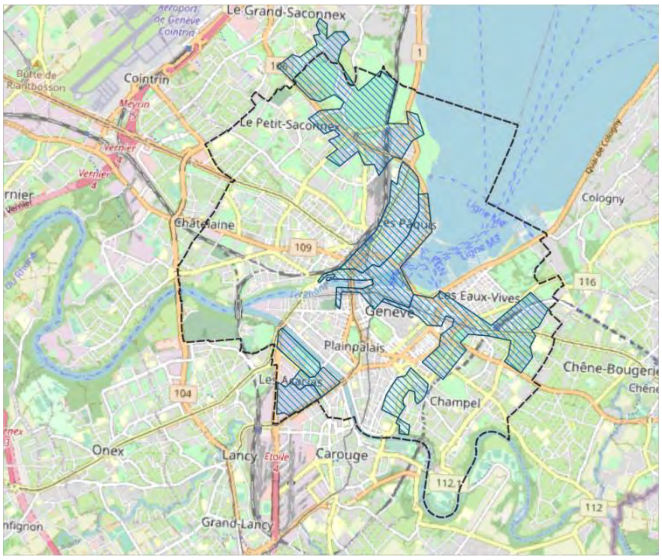


6.1.3. Supply Areas Mapping Results

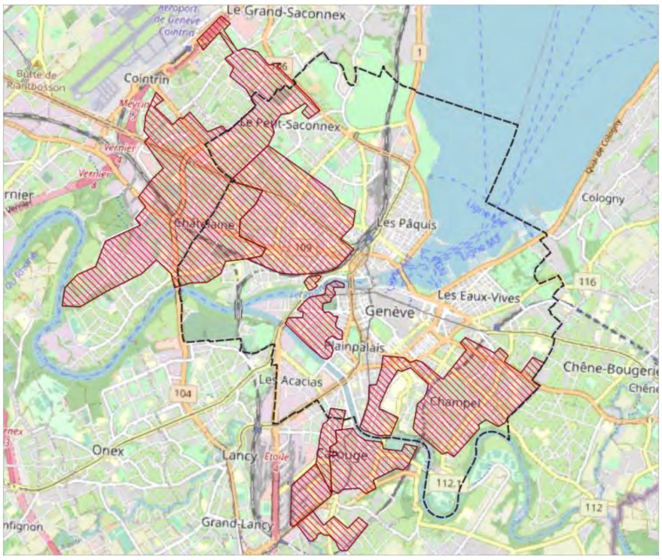
DH Coherent area



Structuring Networks Areas

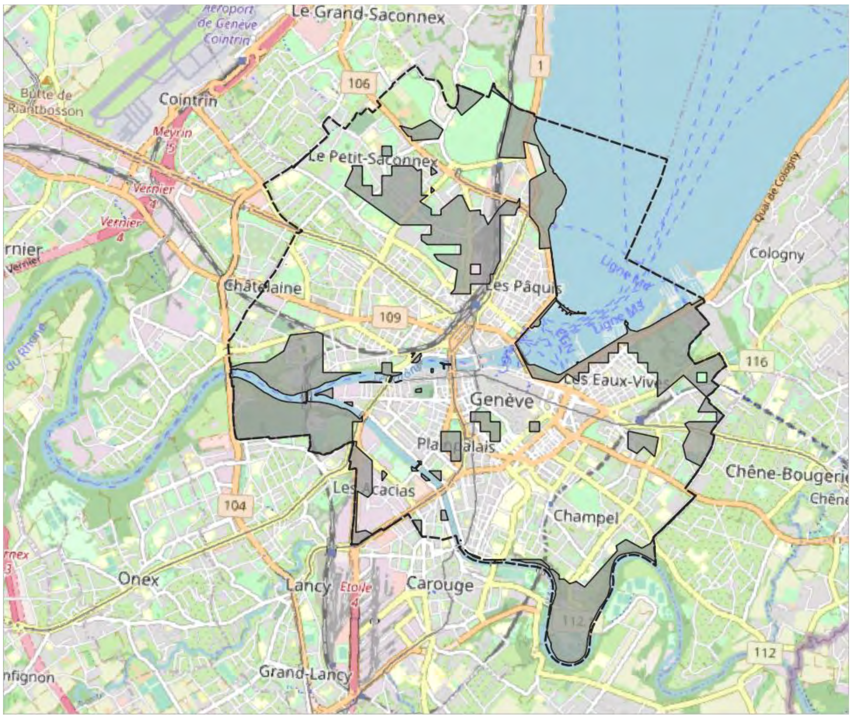


Low-temperature structuring networks GeniLac



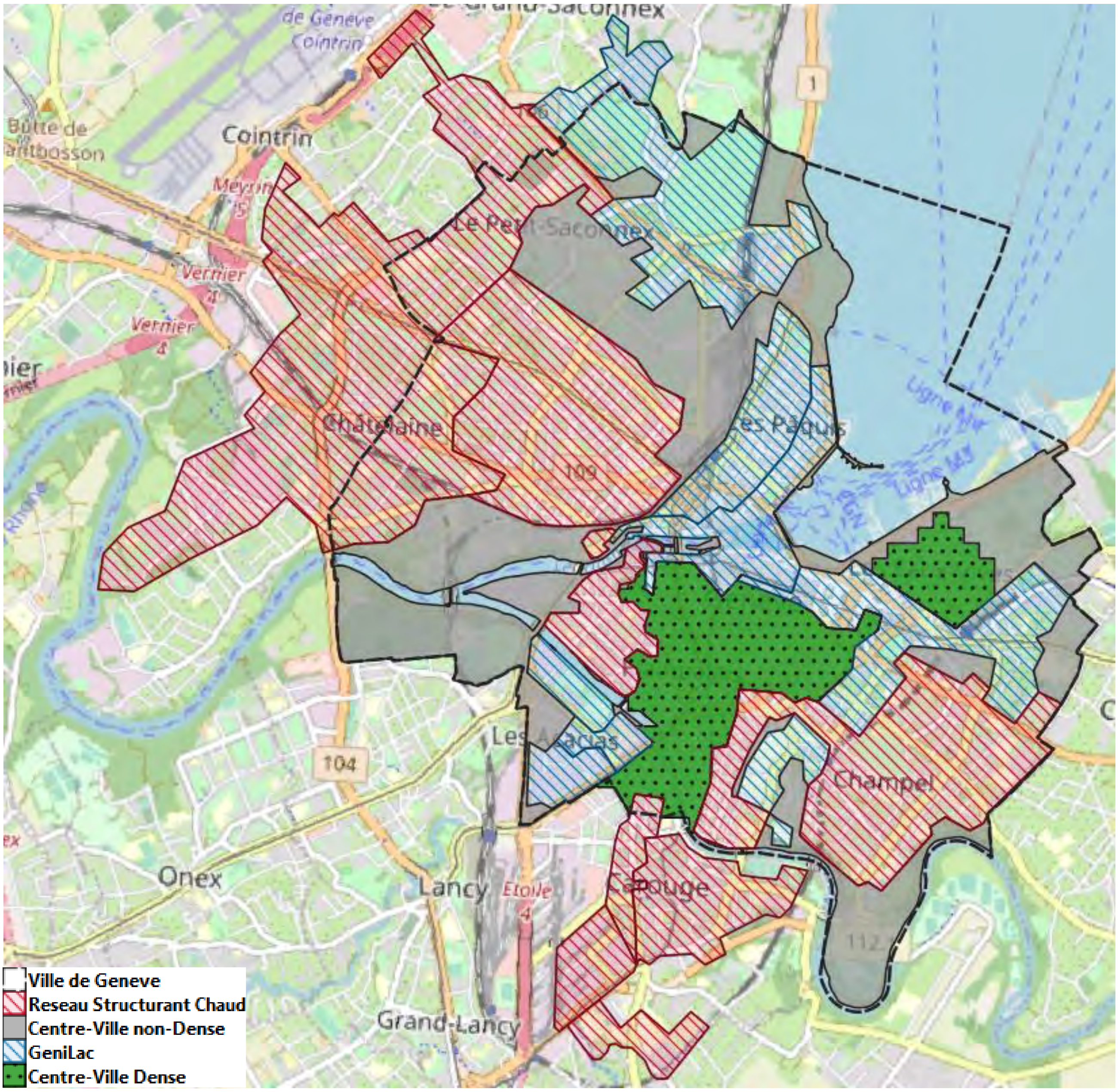
High-temperature structuring networks

Decentral heating area



Manual simplification

Final four working areas

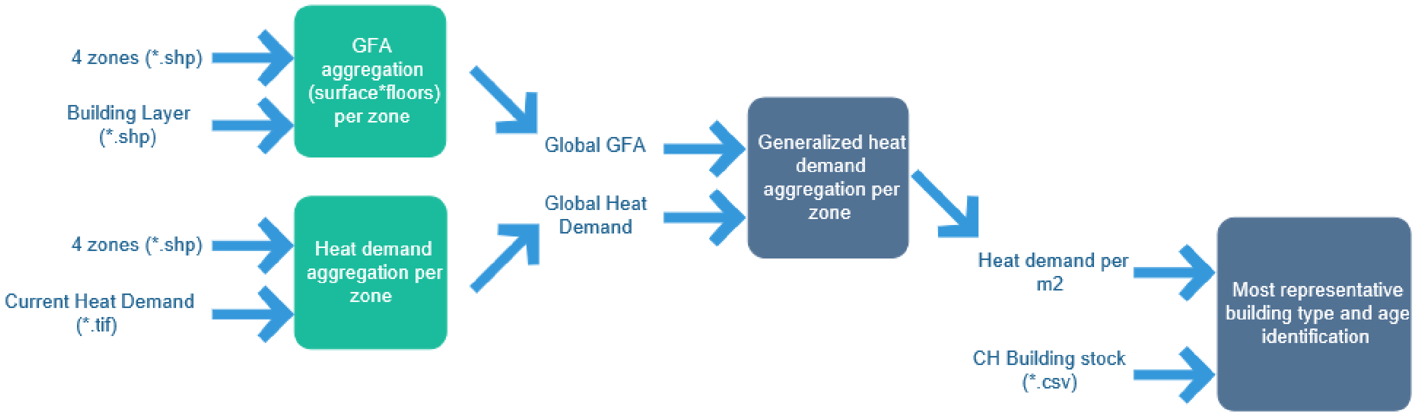


6.2. Determining a Representative Building Type by Zone

In order to quickly obtain results for the evaluation of the scenarios, a first data processing is necessary.

We have chosen to determine a representative building type per zone, defined essentially by the value of heat consumption per gross floor area (kWh/m2*year).

