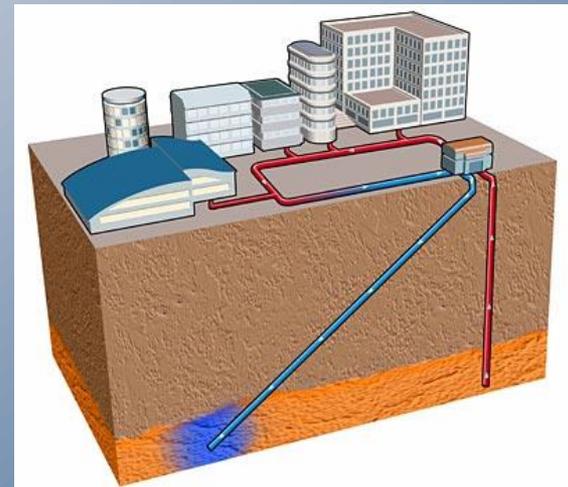
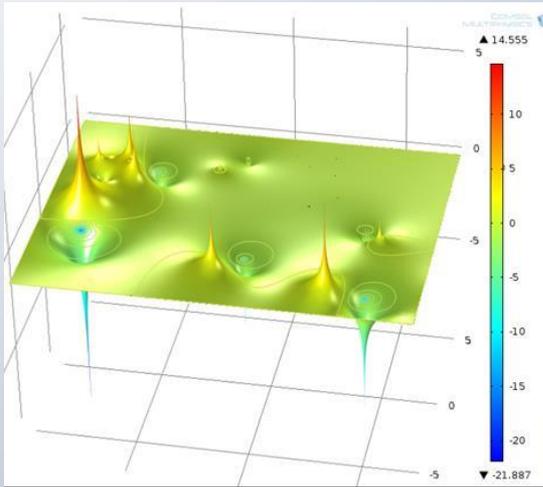
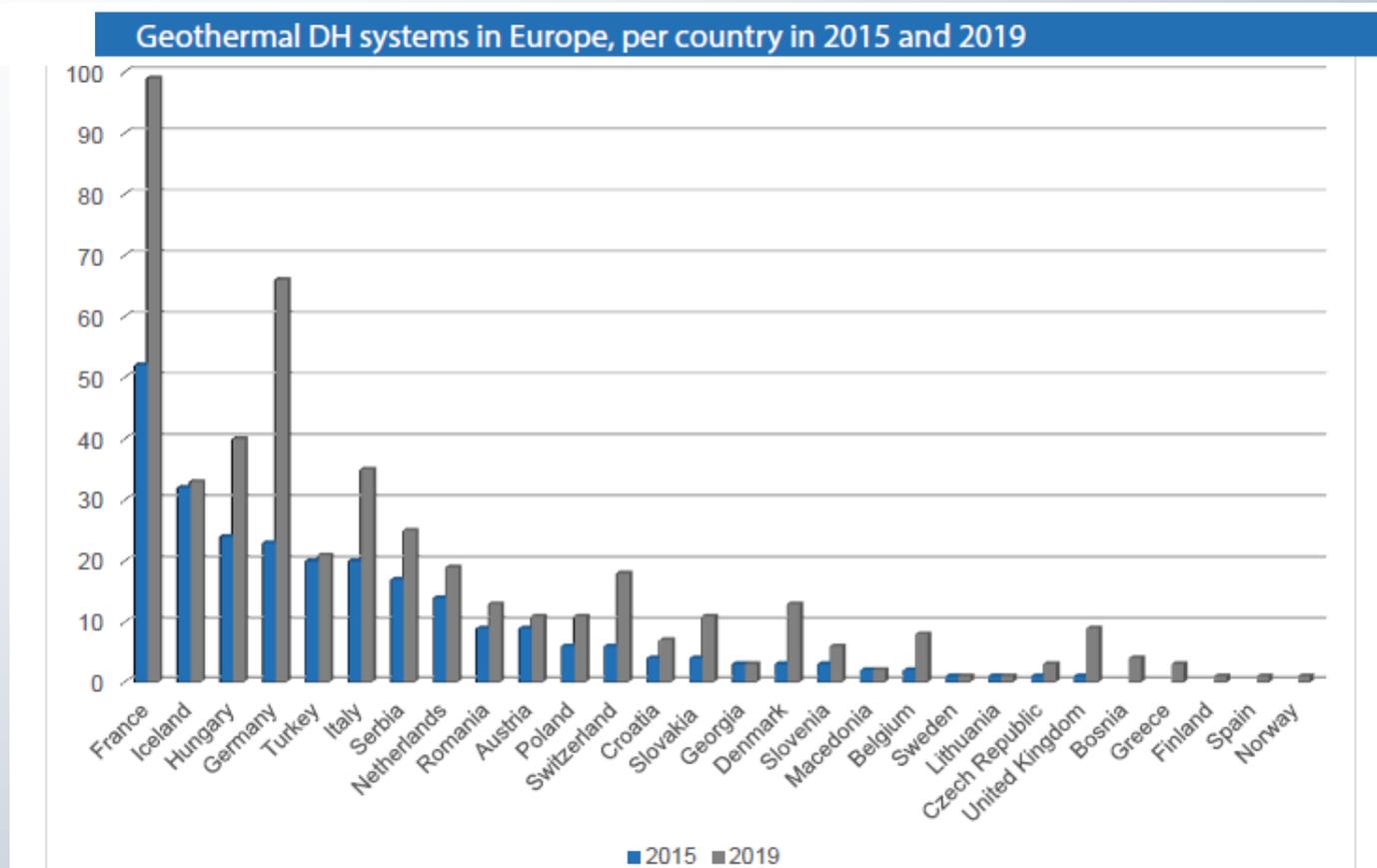


