Integrating low-temperature renewables in district energy systems: Focus on China

Technical challenges and solutions for integrating low-temperature geothermal energy resources: lessons learned from France

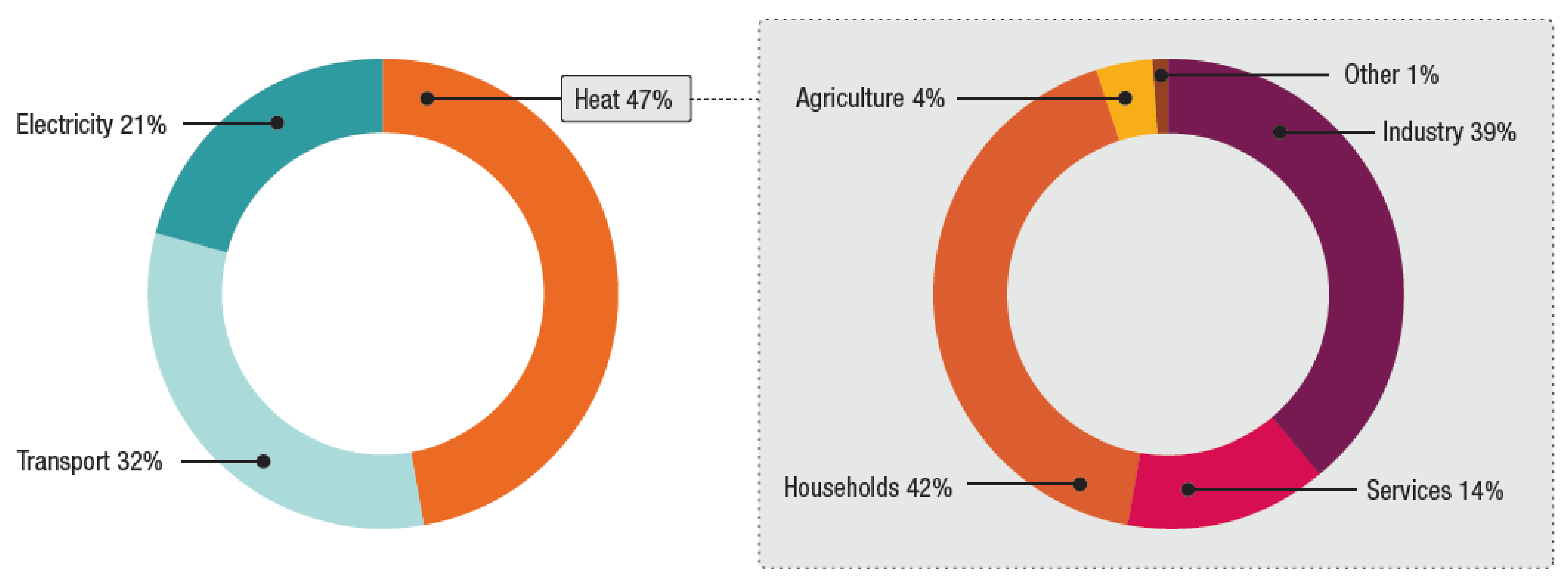
Dr. Miklos ANTICS
President of EGEC
GPC IP/GEOFLUID
165 rue de la Belle Etoile
95946 ROISSY CDG CEDEX
FRANCE
m.antics@geoproduction.fr
www.gpc-france.com www.geofluid.fr www.egec.org

Outline

- Overview of European Geothermal Projects in operation
- Europe’s ETIP DG vision on unlocking geothermal energy
- The Paris Basin Geothermal District Heating (GDH) system
- GDH Economics
- Innovation: Subhorizontal well architectures
- Innovation: Anticorrosion well concept
- Conclusions

GEOTHERMAL HEATING - HEAT DEMAND

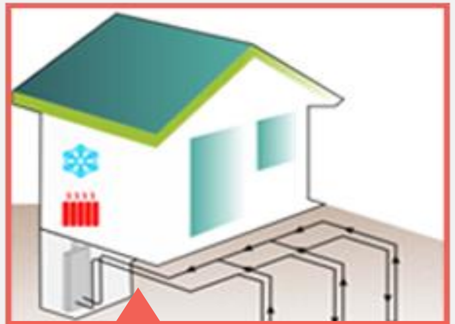
Why is heating so important - and where is it required ?



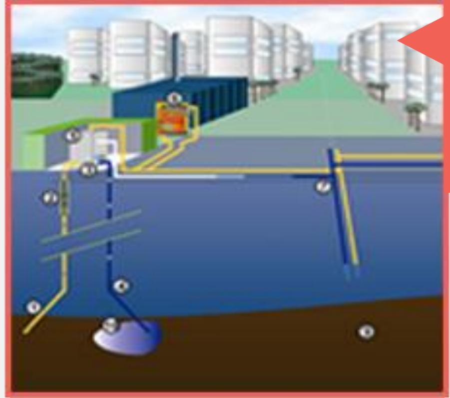
Graph from RHC-Platform – SRIA, 2013 (values for 2010)

Industrial heat is a large share of the heat sector, with huge growth potential

Geothermal heating and cooling technologies



Heat pumps

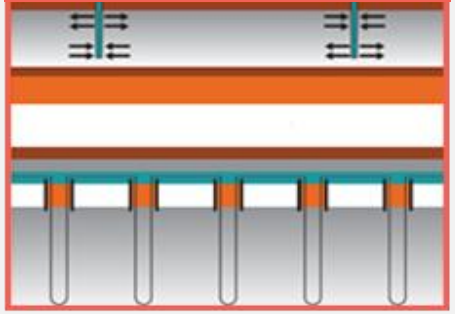


District heating and cooling

Direct uses: e.g. in agro-industry

EGS and cogeneration

Underground thermal storage

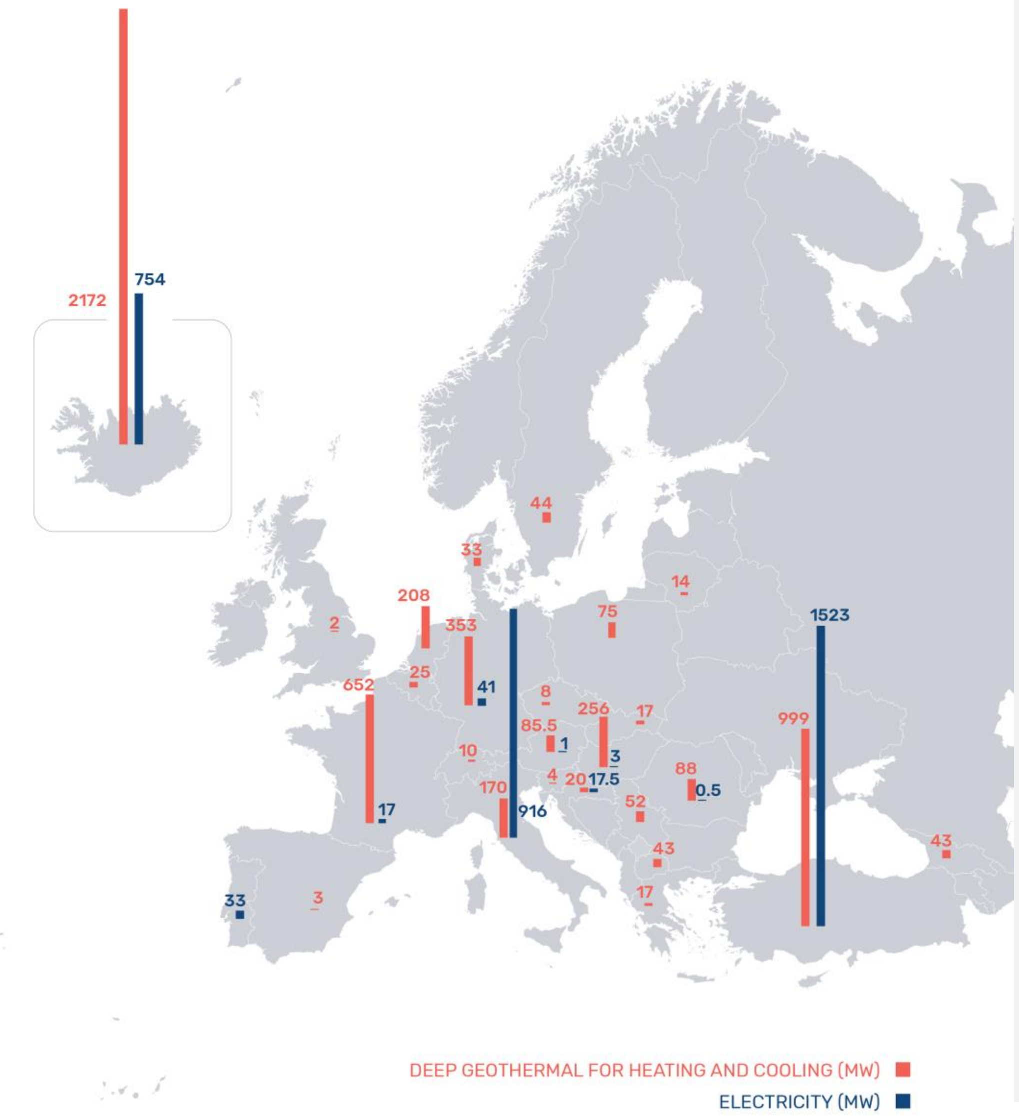


EGEC GEOTHERMAL

Overview Geothermal Projects in operation - Europe

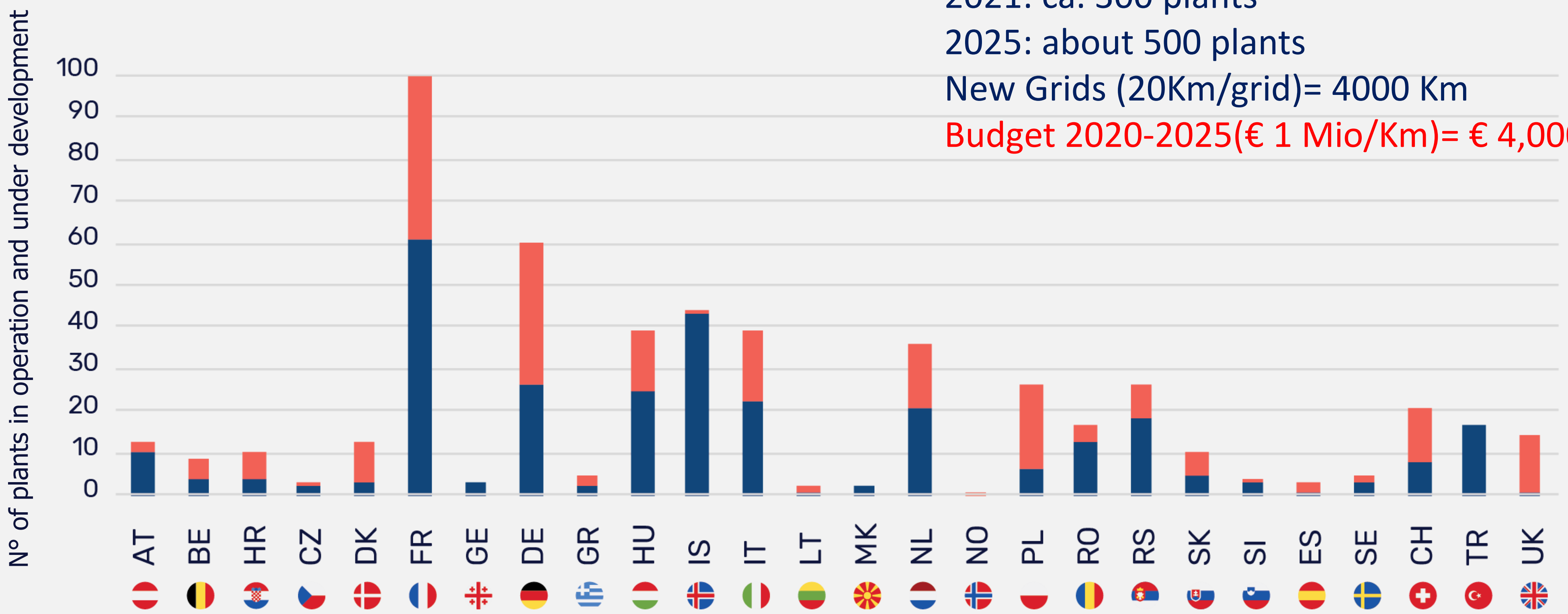
Some key figures-2019

- 130 **Geothermal electricity** plant, with a capacity factor of 84% !
- The EU passes the 2 GWth threshold for **geothermal heating** systems (300 geothermal DH, greenhouses…)
- More than 2 million **geothermal heat pumps** in Europe at the end of 2019
- 2019 marks the start of **geothermal lithium** extraction in Europe !