The process is as follows:

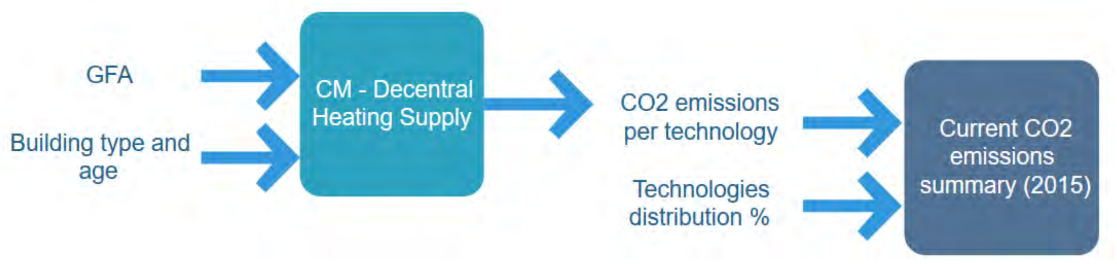


Thus, a unique building typology is used for each zone for further processing with the **Hotmaps toolbox**.

6.3. Reference Baseline in 2015

In order to make the scenarios comparable, a baseline summary must be established. This will allow the assessment of the advantages/disadvantages of each scenario.

The starting situation can be considered as a situation mainly covered by decentralised heating systems. A first "run" of the ***CM-Decentral heating supply*** is carried out, by zone, in order to determine the reference energy consumption and CO2 emissions.