Towards the industrialisation of geothermal energy in Denmark:

A look at 35 years of success in geothermal energy for district heating in France.



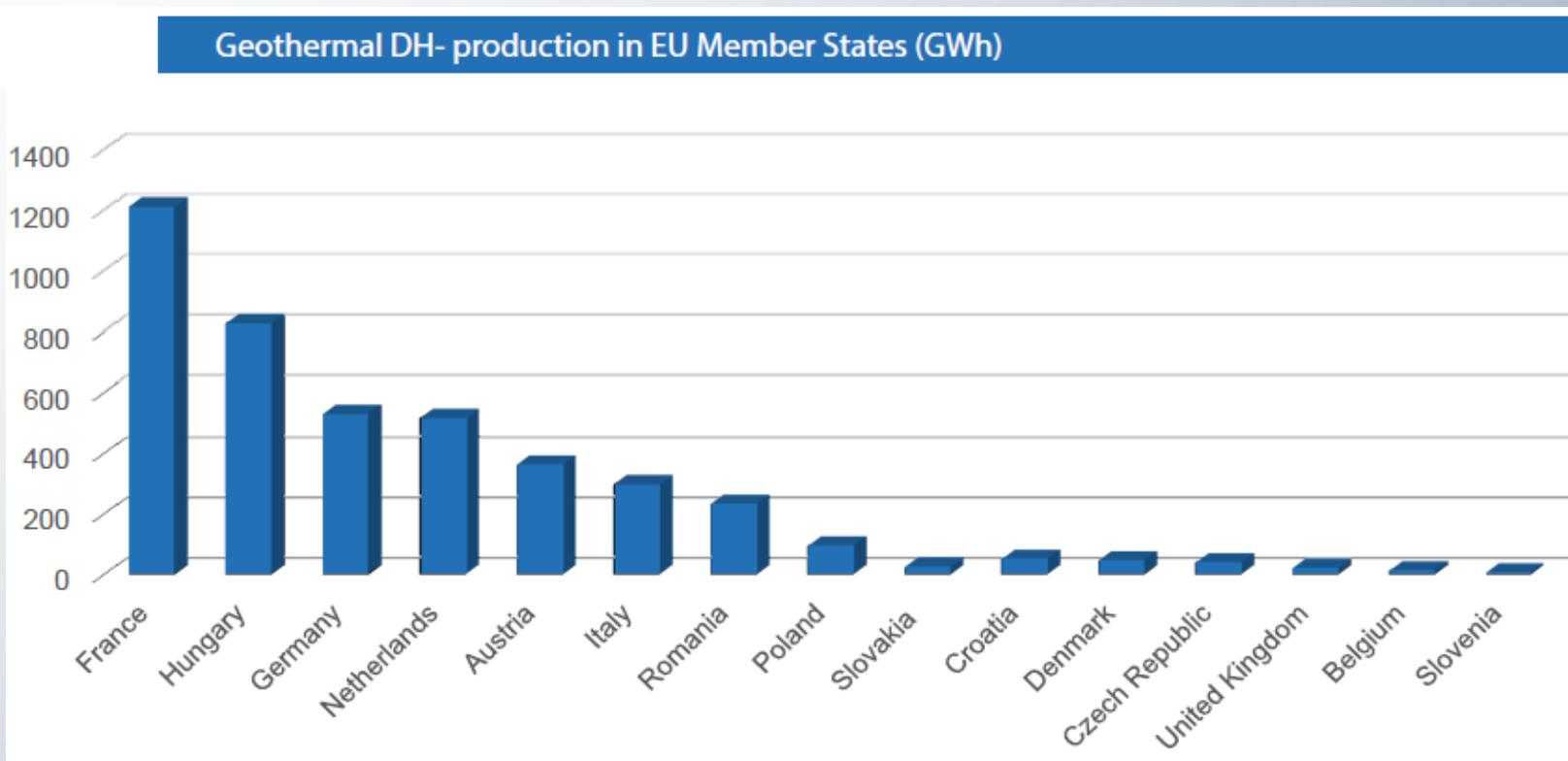
GEOTHERMAL DISTRICT HEATING IN FRANCE



Source: EGEN 2015 Market Report

- There are 50 district heating networks running on geothermal in France. That number should double by 2019.
- Providing geothermal heat to more than 750 000 people (mostly in the Paris basin)