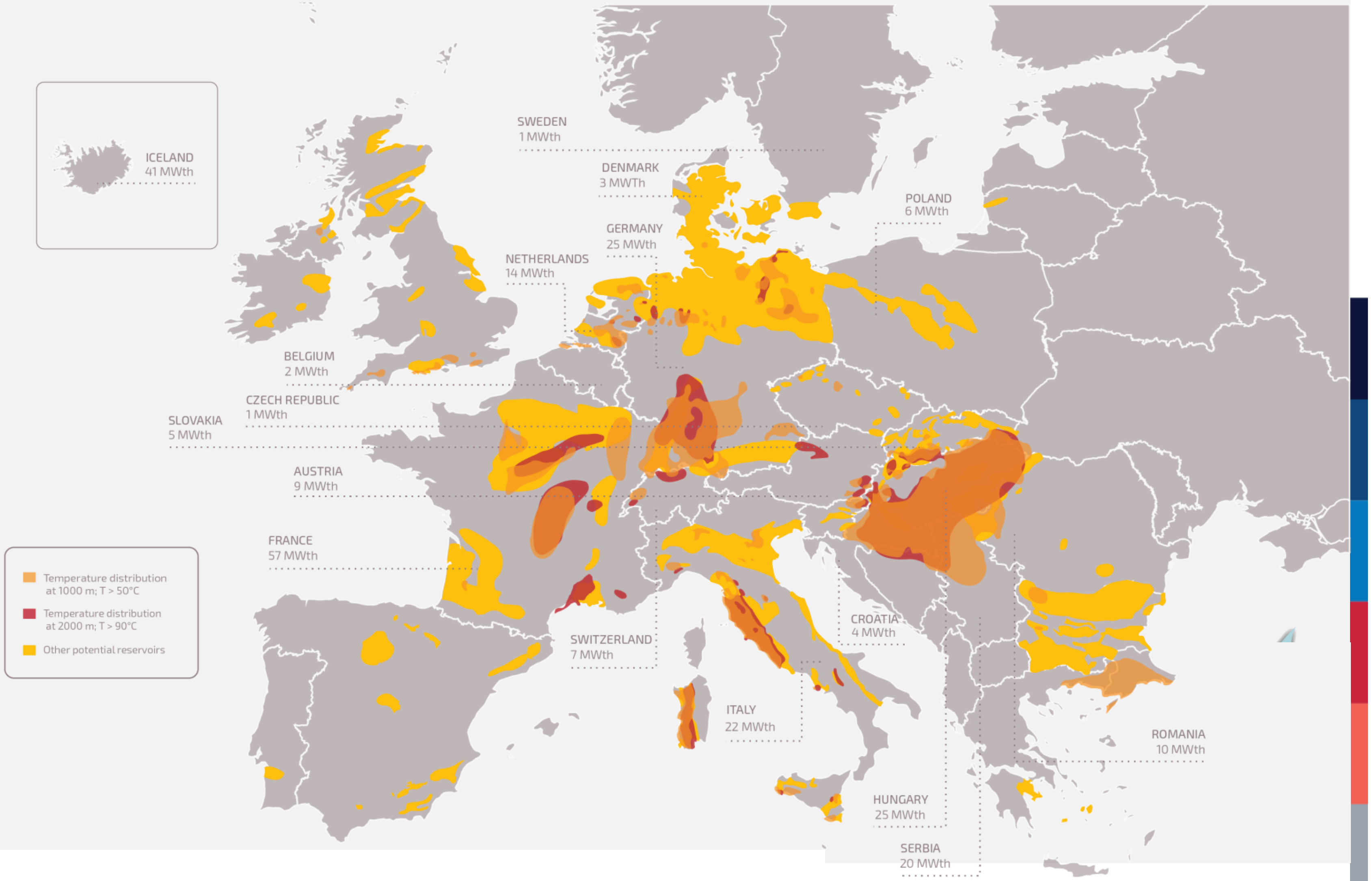


Geothermal district heating & cooling systems in operation and under development

2021: ca. 300 plants
2025: about 500 plants
New Grids (20Km/grid)= 4000 Km
Budget 2020-2025(€ 1 Mio/Km)= € 4,000 millions

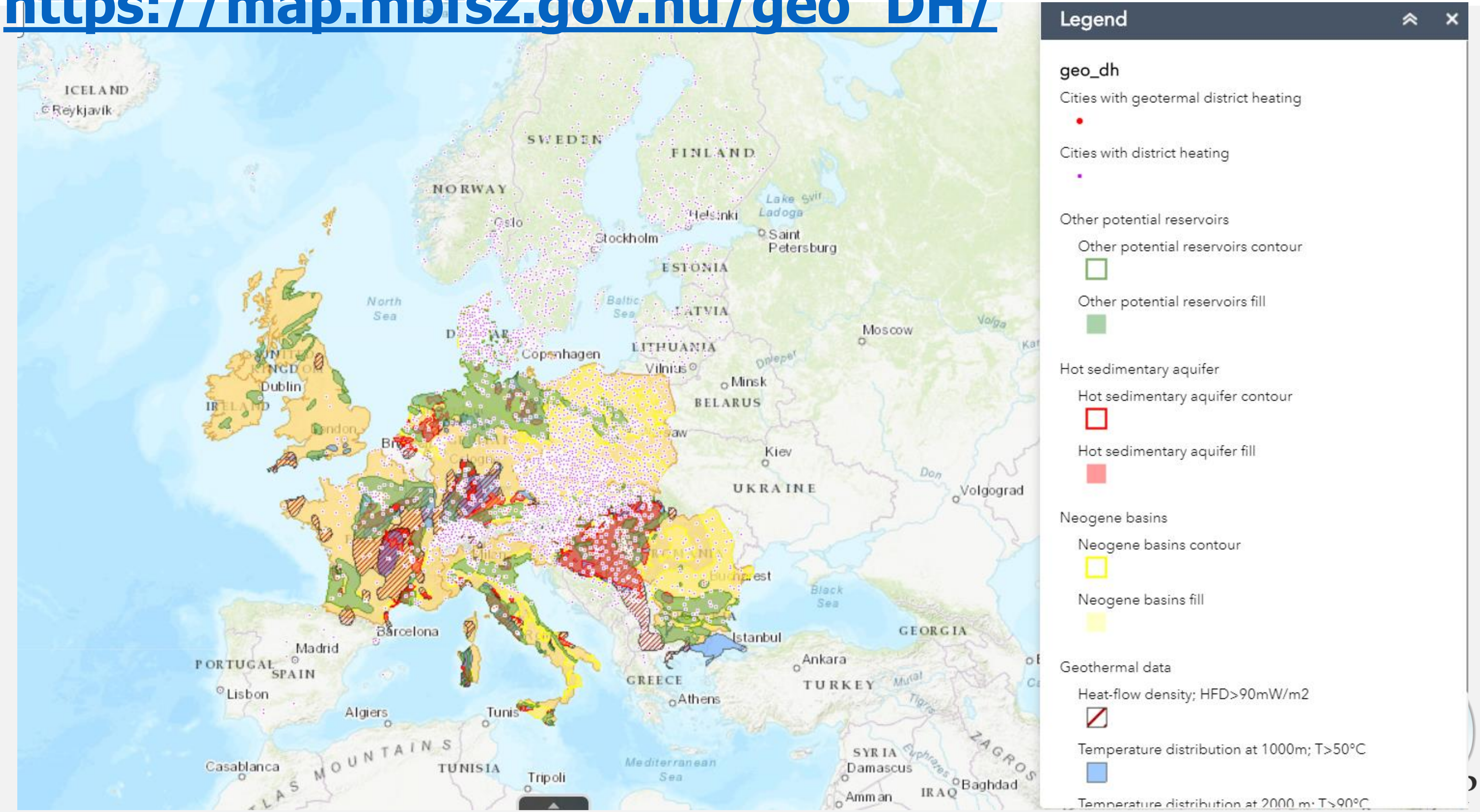


More than 25% of the EU population lives in areas directly suitable for geothermal district heating



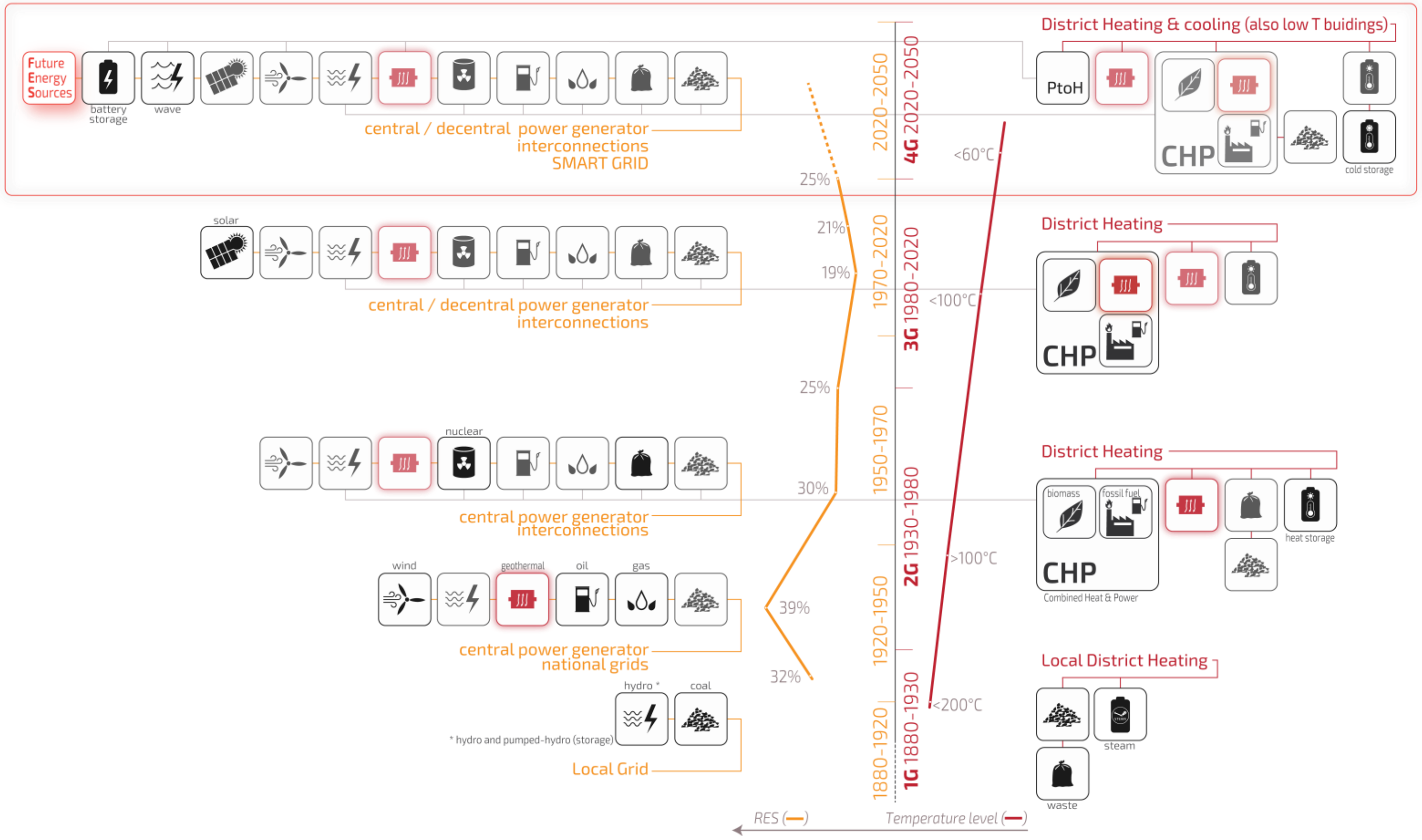
Map of areas suitable for geoDH networks and actual geoDH installed capacity according to available geological data

Source: ETIP-DG, adapted from GEODH and EGEC market report https://map.mbfsz.gov.hu/geo_DH/



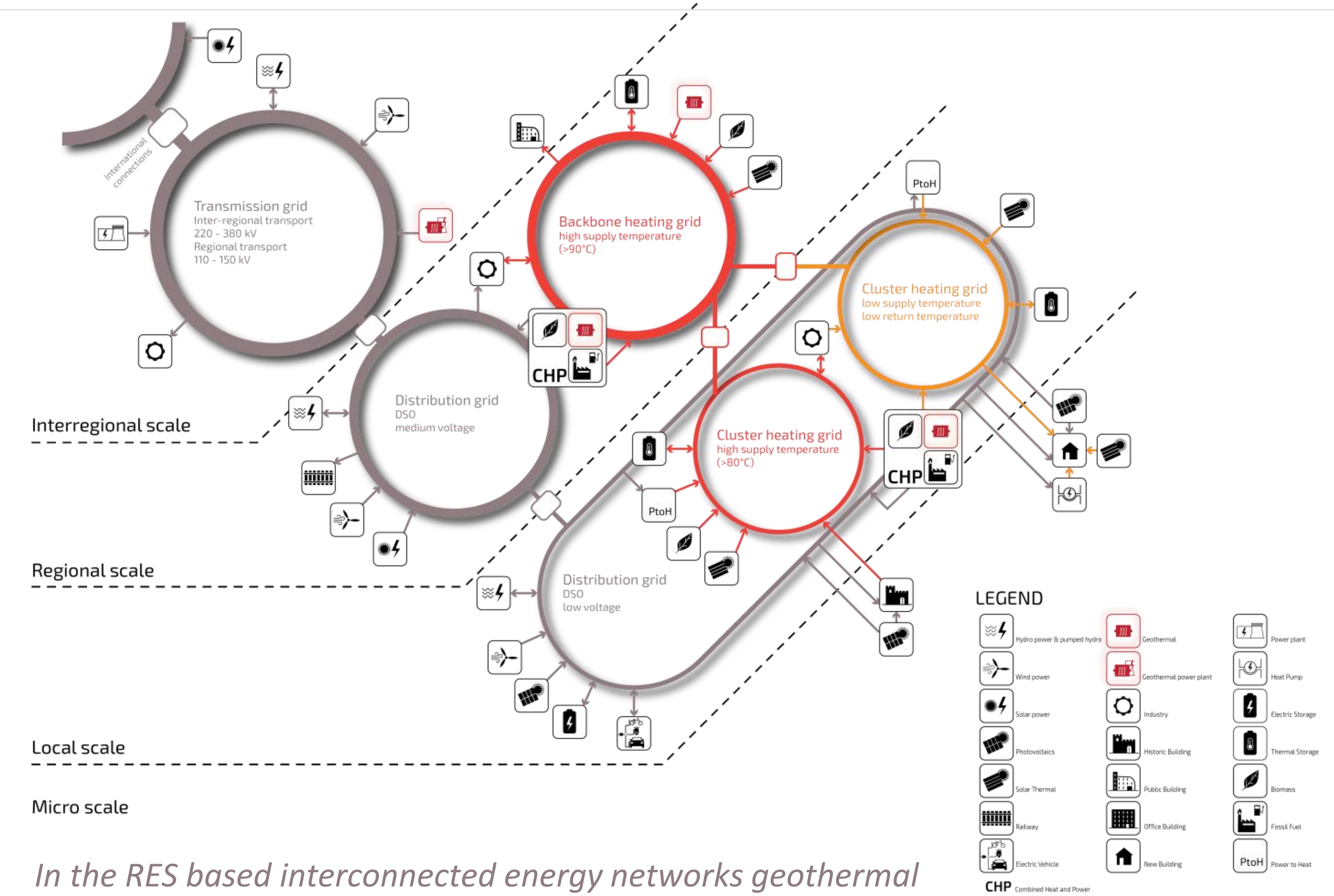
Unlocking Geothermal Energy: Heat development