6.3.1. Reference variables

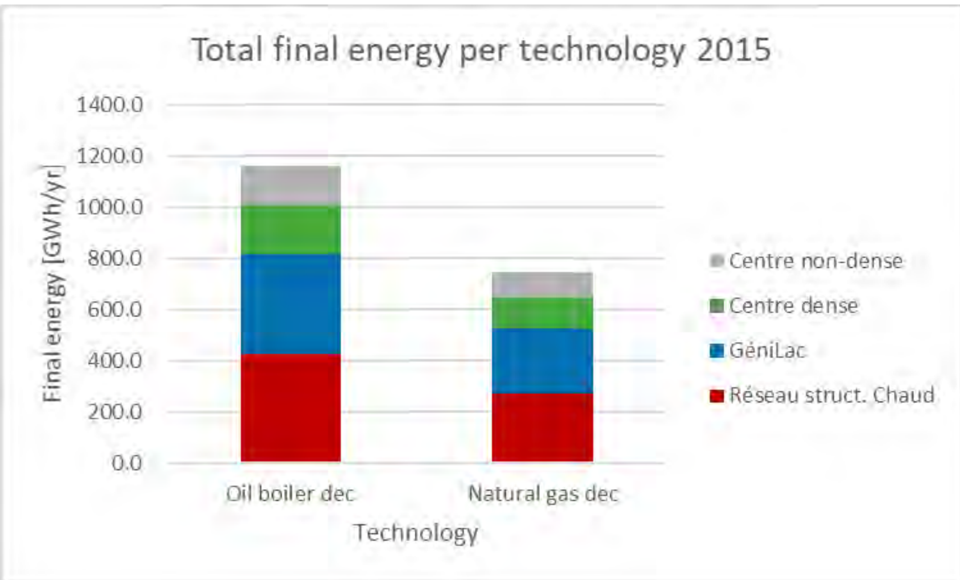
Scénario 2015				
Mix technologies	**Réseau str chaud**	**GéniLac**	**Centre dense**	**dense**
Oil boiler	59%	59%	59%	59%
Natural gas	40%	40%	40%	40%
HP Brine-to-Water	0%	0%	0%	0%
Other	1%	1%	1%	1%
Total	100%	100%	100%	100%

The "Other" value can be considered as gas (small DH networks) or possibly firewood (marginal share), whose CO_2 impact is neutral.

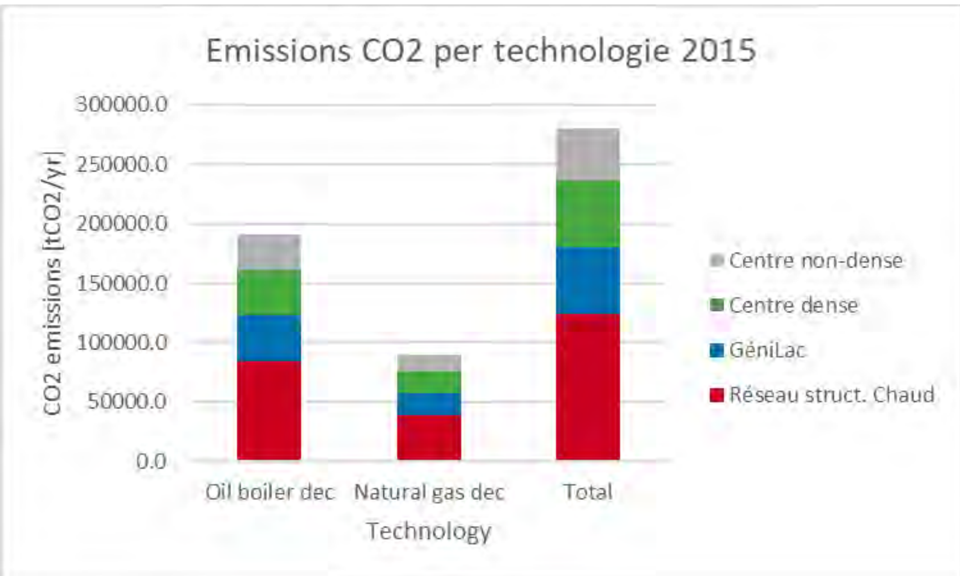
6.3.2. 2015 baseline results

A summary table of results is presented in Annex.

Final Energy Demand (MWh/yr) per area



Emissions CO2 (tCO2/yr) by area



6.4. Example of Scenario 1: Business as usual

6.4.1. Main variables of the scenario

Below is a description of the methodology applied with the **Hotmaps toolkit** for a conservative "BAU" scenario. This scenario still includes a large share of gas in the supply mix and a connection ratio ("Réseau structurant chaud" zone - red zone) of 50% to the new heating networks, themselves supplied by 50% renewable energy (CO_2 neutral). The red zone's indicators are calculated with the CM-District heating supply dispatch for the heat demand covered by the network. Indicators for the remaining demand are calculated with the CM-Decentral heating supply.

The blue zone GeniLac is considered as an area where the "lake water" resource is delivered to the foot of the buildings, but the building is equipped with an individual heat pump. In fact, the zone is considered as a decentralized heating zone, with a preponderance of heat pump technology. The scenario does not include the development of heat networks in the "Dense Centre" zone (green zone) and the "Non-Dense Centre" zone (grey zone). These three zones (blue, green and grey) are therefore studied with the CM-Decentral heating supply.