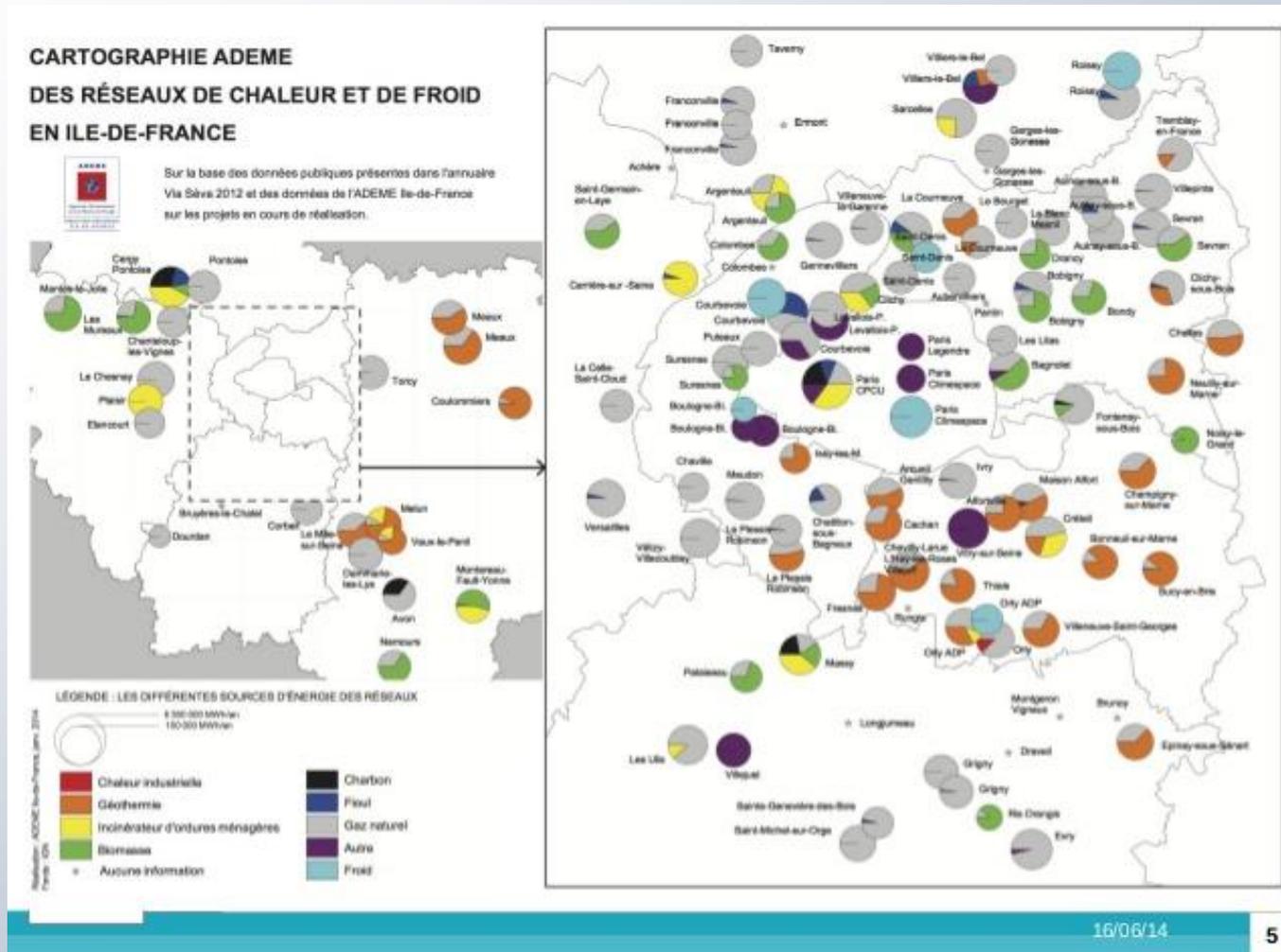
GEOTHERMAL DISTRICT HEATING IN FRANCE



Source: EGEN 2015 Market Report

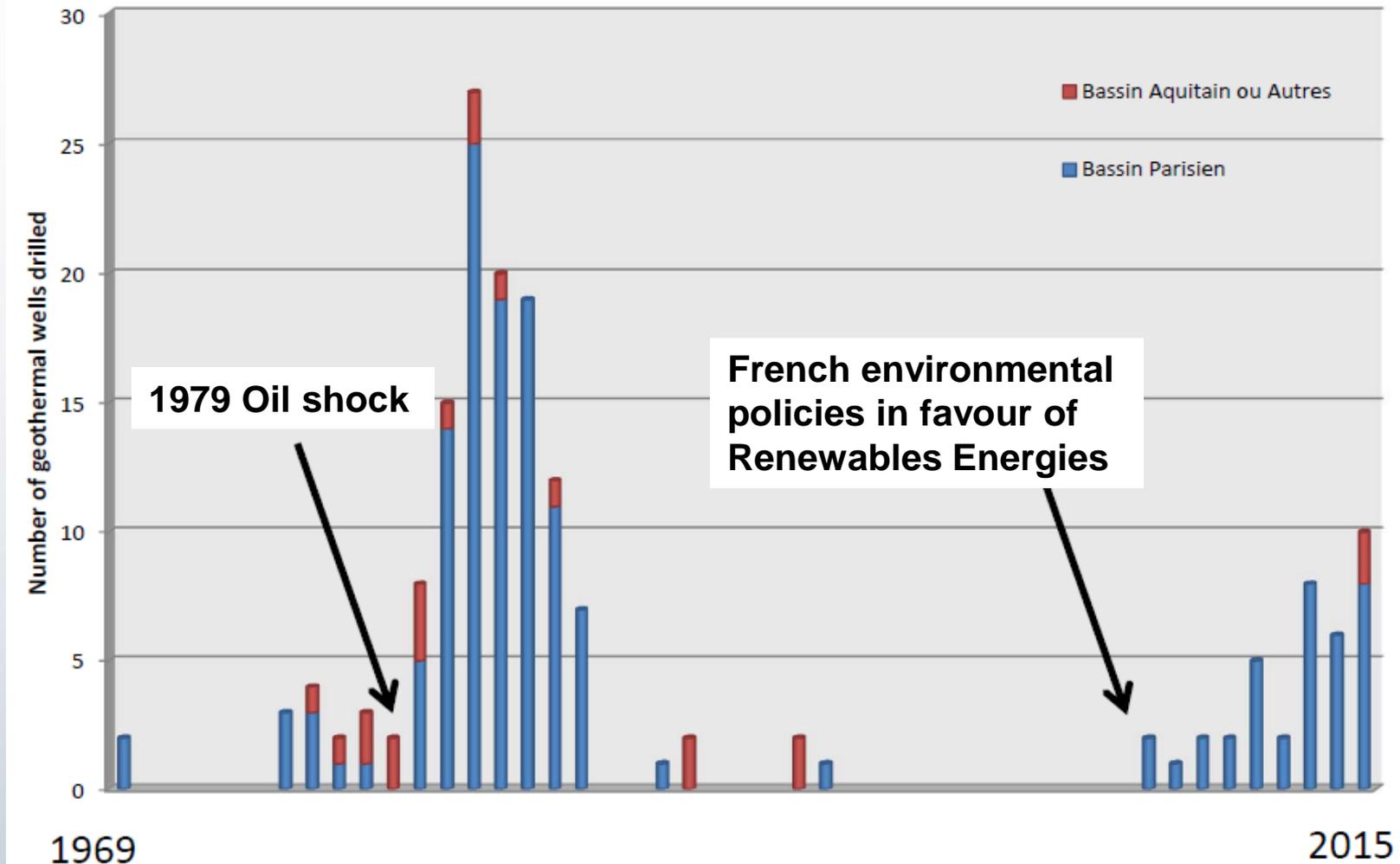
- **Each year in France, geothermal energy for district heating networks produces 1 200 GWh**
- **Under the current mid-term development scheme, this figure should double by 2020**