> Operative temperatures of the DHC network can be reduced
> By demand site management or by thermal energy storage it will be possible to balance heat demand and supply in a DH network.
> Cascade applications
> CHP



Evolution of power generation and district heating

Unlocking Geothermal Energy: Combined production



In the RES based interconnected energy networks geothermal and underground thermal storage play an important role

> Coupling renewable heat and electricity sectors and markets for an optimal use of geothermal energy

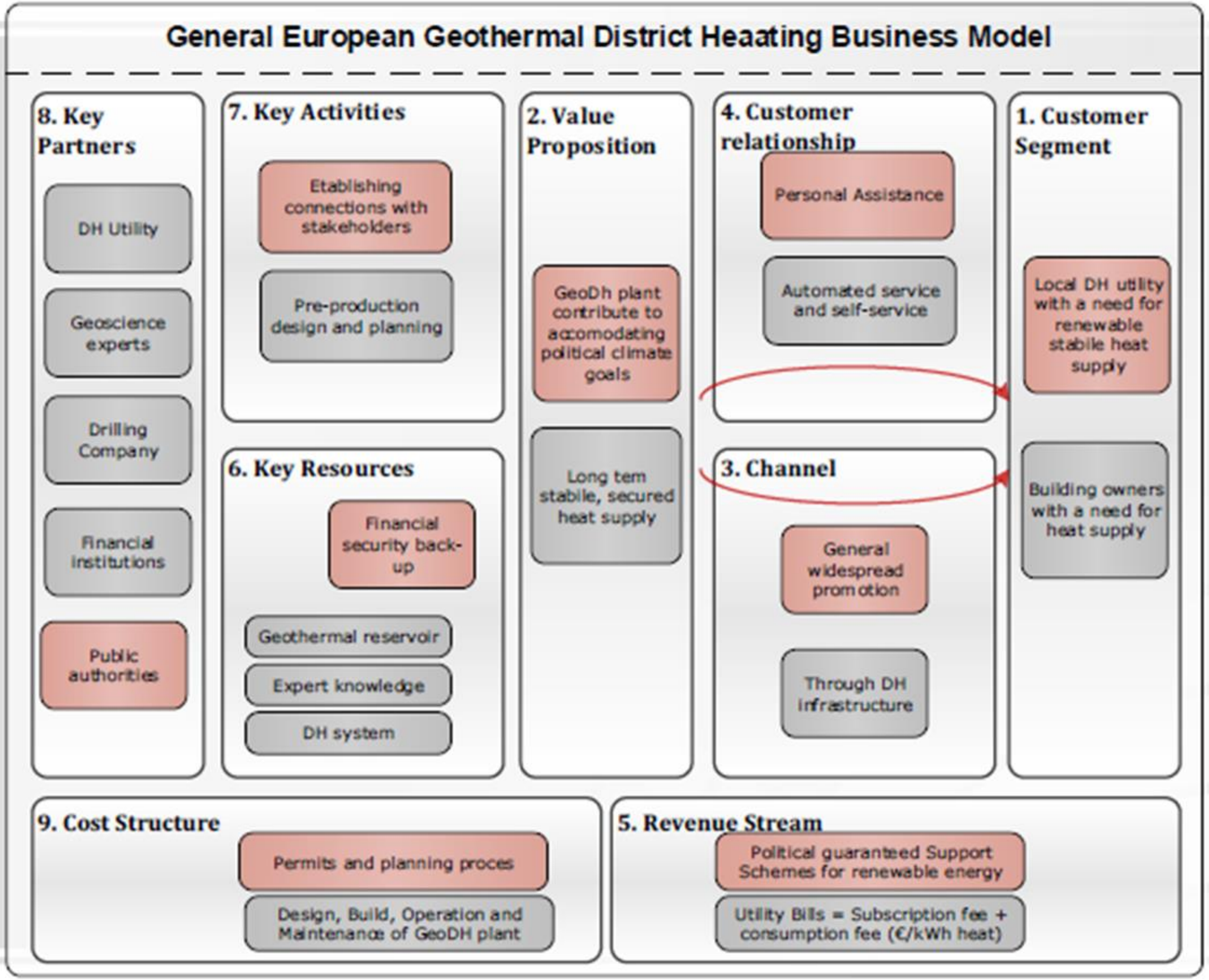
> Consumer-producer-prosumer perspectives

> Thermal storage to help balance and to optimize production

> Cascade, hybrid, synergy (e.g. geothermal-algae-biofuels-transport)