The variables used are summarised in the following tables:

Variables Hotmaps

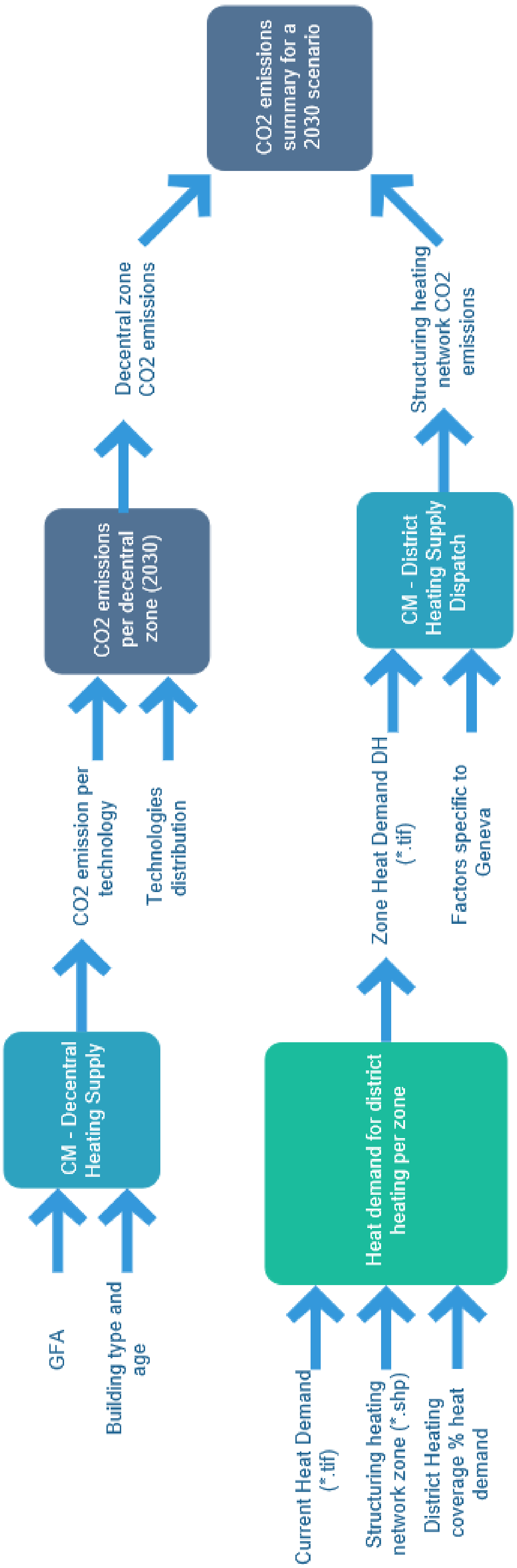
Baseline (2015)	Territorial Average
Gas	40%
Oil	59%
Firewood	1%

Scénario 2030	Réseau str chaud	GéniLac	Centre dense	Centre non dense
Gas	40%	40%	60%	60%
Oil	10%	10%	20%	20%
Firewood				1%
DH mix (50% waste + 50% gas)	50%			
HP		50%	20%	19%

CO2 emission factors	kgCO2/kWh	
Gas	0.1923	
Oil	0.2652	
Firewood	0	
Electricity GE	0.012	
Electricity mixCH	0.145	
HP (cop=3)	0.004	kg/kWh heat
DH Gaz	0.1923	
DH mix (50% waste + 50% gas)	0.1326	

CH- CO2 Tax	Period	Gas	Oil
CHF/tonne		ct/kWh	ct/kWh
96	2018-2020	1.85	2.55
120	2020-2022	2.31	3.18
210	2022-2030	4.04	5.57

The implementation process is as follows:

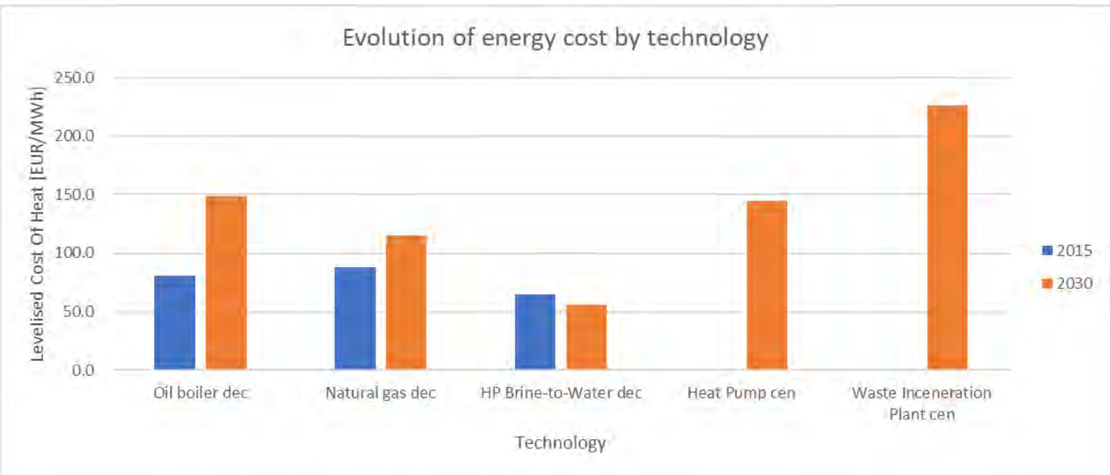


6.4.2. Scenario 1 results by zone

A summary table of results is presented in Annex.

Economic results

LCOH : Levelized cost of heat			2015	2030
decentral	Oil boiler dec	EUR/MWh	80.8	148.8
	Natural gas dec	EUR/MWh	87.9	115.2
	Biomass_Automatic dec	EUR/MWh	49.2	43.8
	HP Air-to-Air dec	EUR/MWh	70.3	59.1
	HP Brine-to-Water dec	EUR/MWh	65.1	55.9
	Electric heater dec	EUR/MWh	207.1	214.3
central	Heat Pump cen	EUR/MWh	0.0	145.0
	Waste Inceneration Plant cen	EUR/MWh	0.0	225.8
Decentral		EUR/MWh	83.7	116.6
Central		EUR/MWh	0.0	187.5
Total		EUR/MWh	83.7	141.2