GEOHERMAL DISTRICT HEATING IN FRANCE



- Most geothermal plants are present in the south-western part of the Paris greater area where the characteristics of the geothermal fluid in the main local geothermal aquifer (Dogger) are the most appropriate
- Principal contender to geothermal energy in France is still natural gas.

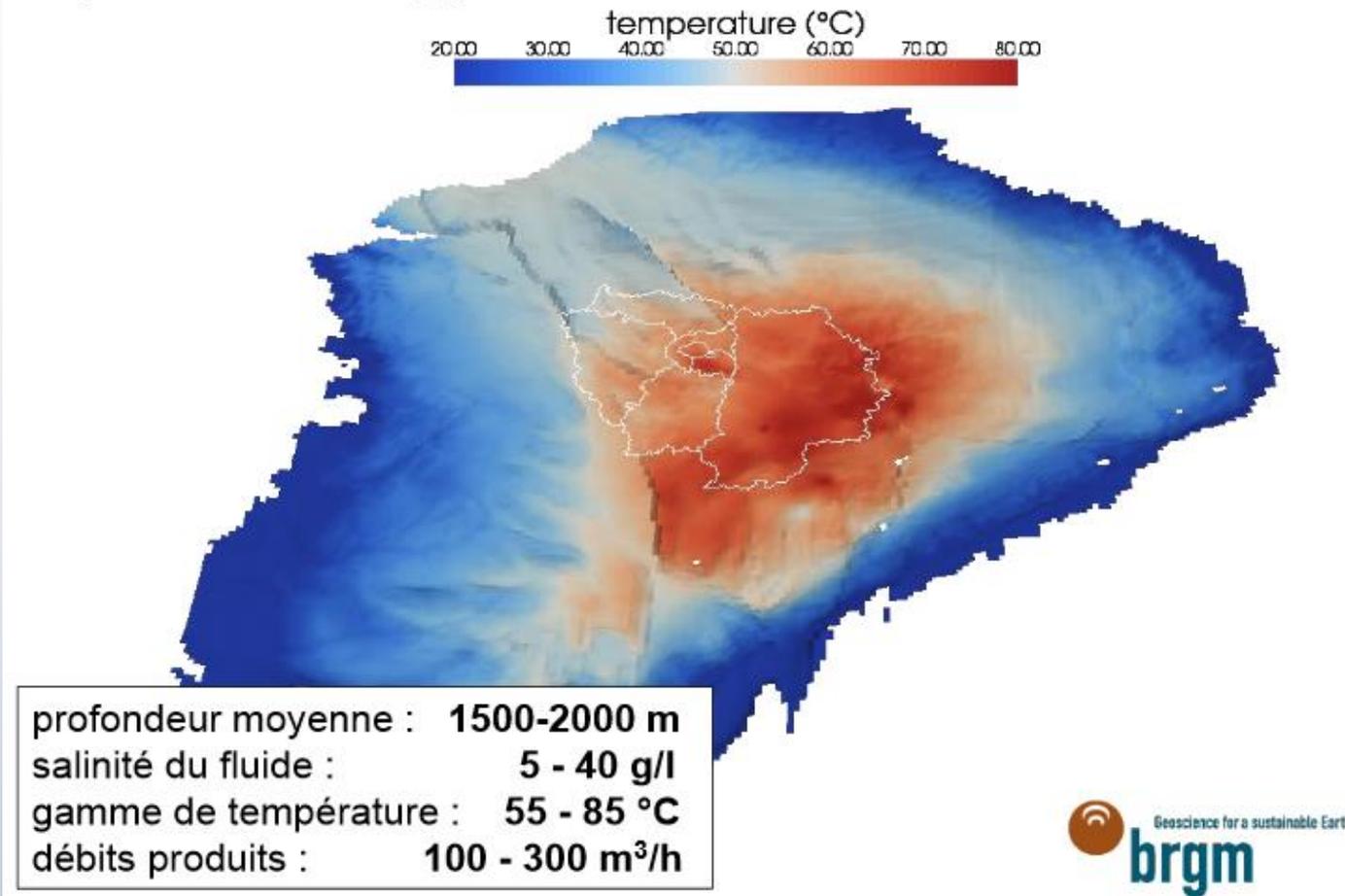
GEOHERMAL DISTRICT HEATING IN FRANCE



- Geothermal drilling activity in France shows the boom of the 80's after the first oil shock, the long pause of the 90's during the low-priced oil era, and the reboot in the mid-2000's corresponding to higher fossil fuel prices but also a new RE-friendly policy environment.

Reason of success n°1: Supply meets demand!

l'aquifère du « Dogger »



- Paris greater area (ca. 10 million people) sits right above the limestones Dogger geothermal aquifer.
- The same favourable conditions can be found in the Aquitaine basin and the Rhine graben, for example.

Reason of success n°2: A short and long term geothermal risk mitigation fund running for 35 years.

The « Geothermal Fund » (Fonds Géothermie) was created in 1980, at the onset of the first geothermal development phase in France in early 80's for a 25 year period (renewed in 2004).

- Hosted by an ad hoc company (SAF Environnement) 100% subsidiary of the CDC state-owned bank.
- Covering the entire french territory for heating district network.
- Technical committee headed by ADEME (French Agency for Energy Savings) -
Note that a geothermal project cannot benefit from the Heat Fund subsidies if it's not insured by the Geothermal Fund.
- Offering two type of « insurance »: Short term (or exploration) geothermal mitigation risk and Long-term (or exploitation) geothermal mitigation risk
 - STI reimburse up to 90% of the exploration costs (drilling) in case of failure to discover the expected geothermal ressource
 - LTI covers the risk of geothermal ressource decline or alteration over a 20 years period.

Reason of success n°3:

Pro-renewable energy policies tailored for geothermal energy.