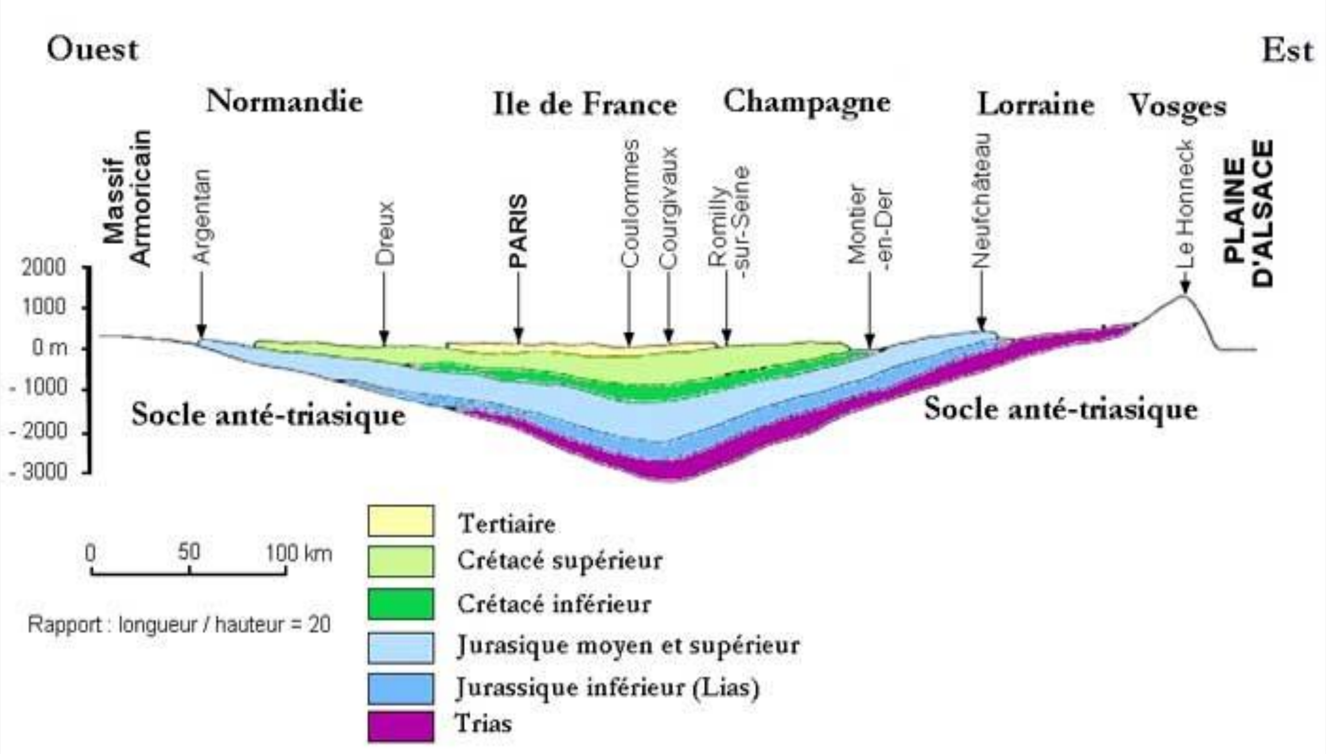
Challenges

- Demand for Heat supply
- Firmness of electricity supply

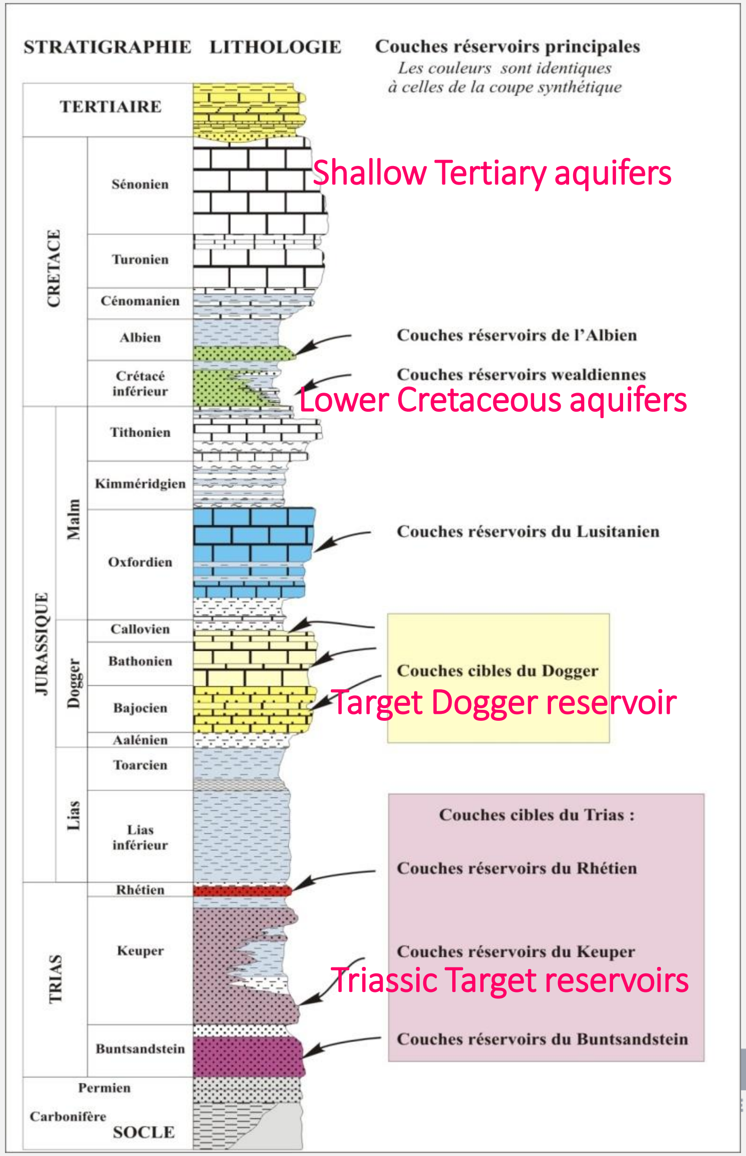


PARIS BASIN EXAMPLE
GEOLOGICAL SKETCHES

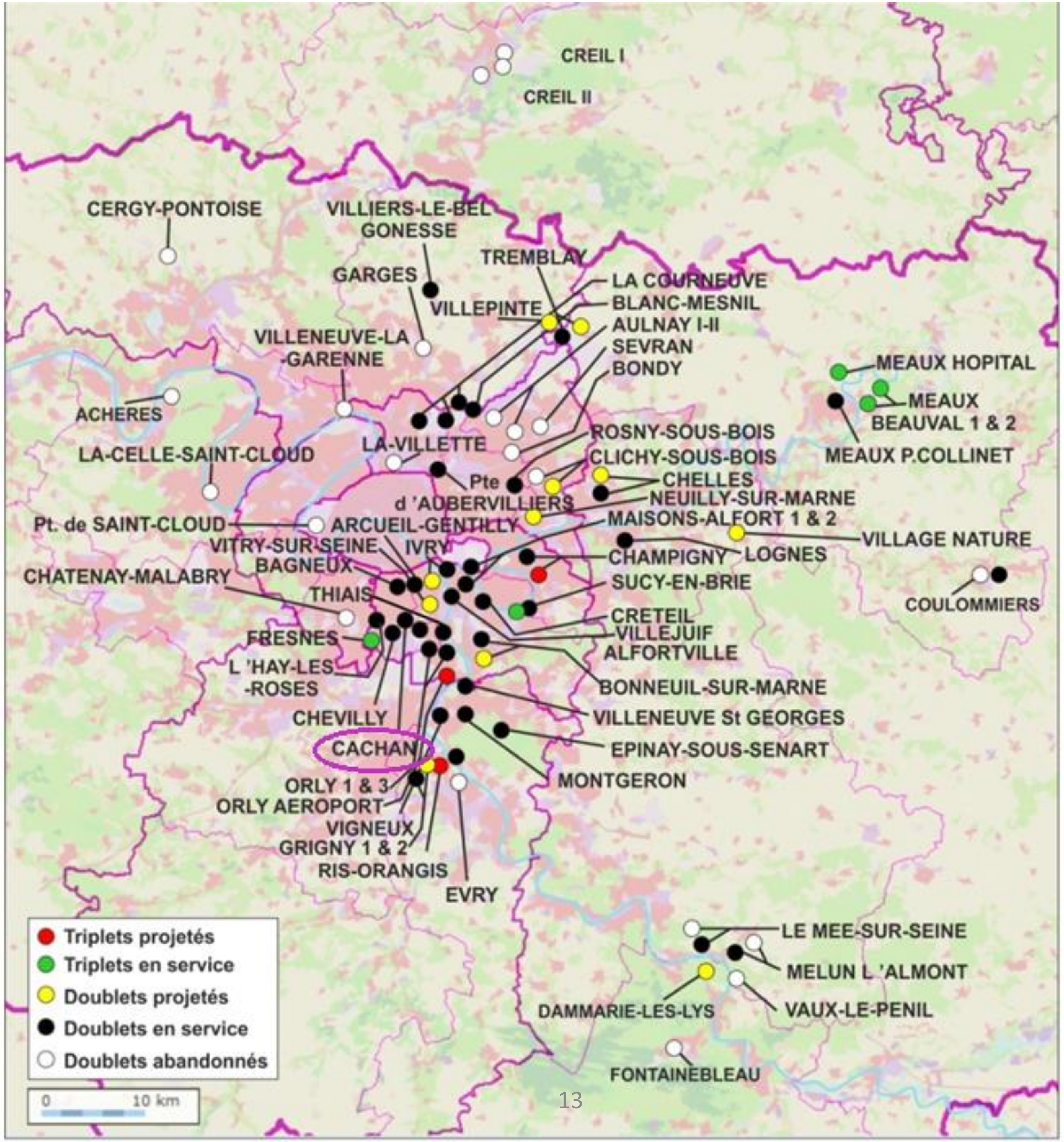
West East Cross Section



Lithostratigraphic column and target reservoir horizons

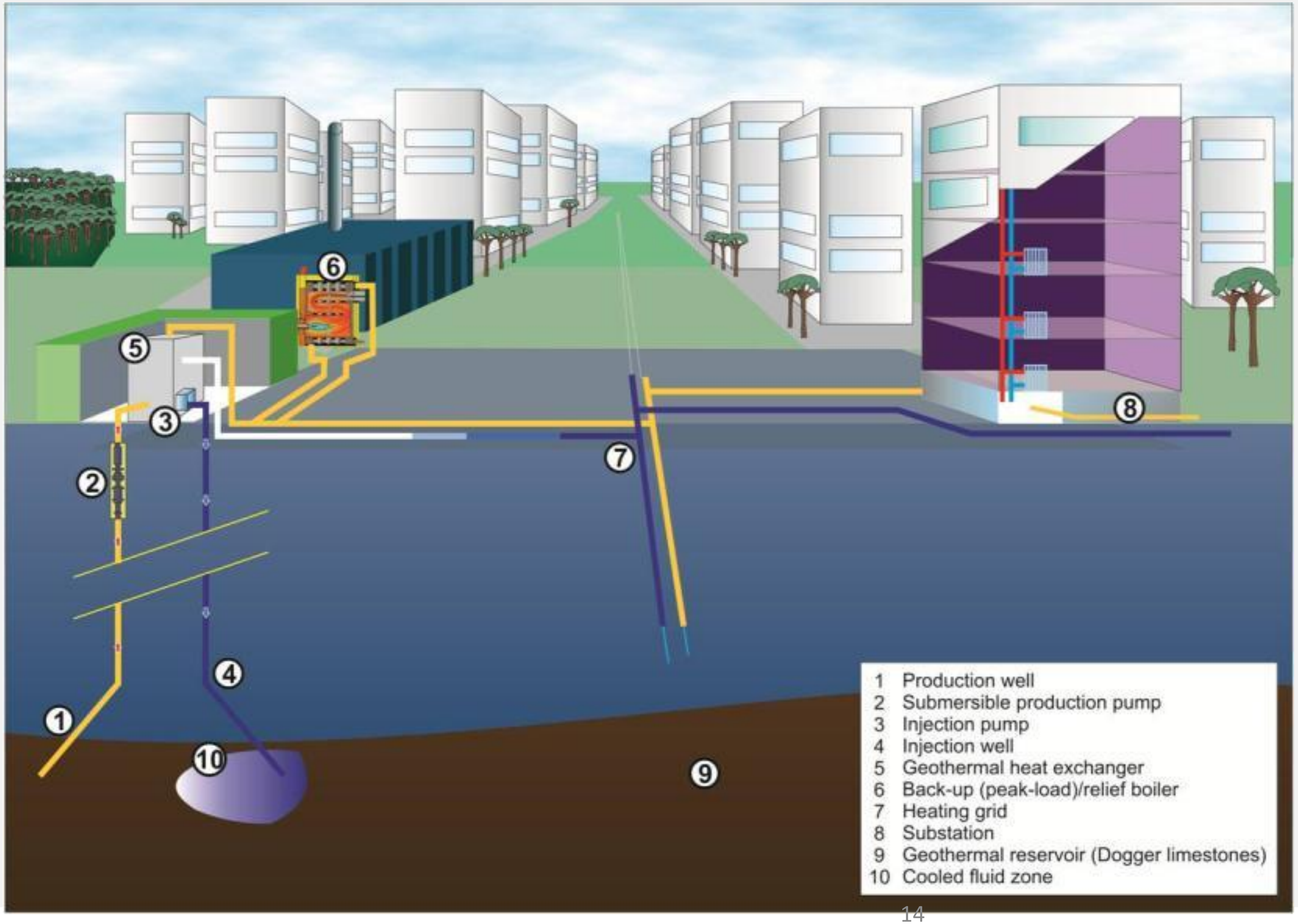


PARIS BASIN GDH STATUS

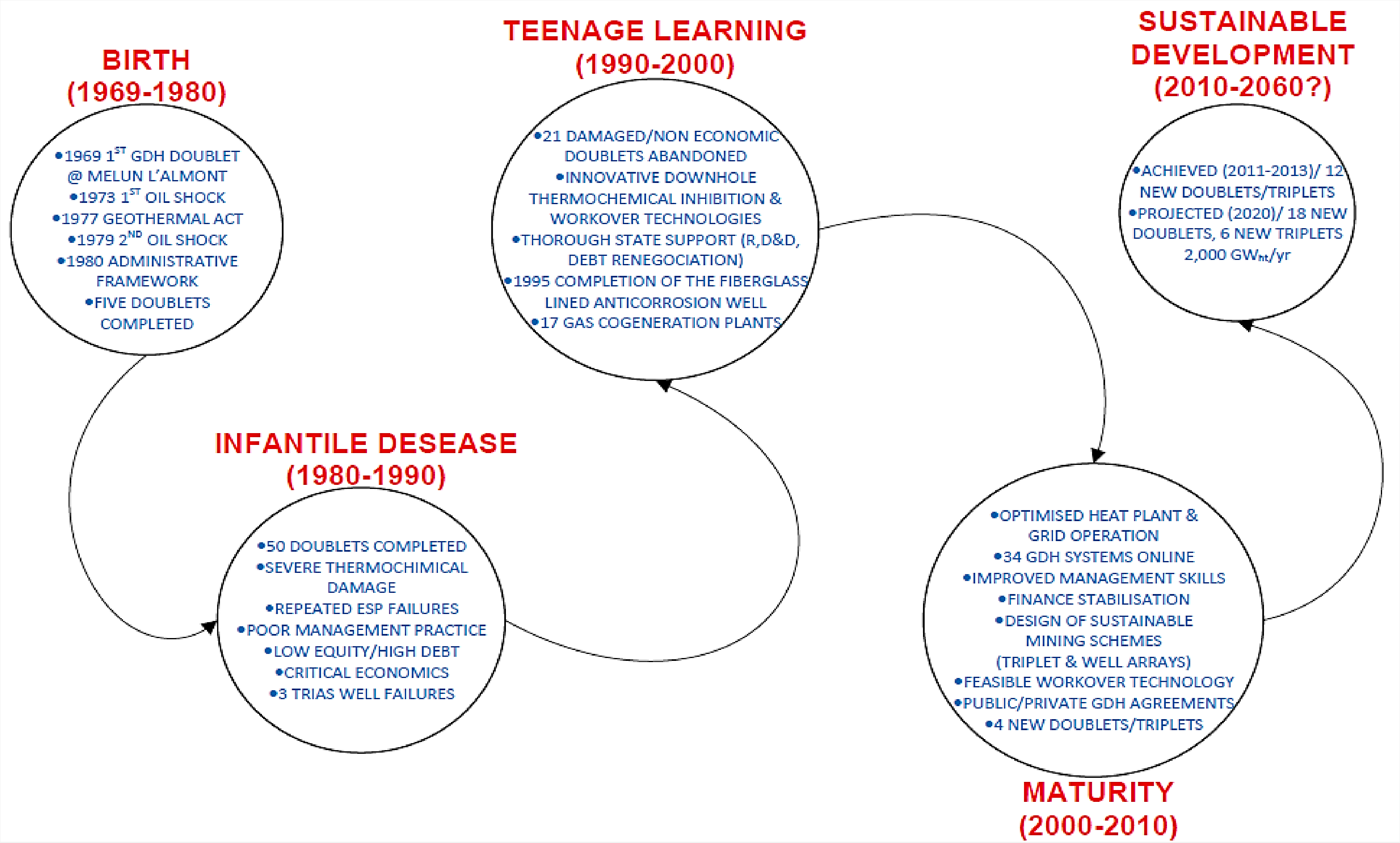


EGEC GEOTHERMAL

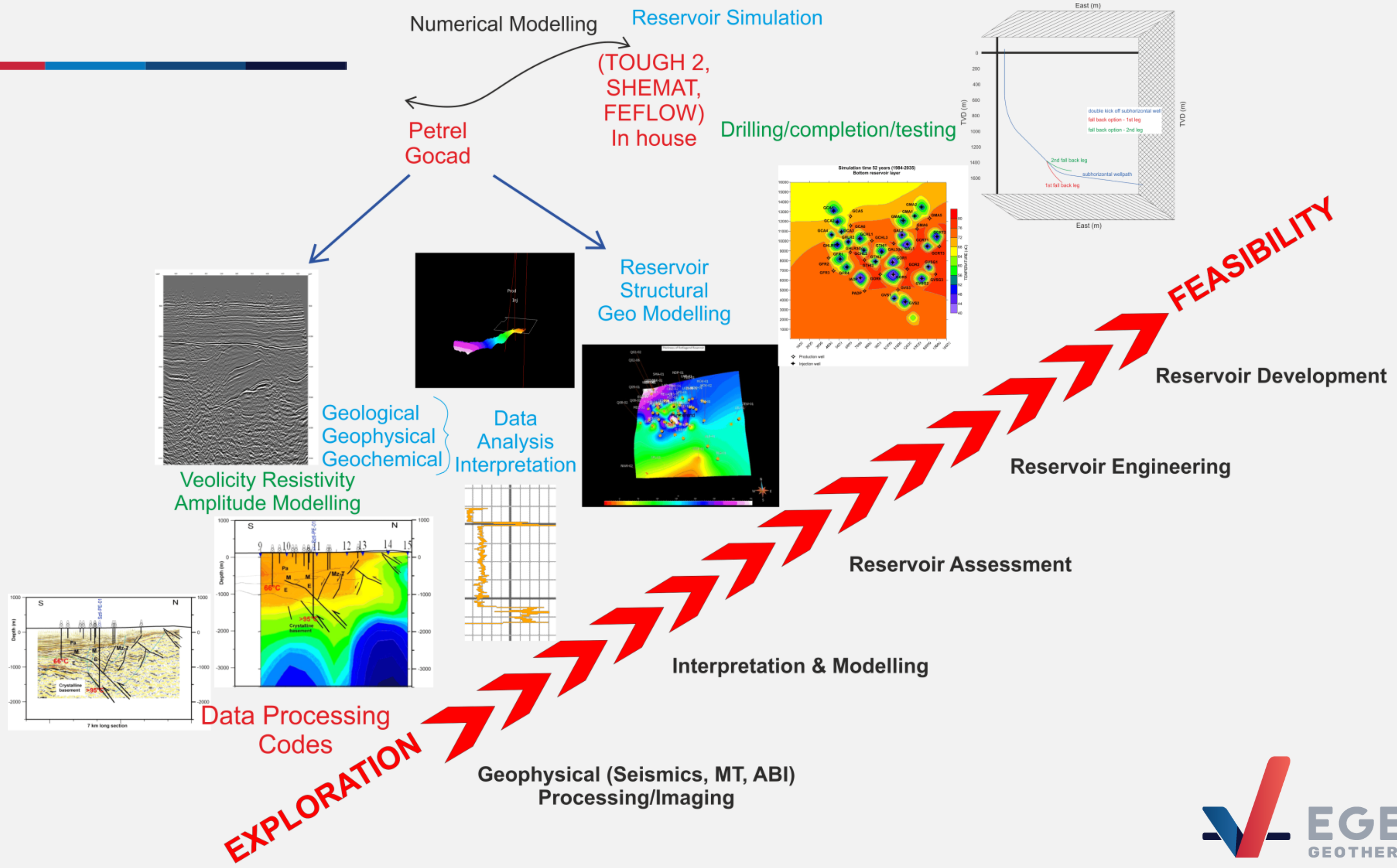
PARIS BASIN GDH SCHEME



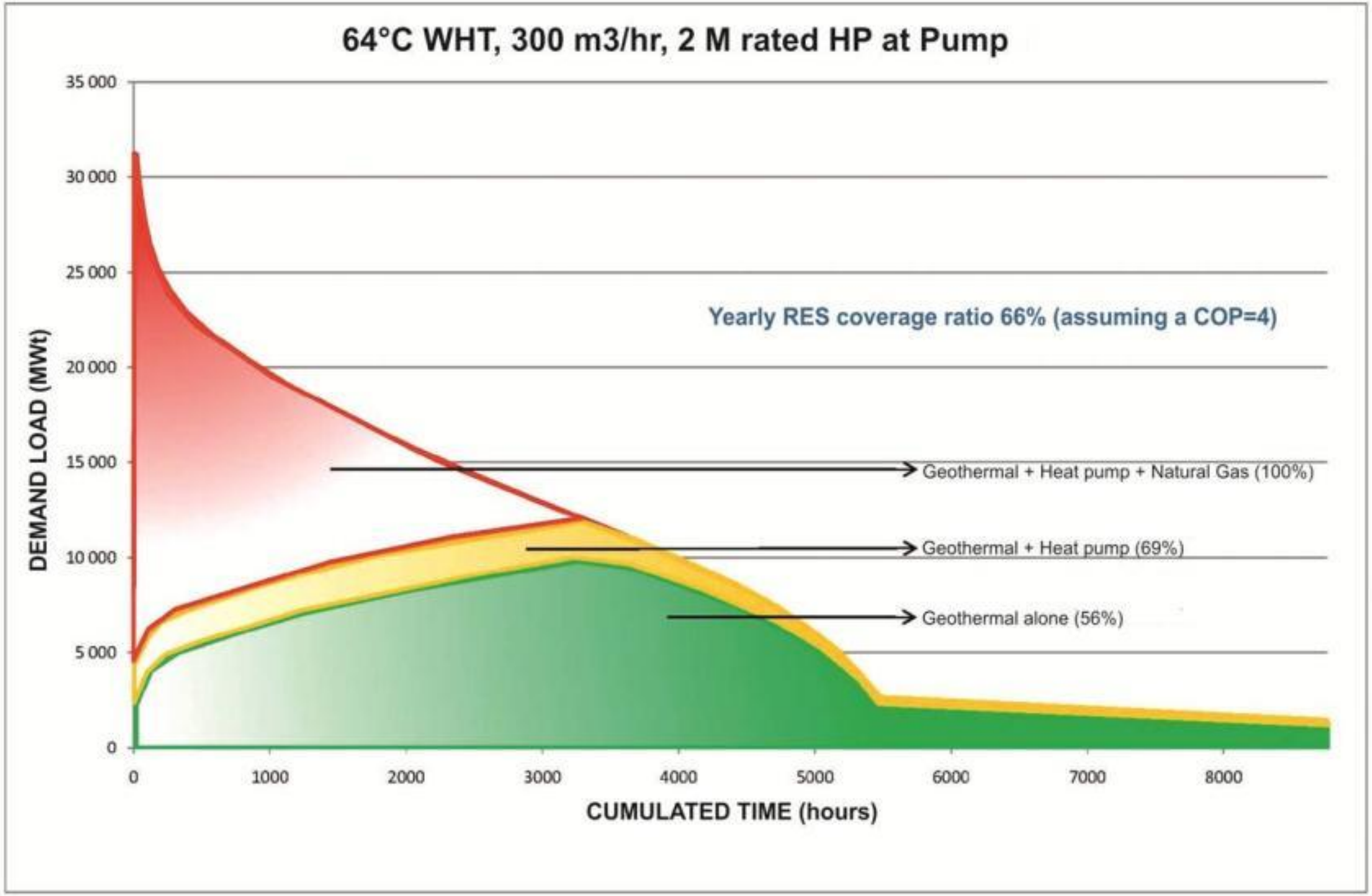
The Paris Basin Geothermal learning curve