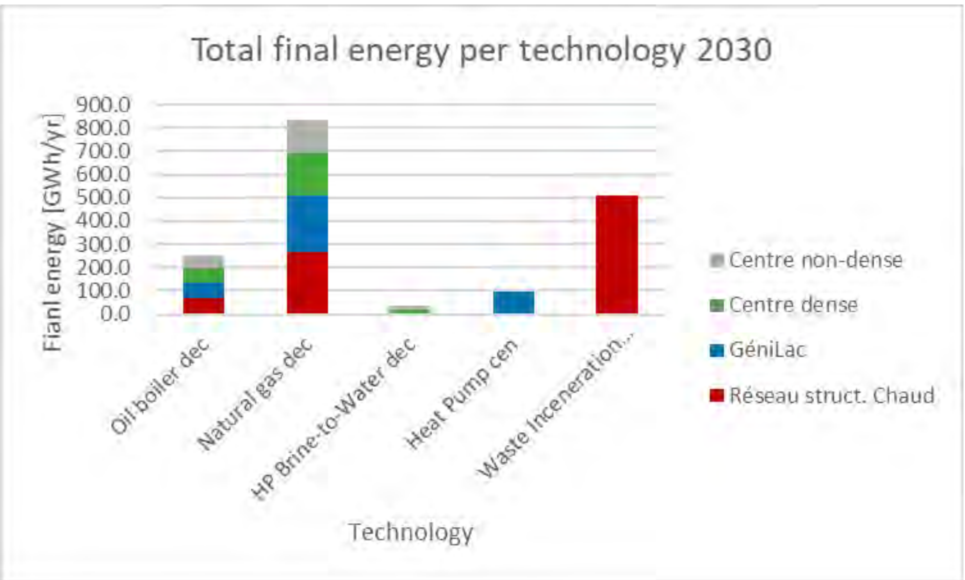


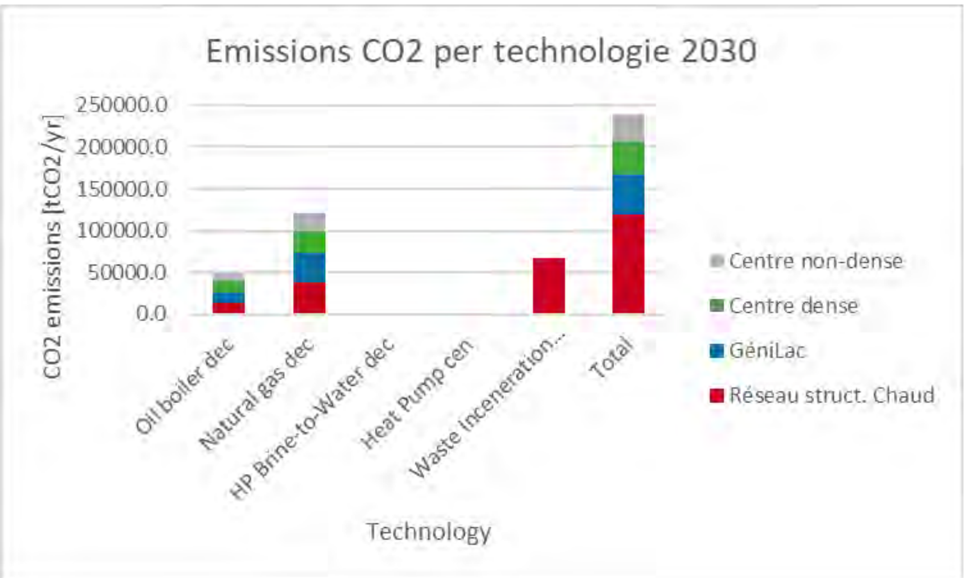
In developing this scenario, the major challenge is to develop an accurate cost estimate for the GeniLac zone and the network structuring zone, as it must be possible to incorporate the costs of network construction. Currently, the toolbox does not propose a CM for the low temperature district heating network.

We have tested the following method: We used the ***CM - Decentralised Heating Supply*** to calculate the costs of decentralised heat pumps and used the ***CM - District Heating Potential*** for the economic evaluation of the costs of building the cold water network.

The results presented are an aggregation of the two CMs. However, it seems that the main difficulty of this methodology is the fine configuration of the inputs in order to reflect as accurately as possible all the costs related to a low temperature network. We still need to refine the inputs to best match the reality in the field. But these tests have made it possible to establish a reproducible methodology.