- Between 2009 and 2013, the « Heat Fund » provided 1,12 B€ for 3000 renewable projects and associated district heating network, representing 1,36 million toe.
- Covers biomass, biogaz, geothermal energy, solar heating.
- Heat fund will be doubled between 2014 and 2017 (420 M€ in 2017).
- When selecting projects, the developer must promote first the local energy (Geothermal energy > biomass in populated areas like the Paris area)
- Subsidies from local regional governments on top of national scheme.
- If the district heating network is powered by >50% of renewable energy, the VAT for the final consumer is 5.5% instead of the normal rate of 20%.
- Typically, a new geothermal doublet + District Heating Network development can be subsidized at 30% by the Heat Fund.



Reason of success n°4: A multi-partner integrated approach for project development, exploration, exploitation and maintenance.

A project owner (typically a city running a District Heating System, a private company for its own heat needs, or a private company operating a public DHS under a « Delegation of Public Service » contract) calls for:

- A Geothermal project manager (engineering services company specialized in underground works for geothermal energy) who will conduct prefeasibility studies, feasibility studies and the drilling supervision, reservoir testing, until the geothermal loop commissioning (See following slide).
- A monitoring and maintenance company, when the facility is running, helping during the exploitation on a short-term or long-term basis (up to 30 years) in order to secure its investment and ensure the sustainability of the geothermal loop (from reservoir to surface) but also in compliance of the regulatory framework associated to deep geothermal systems.



That scheme was progressively installed in France over the last 35 years and has proved resilient to the highs and lows encountered by geothermal energy in the country. As an engineering company, CFG Services is specialized in both aspects since 30 years.