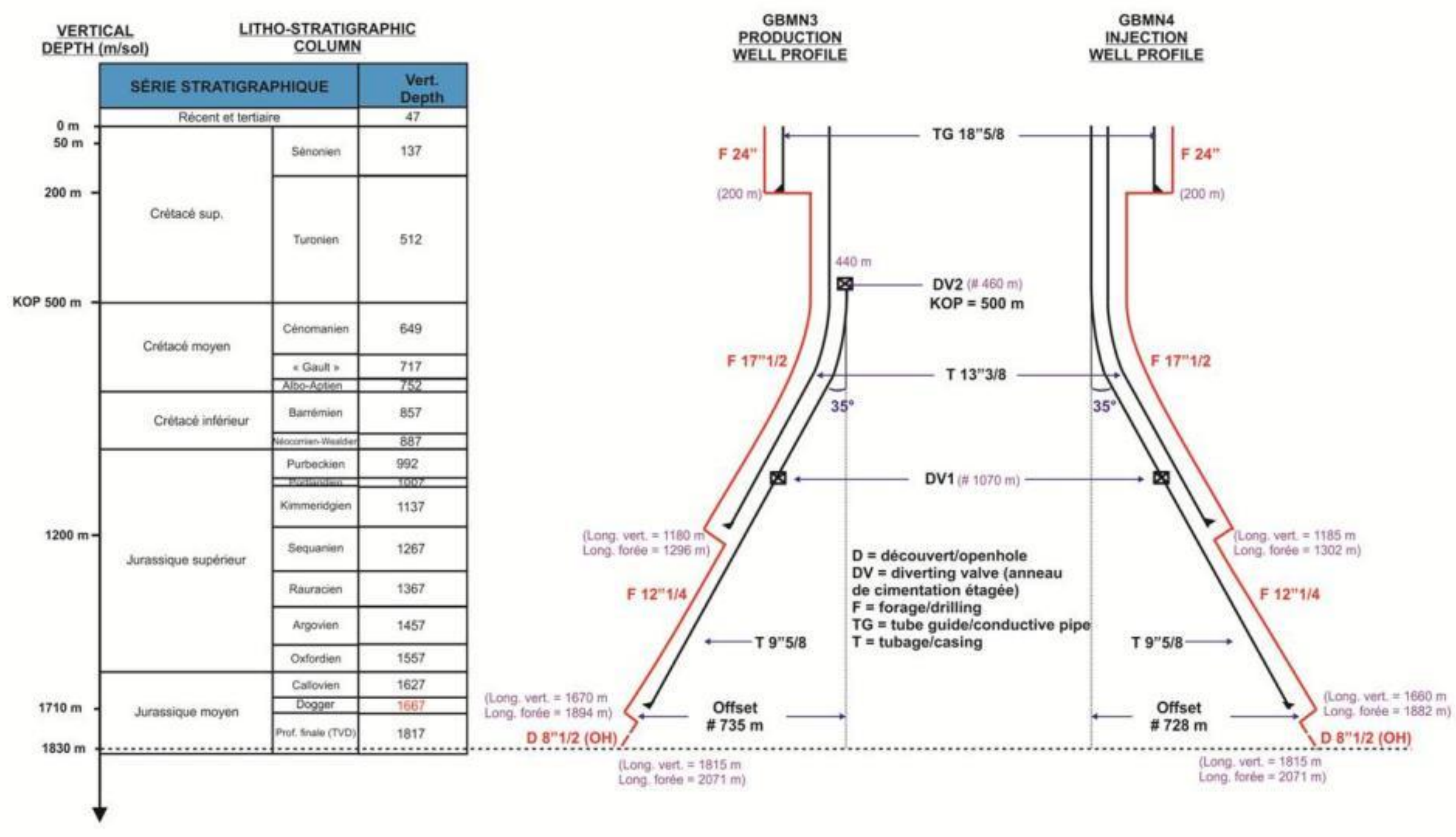
RESERVOIR ENGINEERING AN INTEGRATED APPROACH



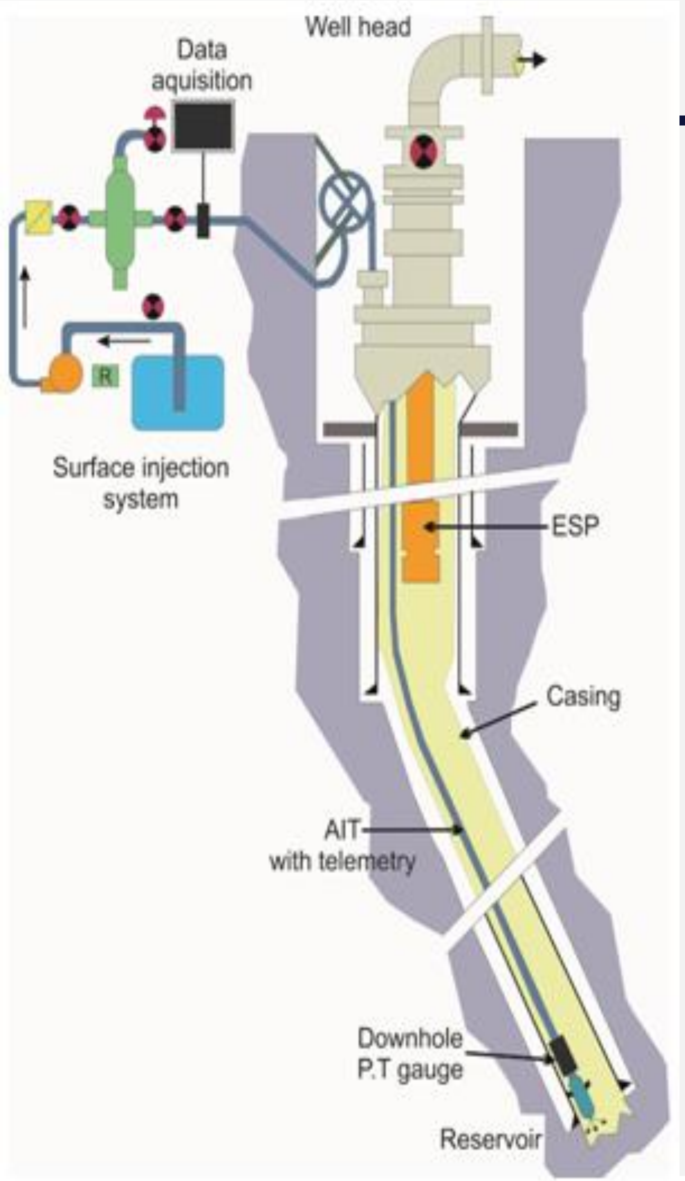
TYPICAL LOAD DURATION CURVE

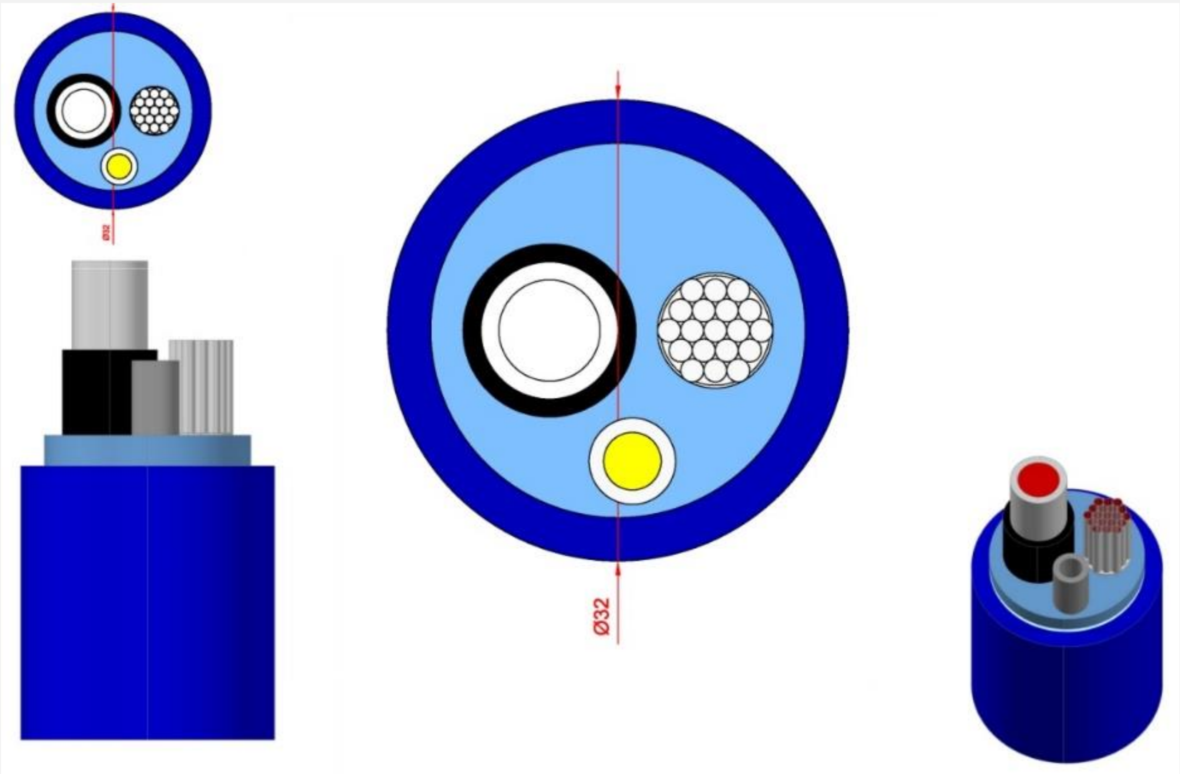


TYPICAL GDH WELL ARCHITECTURE

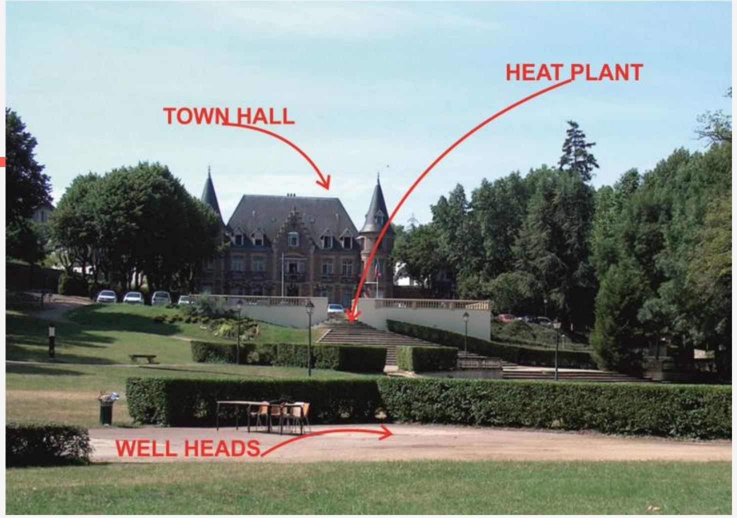


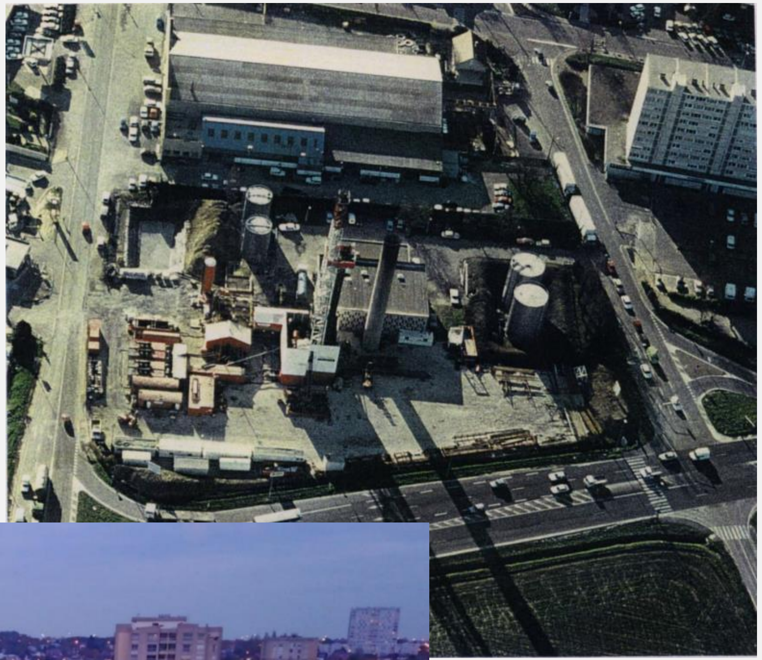
CORROSION AND SCALING ABATMENT. AUXILIARY INJECTION TUBING WITH FO



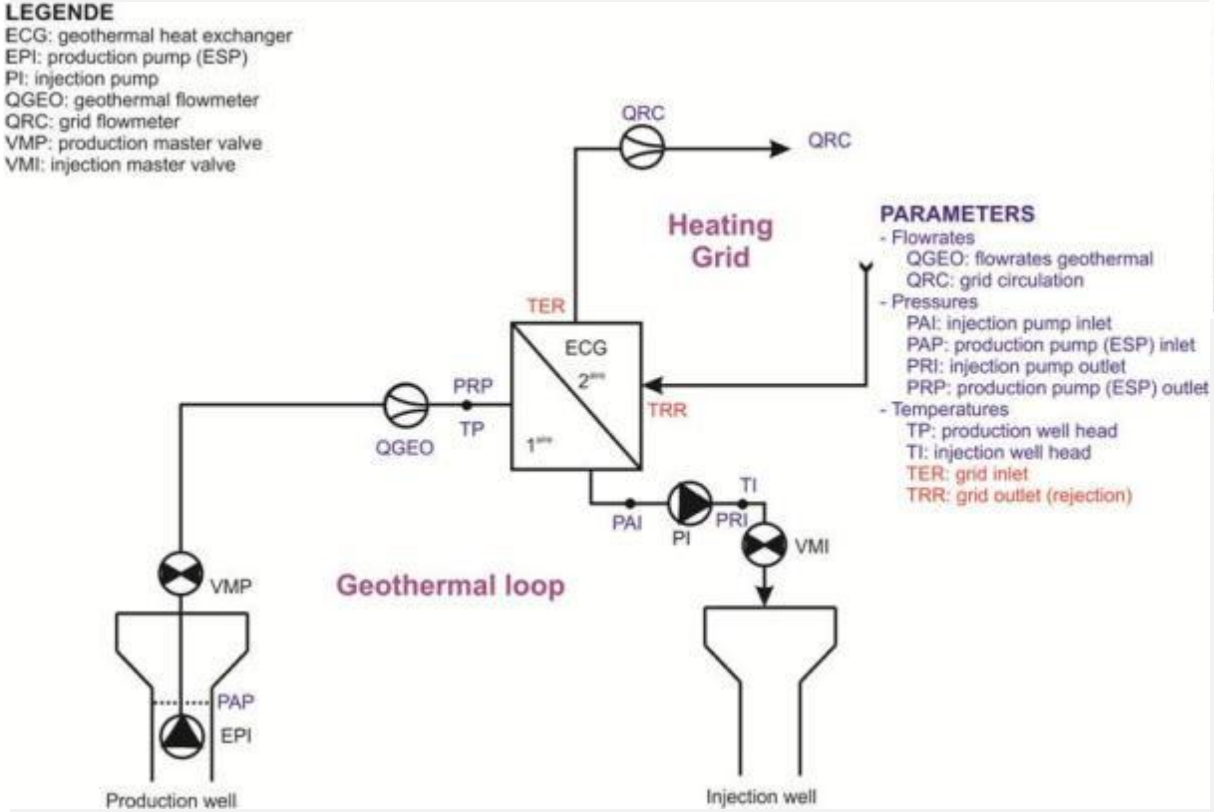


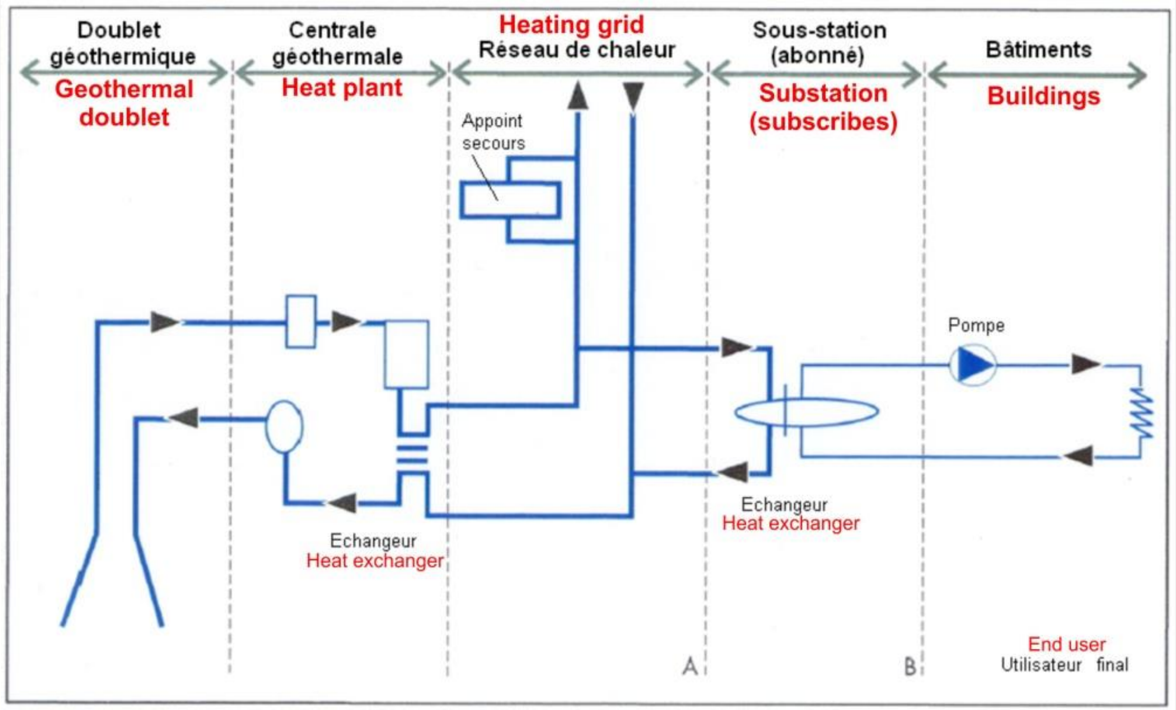
PARIS BASIN. TYPICAL GEOTHERMAL SITES



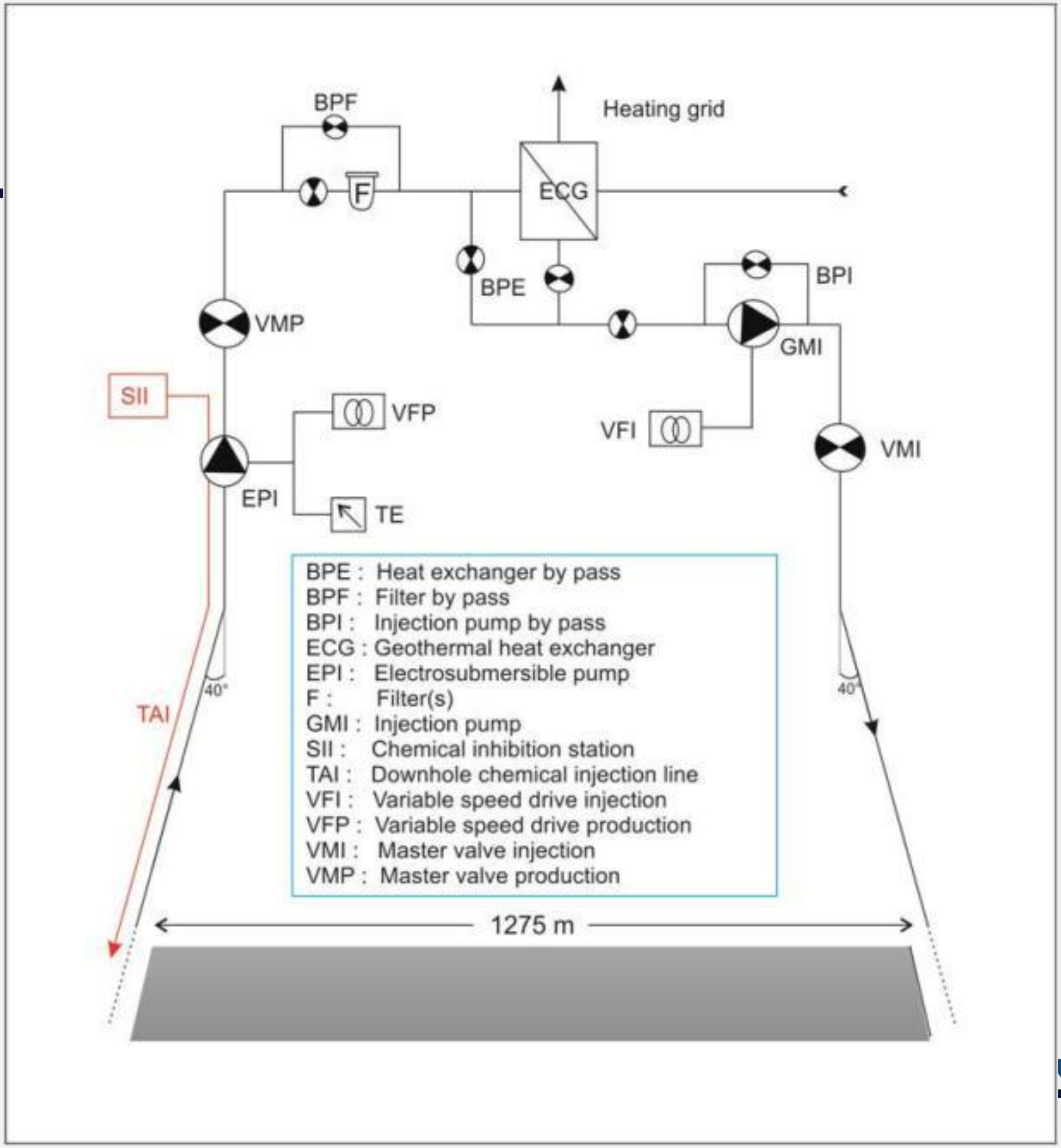


GDH DESIGN AND MONITORING





GEOTHERMAL LOOP DESIGN



THE EXISTING INFRASTRUCTURES

- Many existing DH&C infrastructures are old, high T° and high pressure. e.g. In France half have been developed in the 1980s

- Costs to replace grids range from 500 to 1 000 €/ml, according to diameter and local conditions

Economics of DH&C infrastructures