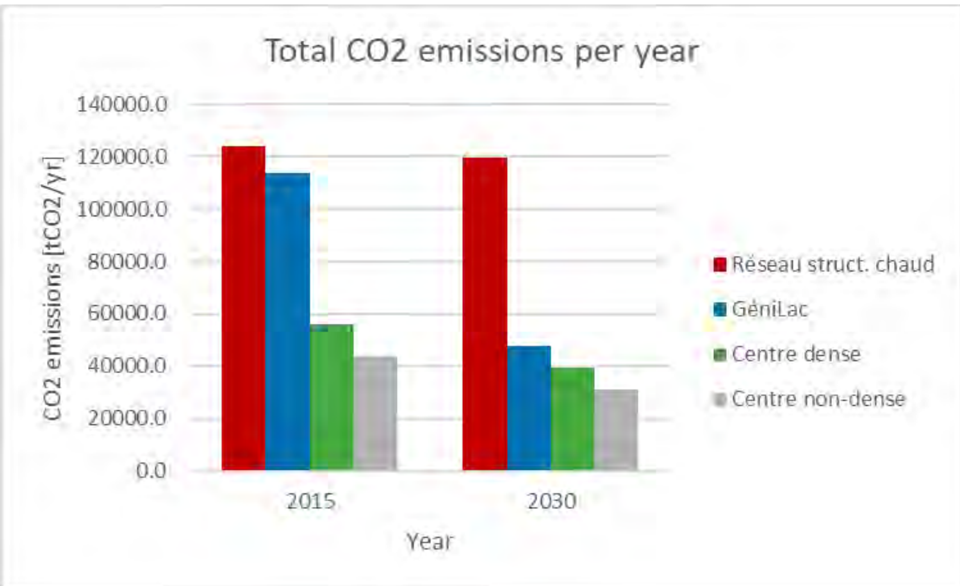
Energy and Climate Results

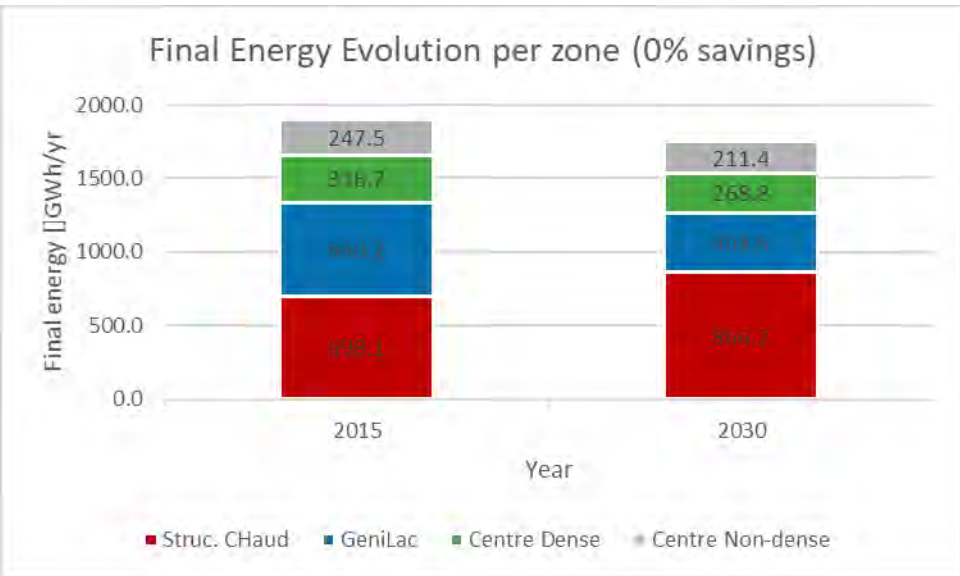




6.4.3. Comparison with the reference baseline

	Réseau str chaud	GéniLac	Centre dense	Centre non dense	Total
CO2 2015	123 913	113 625	56 211	43 928	337 677
CO2 2030	119 682	47 756	39 477	31 160	238 075
Decrease in emissions	3.4%	58.0%	29.8%	29.1%	29.5%
Final Energy 2015	698 124	640 162	316 688	247 488	1 902 462
Final Energy 2030	866 156	401 624	268 832	211 421	1 748 032
Decrease in energy	-24.1%	37.3%	15.1%	14.6%	8.1%





The overall reduction in CO_2 emissions is less than 30%. The energy and climate policy target is not being met.

The greatest reduction in emissions is in the blue zone (GeniLac) with a value of 58%. It is surprising to note that the "Réseau structurant chaud" zone (red zone) only benefits from a 3.4% reduction, less than the green and grey zones which see their emissions reduced by 30%. This small reduction is explained by a very "pessimistic" CO_2 emission coefficient, as the network could be supplied via the heat from waste incineration and a transition share from fossil fuels to renewable energies of only 25%. This means that waste incineration, while it meets the requirement for the development of heating networks, does not meet climatic requirements. In terms of energy planning, this means that an additional renewable heat source must be found and integrated into the projections of the more interventionist scenarios.

The reductions in the green and grey zones are mainly explained by a transfer of heat production from oil to gas or to heat pump.

Useful energy consumption does not really decrease. The scenario does not include actions related to the energy efficiency of buildings. This stability is therefore logical.

7. Conclusion and continuation of the energy planning process

The elements presented in the City of Geneva's strategy are a first step in the territorial energy planning process.

Given the time limits of the **Hotmaps** project, it seemed a priority to us to define and test a methodology for optimum use of the **toolbox**.

The results obtained on the first scenario (BAU) do not meet the objectives of the City of Geneva, but this was expected.

Within the framework of our strategy for using the **toolbox**, these results are not formally important. Our priority was to develop and present a succession of reasoning and results provided by the calculation modules, in order to evaluate the other scenarios and to know the important variables in this way of proceeding.

The main result of this work is to understand how to determine the areas of influence of certain projects and to identify the different technological solutions that will be implemented in these different areas and to determine their economic and climatic impacts.

For the **Hotmaps** project, we carried out a rather simple segmentation of the territory. For the rest of our territorial planning process, we will probably have to refine this territorial segmentation in order to have a more complex model of the territory. In particular by taking into account the concrete obstacles of the territory (subsoil congestion, mobility and traffic on priority axes, trees, etc.), but also to integrate energy efficiency actions on buildings, in order to obtain the most accurate picture possible.

These results and those that will be evaluated with the other scenarios will make it possible to define a medium and long-term territorial strategy to meet the ambitious political objectives that the City of Geneva has set itself. This will still require a lot of work.

Today we know how to carry it out and how to interpret the results provided by the toolbox and we hope that this process can be replicated by other cities in Switzerland and Europe.

The examples presented are an illustration of the methodology that is being put in place in order to achieve an exhaustive municipal planning at the beginning of 2021.

This strategy is only the first chapter of a long and beautiful adventure with **Hotmaps**.

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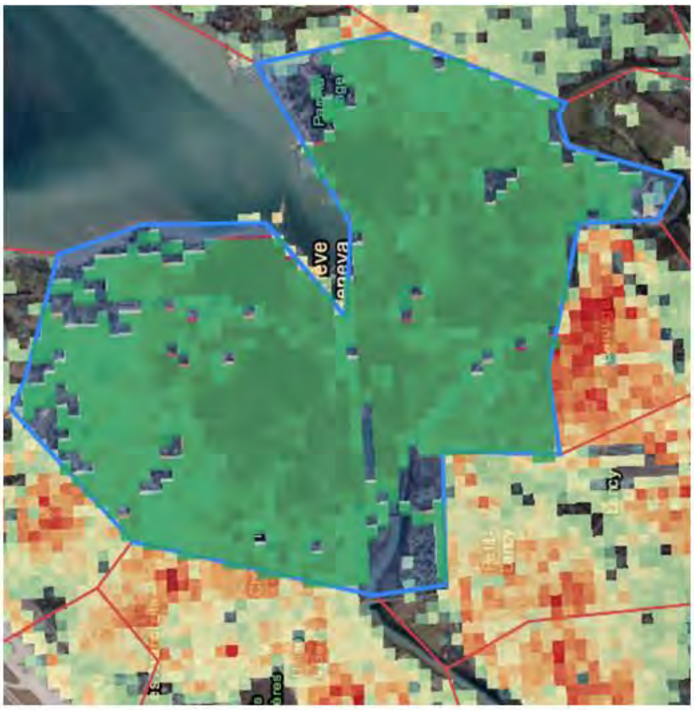
Solar potential

http://ge.ch/sitg/geodata/SITG/CATALOGUE/INFORMATIONS_COMPLEMENTAIRES/RAPPORT_CADASTRE_SOLAIRE_PHASE_2_2014.pdf

Annexes

Interpretation of Toolbox results, section 4.1.6.