The central role of the geothermal project management for a successful geothermal project

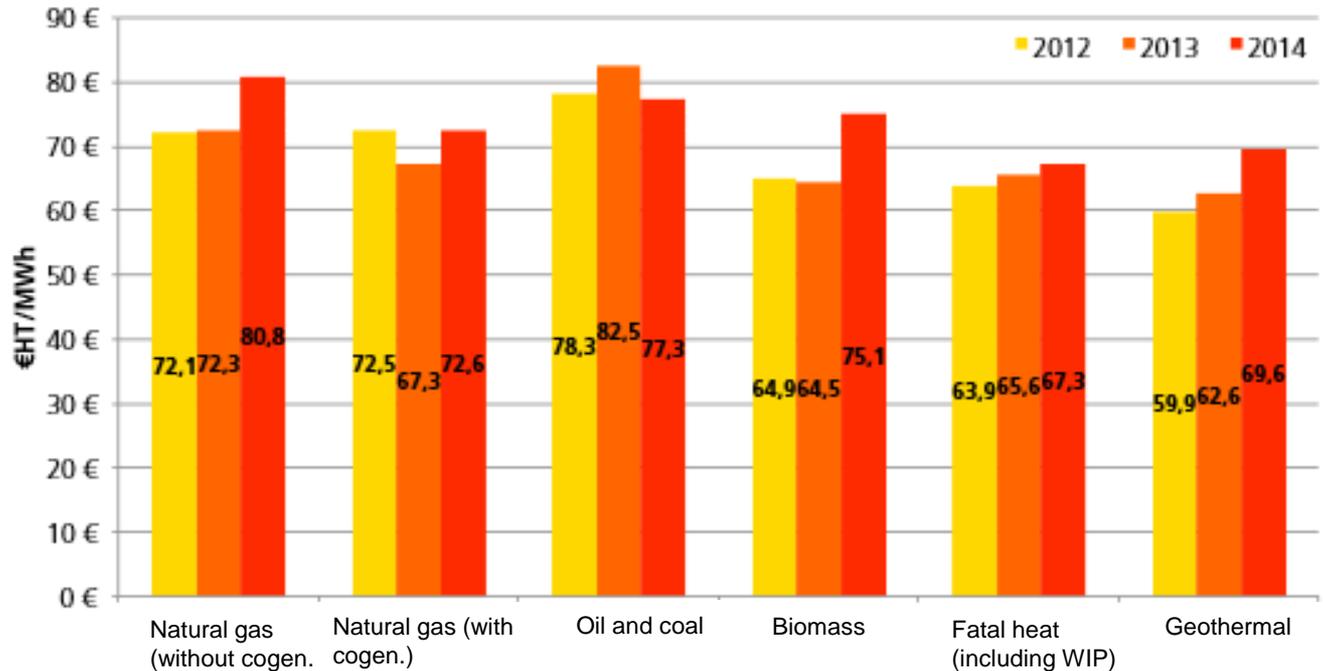
- ✓ **Identify and validate** the most pertinent technical scenario for the geothermal project (including geological, hydrogeological and geochemical studies).
- ✓ **Make the project compliant** with the local legislation/regulation (Mining Code / Regional authorities).
- ✓ **Determine the financial scheme of the project** (in collaboration with a « surface » engineering company) and **plan it**.
- ✓ **Assist the project developer in seeking financing**
- ✓ **Looking for the best performing companies** for the project realisation (Tendering – Companies selection – Realisation control).
- ✓ **Assist the project developer during the contracting phase** (technical and administrative assistance).
- ✓ **Well drilling supervision** (including well pad preparation, geological and mud logging, drilling, production + injection tests, diagraphy controls) and ensure a timely delivery of the operations, liaising with the project owner and the numerous subcontractors.
- ✓ **Final reception of the completed geothermal loop and commissioning.**

How do you measure success?

- Each new geothermal doublet (ca. 10 MWth) avoids the emission of ca.10 000 t of CO₂ each year (compared to natural gas)
- The multi-partner approach with a central role of the geothermal project manager has led to ca. 100% success rate for new geothermal development in the past 7 years.
- A competitive selling price for geothermal heat

Evolution of heat selling prices for DH between 2012 and 2014 depending on the main power source (€HT/MWh)

Source : Enquêtes annuelles des réseaux de chaleur et de froid SOeS/SNCU 2012 à 2014 - Analyse AMORCE