Investment costs versus operating costs

Capital intensive: € 1 million per Km

CHALLENGES & OPPORTUNITIES

- **New DH&C systems:** issue in already built environment, opportunities in new areas with density and for industrial processes

➢ DH&C in Barcelona: **the 'plug' model**

- **Existing DHC:** Equipment past median expected service life, fuel switch challenges for high T° and high Pressure, costly renovation

> esp. in CEE: insufficient and unpredictable revenues, high costs, high commercial risk, limited access to capital and degraded assets.

- **district cooling networks** are the new long term investment.

- **Insufficient subsidies / no or low carbon pricing**

- High commercial risk in the DH sector manifests itself in the reluctance of market players to **make long-term commitments to the sector.**

EGEC GEOTHERMAL

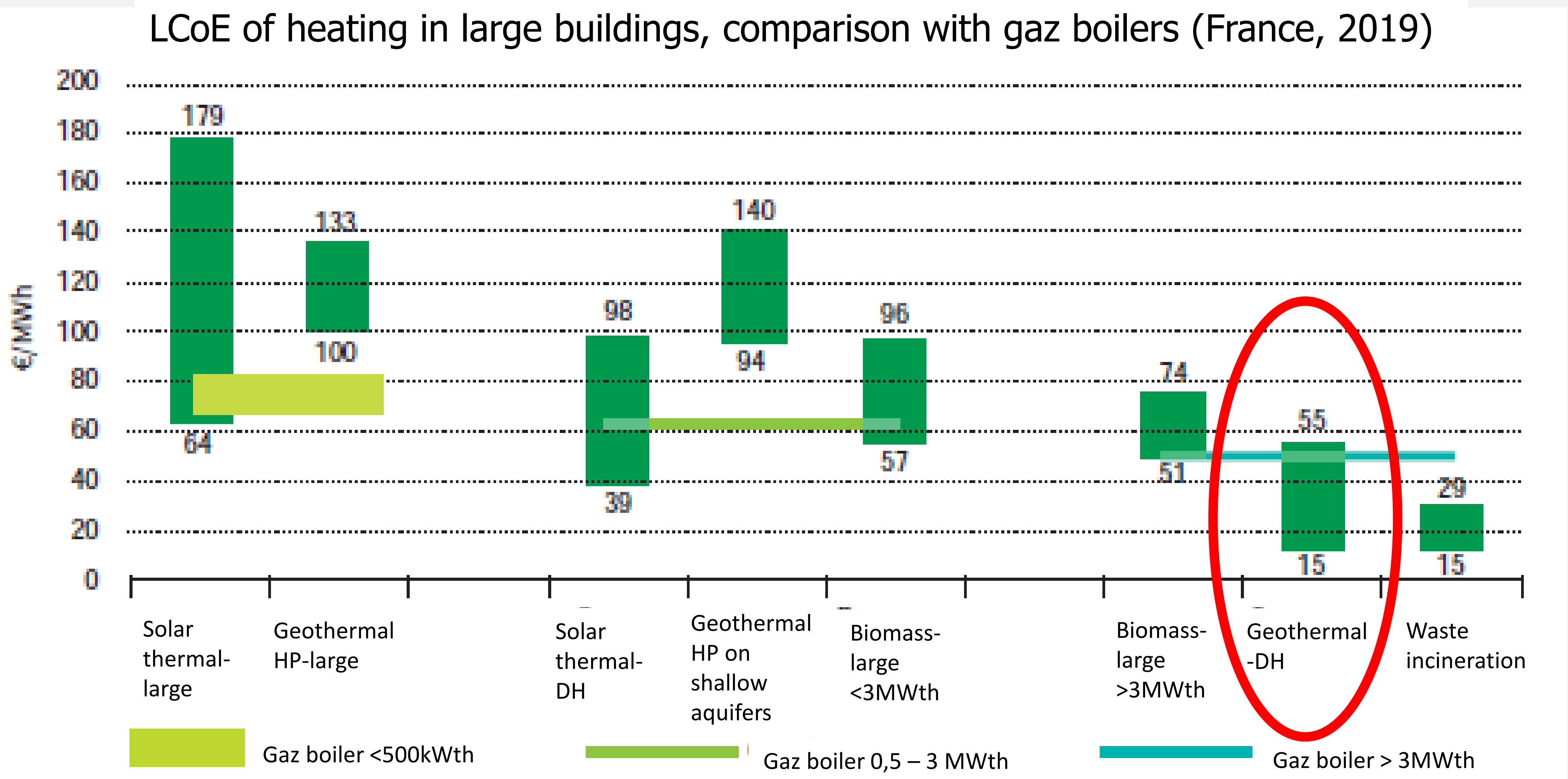
TYPICAL COST BREAKDOWN (103 €)