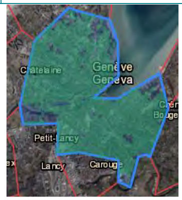
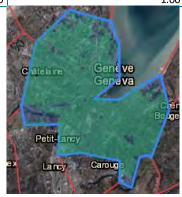
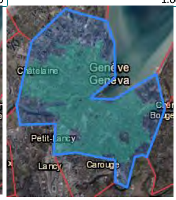
Variation in certain key parameters

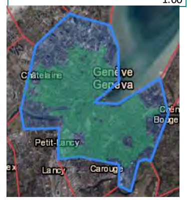


Input parameter [unit]	
First year of investment	2018
Last year of investment	2030
Depreciation time	30
Accumulated energy saving [-]	0.1
DH market share at the beginning of the investment period	0.3
DH market share at the end of the investment period [-]	0.6
Interest rate	0.05
DH grid cost ceiling [EUR/MWh]	150
Construction cost constant – Inner city [EUR/m]	6000
Construction cost constant – Outer city [EUR/m]	5000
Construction cost constant – Park [EUR/m]	5000
Construction cost coefficient – Inner city [EUR/m²]	10000
Construction cost coefficient – Outer city [EUR/m²]	10000
Construction cost coefficient – Park [EUR/m²]	8000
Full load hours	2000

Output parameter [unit]		
heat_tot_curr_density		
heat_tot_curr_density_consumption	1'710	GWh/yr
heat_tot_curr_density_count_cell	1'466	cells
heat_tot_curr_density_consumption_min	1	MWh/(ha*yr)
heat_tot_curr_density_consumption_max	4'022	MWh/(ha*yr)
heat_tot_curr_density_density	1'166	MWh/(ha*yr)
Economics_test1 - CM - District heating potential: economic assessment		
Total demand in selected region in the first year of investment	1'709'717	MWh
Total demand in selected region in the last year of investment	1'538'745	MWh
Maximum potential of DH system through the investment period	920'731	MWh
Energetic specific DH grid costs	130	EUR/MWh
Energetic specific DH distribution grid costs	130	EUR/MWh
Energetic specific DH transmission grid costs	-	EUR/MWh
Specific DH distribution grid costs per meter	551	EUR/m
Specific DH transmission grid costs per meter	-	EUR/m
Total grid costs - annuity	119'814'204	EUR
Total distribution grid costs - annuity	119'814'204	EUR
Total transmission grid costs - annuity	-	EUR
Total distribution grid trench length	217	km
Total transmission grid trench length	-	km
Total number of coherent areas	1	
Number of economic coherent areas	1	

LAU2 : GENEVA		GENEVA	GENEVA	GENEVA	GENEVA	GENEVA	GENEVA	GENEVA	GENEVA
Input parameter [unit]									
First year of investment		2018	2018	2018	2018	2018	2018	2018	2018
Last year of investment		2030	2030	2030	2030	2030	2030	2030	2030
Depreciation time		30	30	30	30	30	30	30	30
Accumulated energy saving [-]		0.1	0.1	0.1	0.1	0.1	0.3	0.1	0.1
DH market share at the beginning of the investment period		0.3	0.3	0.3	0.3	0.3	0.3	0 to 0.2	0
DH market share at the end of the investment period [-]		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Interest rate		0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
DH grid cost ceiling [EUR/MWh]		150	100	80	75	72	**75**	75	100
Construction cost constant – Inner city [EUR/m]		5000	5000	5000	5000	5000	5000	5000	5000
Construction cost constant – Outer city [EUR/m]		5000	5000	5000	5000	5000	5000	5000	5000
Construction cost constant – Park [EUR/m]		5000	5000	5000	5000	5000	5000	5000	5000
Construction cost coefficient – Inner city [EUR/m²]		2067.13	2067.13	2067.13	2067.13	2067.13	2067.13	2067.13	2067.13
Construction cost coefficient – Outer city [EUR/m²]		1763.5	1763.5	1763.5	1763.5	1763.5	1763.5	1763.5	1763.5
Construction cost coefficient – Park [EUR/m²]		1408.76	1408.76	1408.76	1408.76	1408.76	1408.76	1408.76	1408.76
Full load hours		3000	3000	3000	3000	3000	3000	3000	3000
Output parameter [unit]									
Indicators									
heat_tot_curr_density_consumption	GWh/yr	1'709.72	1'709.72	1'709.72	1'709.72		1'709.72	1'709.72	1'709.72
heat_tot_curr_density_count_cell	cells	1'466.00	1'466.00	1'466.00	1'466.00		1'466.00	1'466.00	1'466.00
heat_tot_curr_density_consumption_min	MWh/(ha*yr)	0.50	0.50	0.50	0.50		0.50	0.50	0.50
heat_tot_curr_density_consumption_max	MWh/(ha*yr)	4'021.51	4'021.51	4'021.51	4'021.51		4'021.51	4'021.51	4'021.51
heat_tot_curr_density_density	MWh/(ha*yr)	1'166.25	1'166.25	1'166.25	1'166.25		1'166.25	1'166.25	1'166.25
Economics_test1 - CM - District heating potential: economic assessment									
Total demand in selected region in the first year of investment	MWh	1'709'716.93	1'709'716.93	1'709'716.93	1'709'716.93	No coherent area for given input parameters found!	1'709'716.93	No coherent area for given input parameters found!	1'709'716.93
Total demand in selected region in the last year of investment	MWh	1'538'745.23	1'538'745.23	1'538'745.23	1'538'745.23	Not available	1'196'801.85	Not available	1'538'745.23
Maximum potential of DH system through the investment peri	MWh	920'731.48	920'731.48	807'736.39	715'431.29		226'787.17		789'725.94
Energetic specific DH grid costs	EUR/MWh	90.23	90.23	76.15	71.10		71.01		95.00
Energetic specific DH distribution grid costs	EUR/MWh	90.23	90.23	76.15	71.10		71.01		95.00
Energetic specific DH transmission grid costs	EUR/MWh	-	-	-	-		-		-
Specific DH distribution grid costs per meter	EUR/m	382.36	382.36	384.25	384.87		358.18		487.57
Specific DH transmission grid costs per meter	EUR/m	-	-	-	-		-		-
Total grid costs - annuity	EUR	83'079'089.08	83'079'089.08	61'512'196.28	50'868'342.77		16'103'563.54		75'020'985.32
Total distribution grid costs - annuity	EUR	83'079'089.08	83'079'089.08	61'512'196.28	50'868'342.77		16'103'563.54		75'020'985.32
Total transmission grid costs - annuity	EUR	-	-	-	-		-		-
Total distribution grid trench length	km	217.28	217.28	160.08	132.17		44.96		153.86
Total transmission grid trench length	km	-	-	-	-		-		-
Total number of coherent areas		1.00	1.00	1.00	1.00		2.00		1.00
Number of economic coherent areas		1.00	1.00	1.00	1.00		1.00		1.00