Ross Offshore and CFG Services teaming up in Denmark on this model



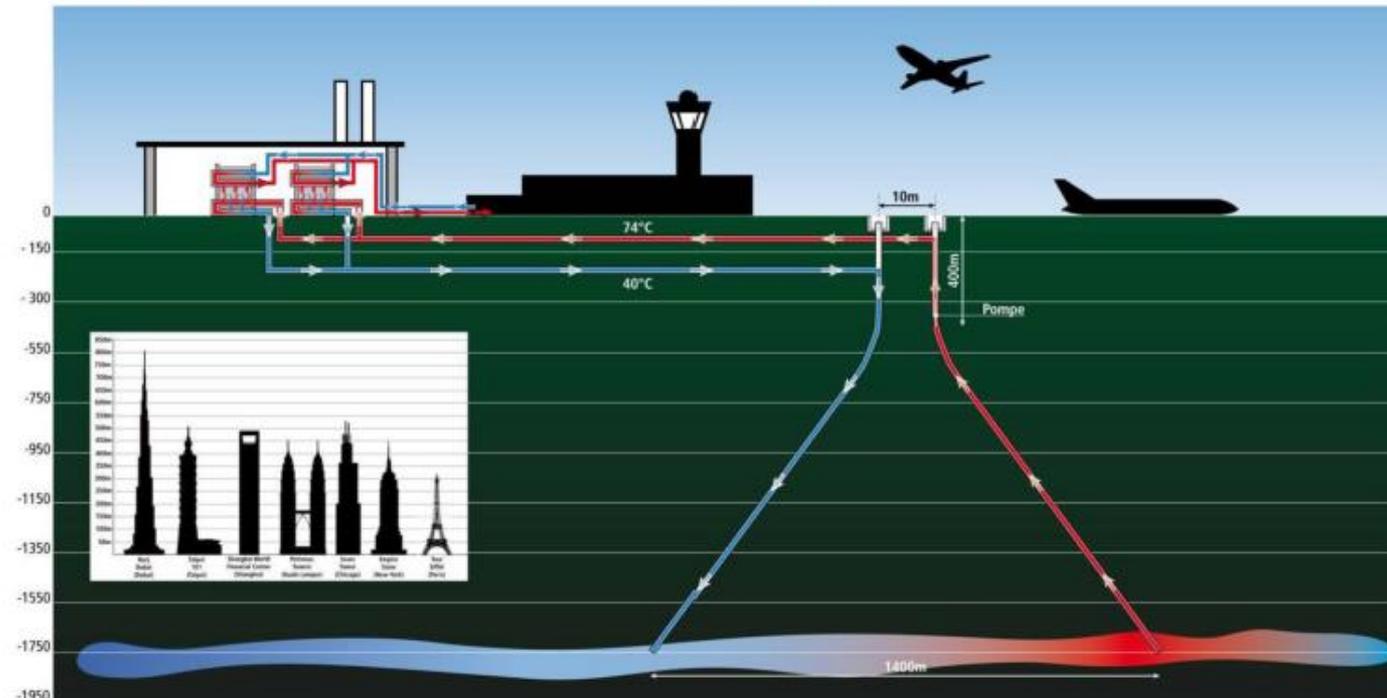
Ross Offshore and CFG Services are teaming up in Denmark to replicate the level of success obtained in France for district heating, bringing together their own expertise into the GEOOP entity:

- Deep drilling expertise for geothermal energy brought by Ross Offshore (drilling services, supervision, etc...)

- Engineering services for geothermal energy by CFG Services (geological and hydrogeological studies, reservoir modeling, drilling supervision, monitoring and maintenance of geothermal facilities, corrosion and scaling inhibition systems design and installation).

Example of non-DH geothermal projects: ORLY AEROPORT

Example of a doublet in Orly airport, South Paris, 2011



Specifications (limestones Dogger)

Temperature prod.: **74 °C** (& T°injection 44°C) / 30°C

Maximum flow: **300 m³/h**

Installed capacity **10 MWt - 45,000 MegaWatt-hour / year**

5000 equivalents-housing

savings of **10 000 t CO₂ / year**

GUIDOCLAST Project Cost of underground works: **€ 9 millions**



Example of non-DH geothermal projects: Sturgeon and caviar farm in SW France



- Oil exploration well rehabilitated for geothermal production
- T°C: 72°C
- Flow: 100 m³/h
- Geothermal exploitation since 1989
- Low mineralization of geothermal water allows discharge in local river.

Example of non-DH geothermal projects: Disneyland Paris – Villages Natures



- Drilling took place in 2015
- Supplying a recreational area (« Geothermal lagoon ») + housings
- Will be eventually connected to the Disneyland Paris Park heat network