Summary table of results – § 6.3.2. and § 6.4.2.

Final table Baseline / Scenario BAU

OUTPUT DATA

	Parameter	Subparameter	Unit	2015 Str.Ch.	2015 GeniLac	2015 CentreD	2015 CentreND	2030 Str.Ch.	2030 GeniLac	2030 CentreD	2030 CentreND	Baseline (2015)	Scenario BAU - 2030
CAPEX / OPEX:	**decentral**	capex dec	M EUR/yr	0.06	0.06	0.04	0.03	0.03	0.03	0.26	0.20	0.20	0.51
		opex dec	M EUR/yr	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.03
		energy dec	M EUR/yr	39.50	36.22	17.92	14.00	25.03	22.67	21.82	17.10	107.63	86.62
		CO2 dec	M EUR/yr	15.86	14.54	7.19	5.62	14.65	13.26	11.05	8.72	43.22	47.69
	central	capex cen	M EUR/yr					11.84	0.62				12.46
		opex cen	M EUR/yr					4.10	0.01				4.11
		energy cen	M EUR/yr					1.81	11.48				13.29
		CO2 cen	M EUR/yr					11.28	0.06				11.34
	Grid	grid costs	M EUR/yr					44.19	30.14				74.33
	Total		**M EUR/yr**	**55.44**	**50.84**	**25.17**	**19.67**	**112.93**	**78.28**	**33.14**	**26.03**	**151.12**	**250.37**
LCOH:	**decentral**	LCOH dec	EUR/MWh	83.63	83.63	83.69	83.70	121.88	121.88	110.20	110.75	83.65	116.58
	central	LCOH cen	EUR/MWh					225.80	145.00				187.53
	Total	LCOH total	**EUR/MWh**	**83.63**	**83.63**	**83.69**	**83.70**	**173.71**	**133.37**	**110.20**	**110.75**	**83.65**	**141.23**
CO2 Emissions:	**decentral**	Oil boiler dec	tCO2/yr	84494.8	77479.6	38329.2	29953.9	13939.3	12622.8	12863.0	10153.8	230257.5	49579.0
		Natural gas dec	tCO2/yr	39418.6	36145.8	17881.3	13974.1	38367.5	34744.0	26553.8	20961.1	107419.8	120626.5
		HP Brine-to-Water dec	tCO2/yr							60.1	45.1		105.2
	central	Heat Pump cen	tCO2/yr						389.0				389.0
		Waste Inceneration Plan	tCO2/yr					67371.2					67371.2
		Heat Boiler cen	tCO2/yr					4.2					4.2
	Total		**tCO2/yr**	**123913.4**	**113625.4**	**56210.5**	**43927.9**	**119682.3**	**47755.9**	**39477.0**	**31160.1**	**337677.3**	**238075.2**
Final Energy:	**decentral**	Oil boiler dec	GWh/yr	424.8	389.5	192.7	150.6	70.1	63.5	64.7	51.1	1157.7	249.3
		Natural gas dec	GWh/yr	273.3	250.6	124.0	96.9	266.0	240.9	184.1	145.3	744.8	836.4
		HP Brine-to-Water dec	GWh/yr							20.0	15.0	0.0	35.1
	central	Heat Pump cen	GWh/yr						97.3				97.3
		Waste Inceneration Plan	GWh/yr					508.1					508.1
		Heat Boiler cen	GWh/yr					22.0					22.0
	Total		**GWh/yr**	**698.1**	**640.2**	**316.7**	**247.5**	**866.2**	**401.6**	**268.8**	**211.4**	**1902.5**	**1748.0**
Useful Energy:	**decentral**	Oil boiler dec	GWh/yr	395.1	362.3	179.2	140.1	65.2	59.0	60.1	47.5	1076.6	231.8
		Natural gas dec	GWh/yr	267.8	245.6	121.5	95.0	260.7	236.1	180.4	142.4	729.9	819.6
		HP Brine-to-Water dec	GWh/yr							60.1	45.1		105.2
	central	Heat Pump cen	GWh/yr						291.8				291.8
		Waste Inceneration Plan	GWh/yr					305.1					305.1
		Heat Boiler cen	GWh/yr					19.1					19.1
	Total		**GWh/yr**	**662.9**	**607.9**	**300.7**	**235.0**	**650.1**	**586.9**	**300.7**	**235.0**	**1806.5**	**1772.7**
Shares:	decentral supply	RES share dec (final ener	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	DH supply	RES share cen (final ener	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	whole system	RES share total (final ene	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	whole system	DH share (final energy)	**%**	**0.0**	**0.0**	**0.0**	**0.0**	**61.2**	**24.2**	**0.0**	**0.0**	**0.0**	**35.9**