CAPEX		
Mining	min	max
Well drilling/completion	8500	9000
Primary (geothermal) loop	1200	1300
Geothermal heat exchanger	300	400
Total	10000	10700
Surface		
Secondary (grid) loop	600	700
Heat plant	800	900
Grid (piping)	8000	10000
Grid (substations)	2500	3000
Total	11900	14600
GRAND TOTAL	21900	25300

OPEX		
Mining	min	max
P1 Power, chemicals, consummables	200	250
P2 Monitoring, light maintenance	75	90
Heavy duty maintenance, well workover, on duty call	250	300
Miscellaneous	30	50
Total	555	690
Surface		
P1 Power, chemicals	40	50
P2 Heat plant/grid monitoring/maintenance	400	450
P3 Provisions for depreciation	250	350
Miscellaneous	40	60
Total	730	910
GRAND TOTAL	1285	1600

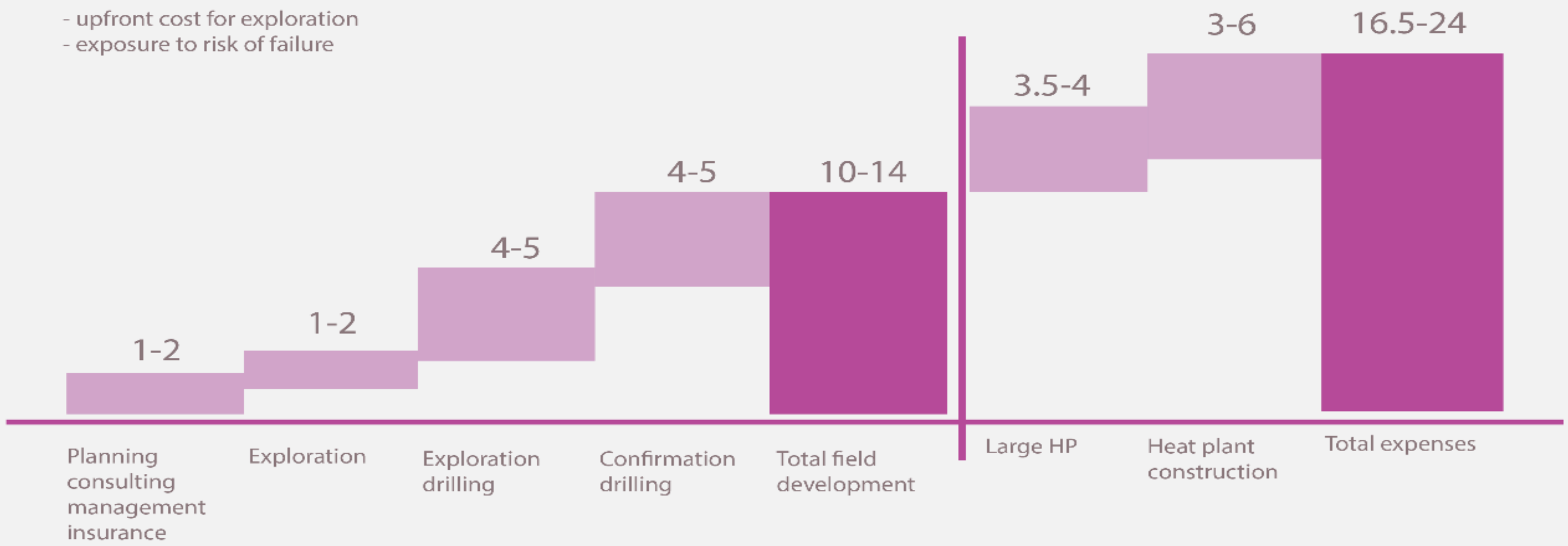
	BREAKEVEN		**SELLING COST**
	WORST CASE	BEST CASE	MEDIUM CASE
CAPEX (10^3€)	25000	22000	23000
OPEX (10^3€/yr)	1600	1285	1400
SUBSIDY (% CAPEX)	0	35	25
BREAKEVEN (€/MWh_t)	**81**	**56**	**64**

The competitiveness in the heat sector– Large buildings



Source: ADEME, 2019

PROJECT DEVELOPMENT PHASE



10 MWth heating plant: example of some plants installed in Paris region Ile-de-france, France. In Million €

A national Heat Fund

- French « **Fonds chaleur** » from ADEME: about 20% subsidies on geothermal DH

- Energy efficiency Certificates / White-Green certificates

Crowdfunding as a novel financial tool for district heating projects

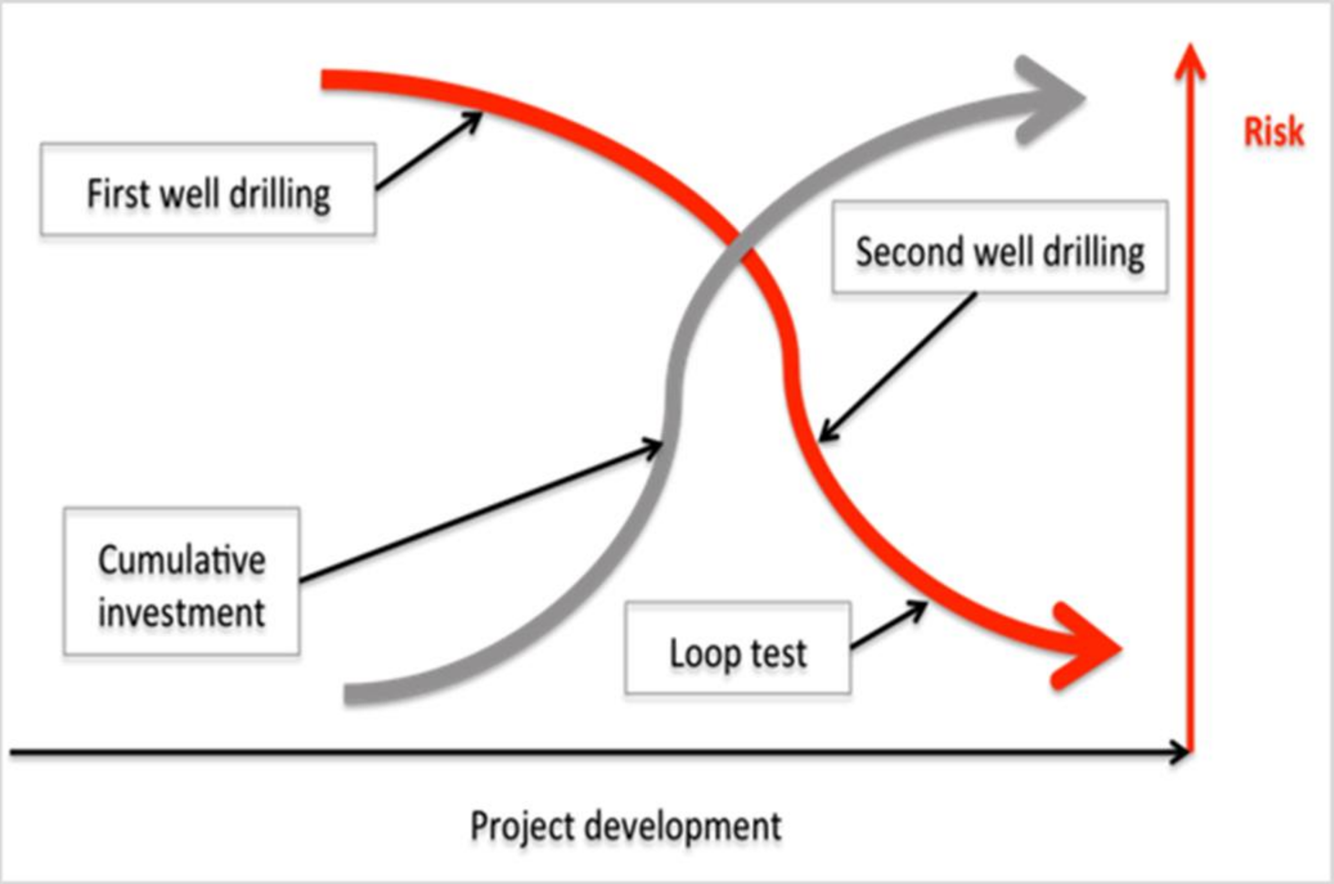
- An alternative finance, which allows to fund a project or venture by raising small amounts of money from a large number of people, via web-based platforms

- Adding new sources of finance, raising capital from diffused investors. The latter could accept a lower and a long term ROI

- Involvement of cities, local authorities, urban and regional networks and public engagement.

- Crowdfunding platforms have the strength to engage citizens, maximise the impact of new projects and raise the local stakeholders' awareness and at the same time redistributing more equally royalties and revenues

Risks in investments



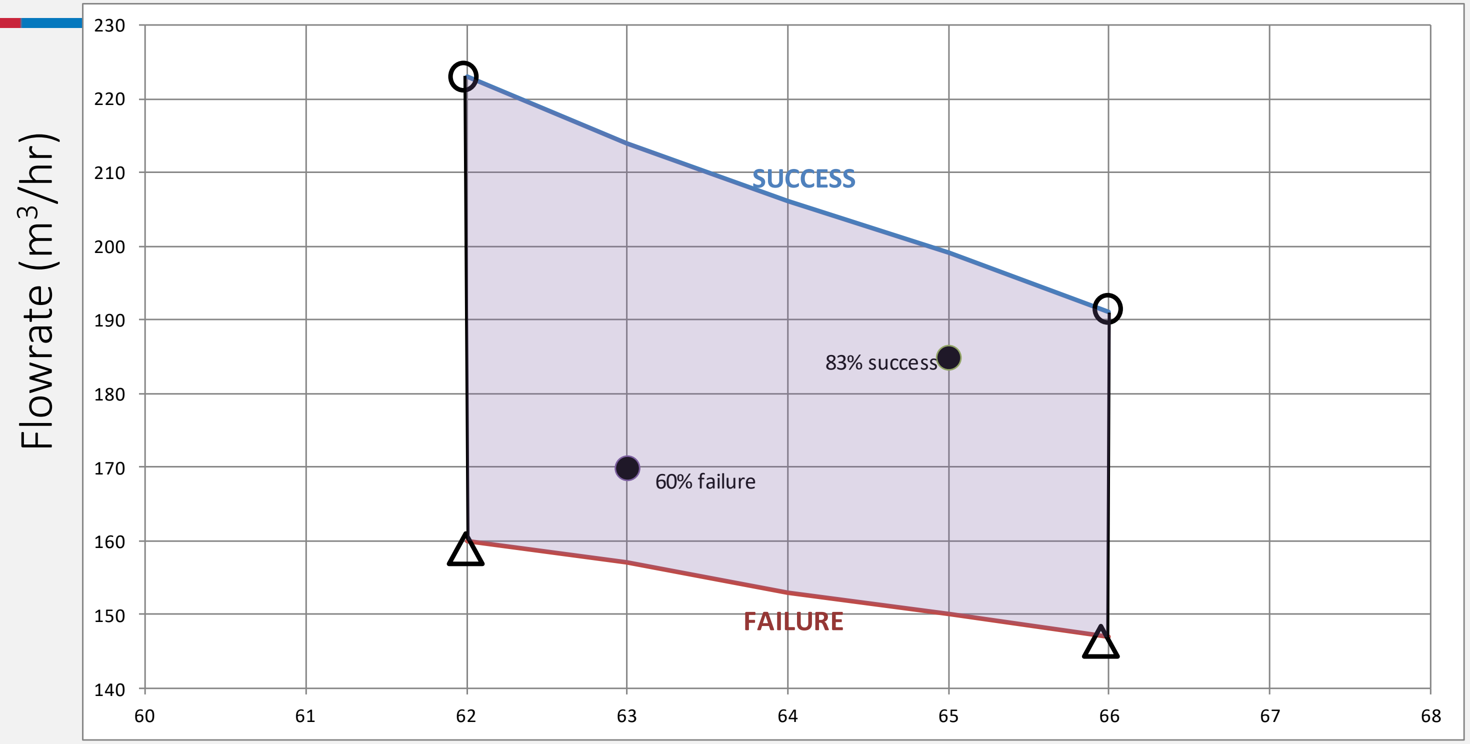
Two important news:

- **New scheme established in 2018 in Denmark and in Flanders (Belgium)**
- **New scheme accounced for 2019 in Walloon region (Belgium)**

EGEC GEOTHERMAL

GIP

RISK ASSESSMENT
SUCCESS/FAILURE CRITERIA



Numerical application:

CAPEX=12 10^6 €
OPEX= 5 10^5 €
n=20 years
nh=8256 hr/yr
r=5% (total failure)

r=10% (total success)
Full equity (no debt)
Subsidies=0 ; 25% CAPEX
c=35 ; 40 ; 45 €/MWht
T_i=40 ; 45 ; 50°C

DERISKING – PARIS BASIN SPECIFIC

FOCUS, PRIOR TO DRILLING, ON

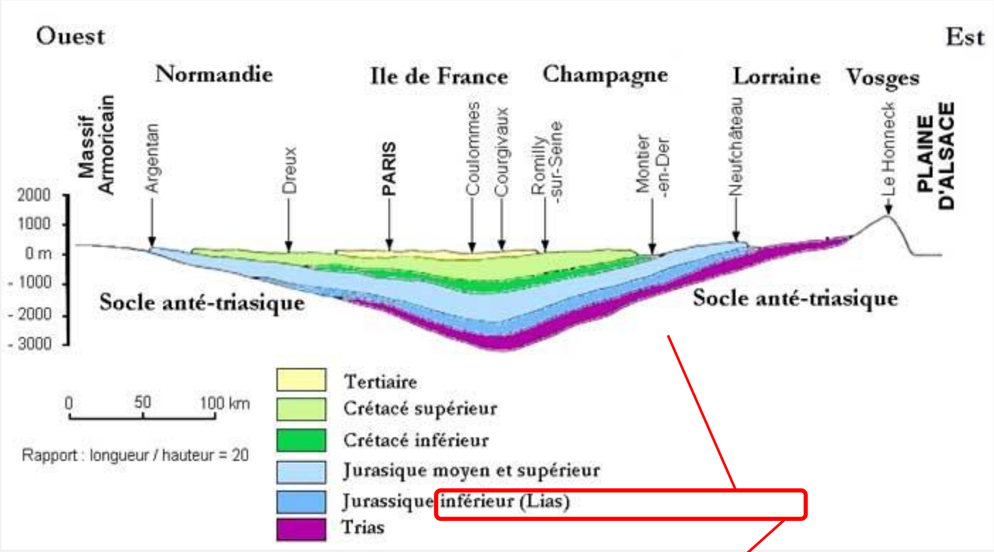
1. **sectorial lithostratigraphic correlations**, to identify, within the Dogger carbonate platform, those layers exhibiting favourable porosity and permeability trends and design accordingly well architectures departing from the routinely engineered deviated well trajectories aimed at intercepting the whole pay interval,
2. **reprocessing of existing seismic lines** and, whenever needed, **acquisition of new high resolution 2D lines** and, exceptionally, **3D surveys**,
3. **innovative well architectures** (horizontal, subhorizontal drains, multiradial, multilateral),
4. **(wildcat?) well siting vis-à-vis identified geologic structures** (faults, anticline, horst…),
5. play reevaluation in the light of newly acquired (wireline, test) data sets (offset wells),
6. **screening** and eventual **validation** of Candidate Dogger project opportunities,
7. selection of an **eligible drill site**, and,
8. **last but not least implementation of innovative well architectures.**

EGEC GEOTHERMAL

IP

INNOVATION: SUBHORIZONTAL WELL ARCHITECTURES

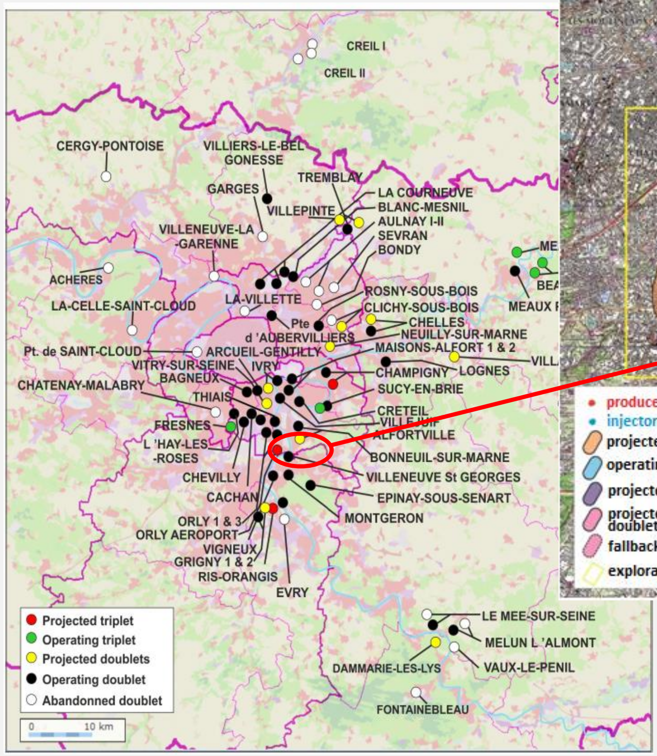
WEAST EAST CROSS SECTION



The Dogger (Bathonian member) target reservoir is hosted by the Upper part of the carbonate platform.

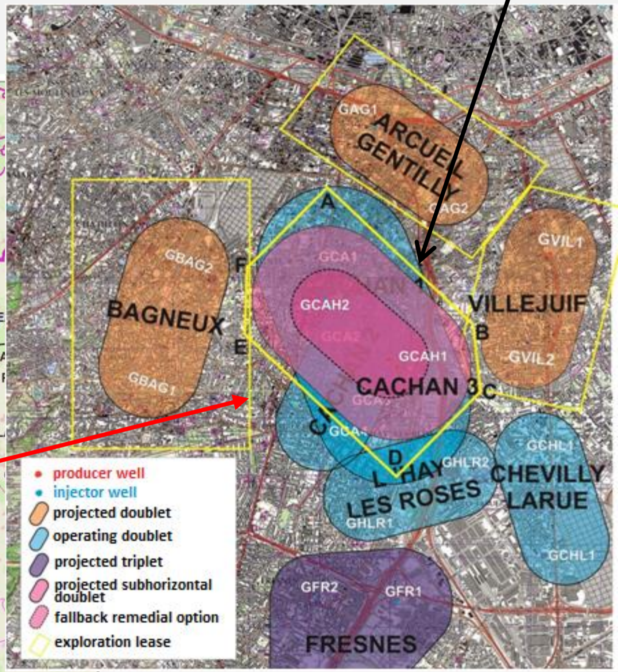
Within the platform oolithic limestone sequences exhibit high connected porosities and related permeabilities portraying a dependable multilayered reservoir structure.

LOCATION



PARIS BASIN GEOTHERMAL DISTRICT HEATING (GDH) STATUS

Target area

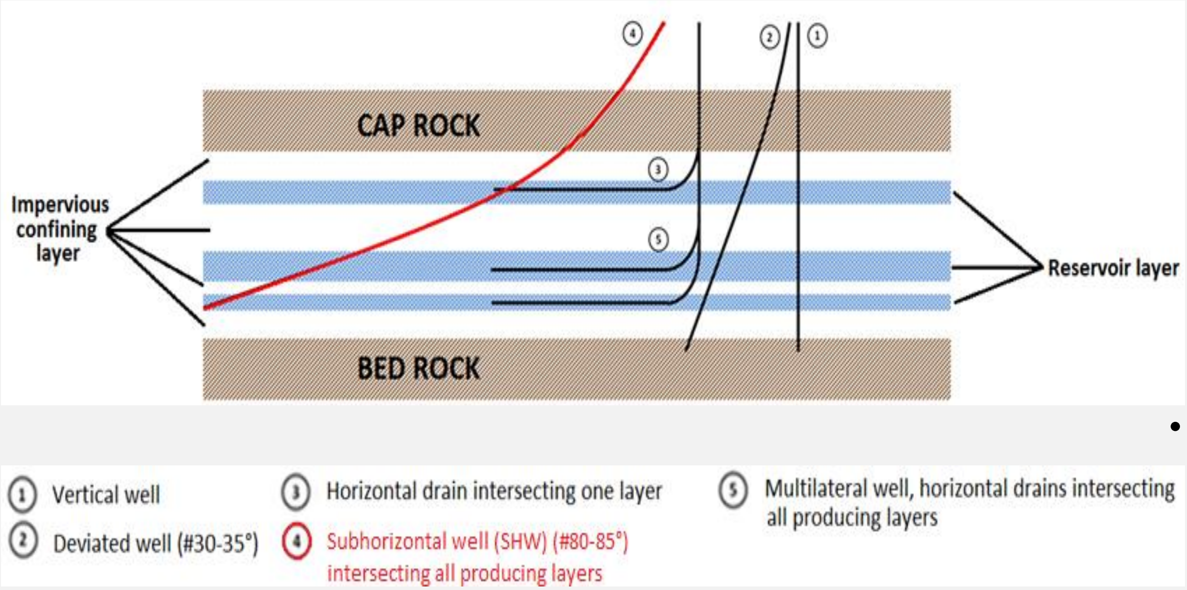


CACHAN SITE AND SURROUNDING DH DOUBLETS/TRIPLET

EGEC GEOTHERMAL

SUBHORIZONTAL WELL (SHW) CONCEPT AND EXPECTATIONS

CONCEPT

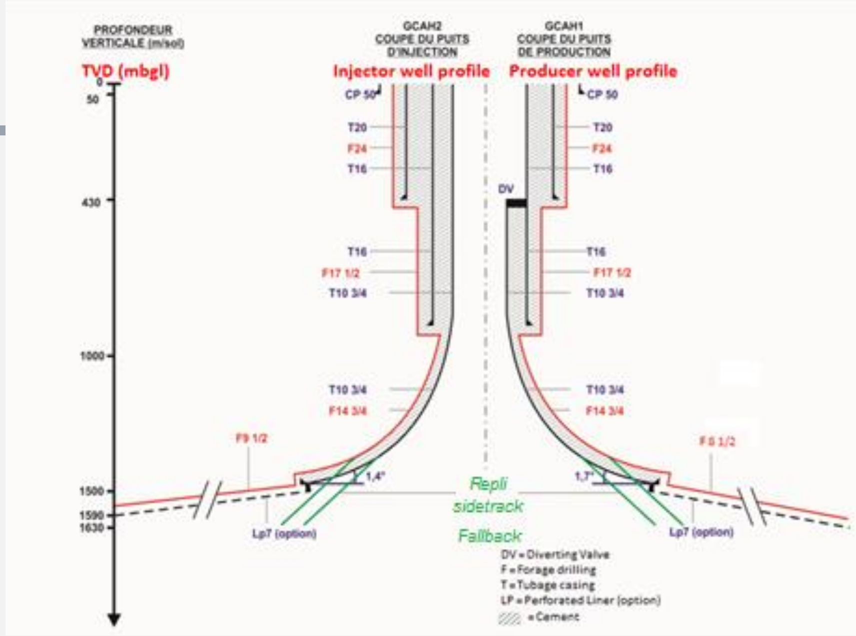


EXPECTATIONS

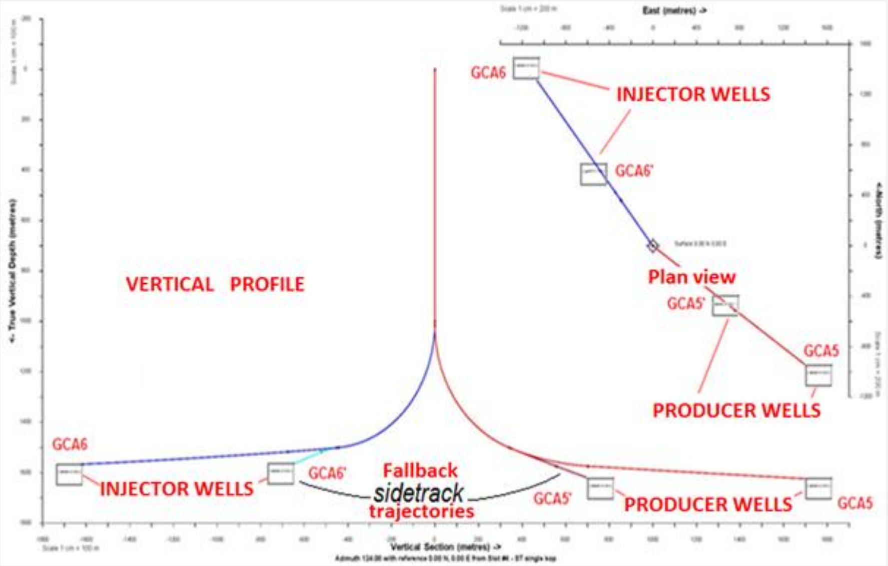
- **General**
  - **Optimise** land occupation in densely populated urban environments
  - **Added value** to presently unchallenged low permeability reservoir settings
  - **Maximise** geothermal exposure & minimise drilling/completion risk
  - **Upgrade** geothermal well architecture & reservoir evaluation standards

- **Site specific**
  - Well architecture → Innovation
  - Extend exploitation until 2045 → Sustainability
  - Increase capacity 350->450/500 m^3/hr → Well performance
  - CAPEX/OPEX reduction → Economy
  - Multilayered reservoir appraisal → Geology

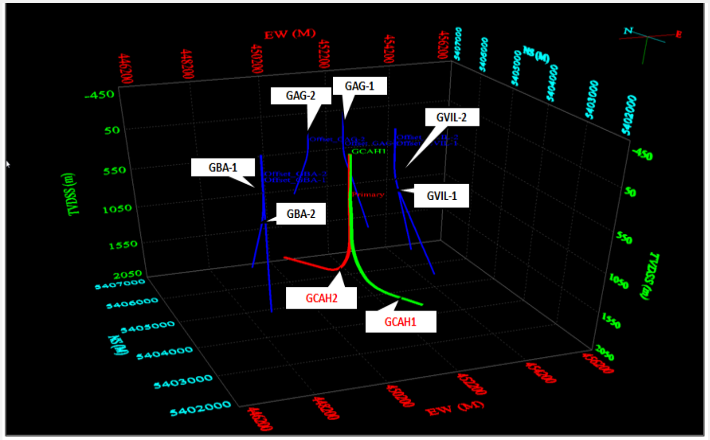
SHW DOUBLET ARCHITECTURE AND OFFSET WELL TRAJECTORIES



a) Well architectures

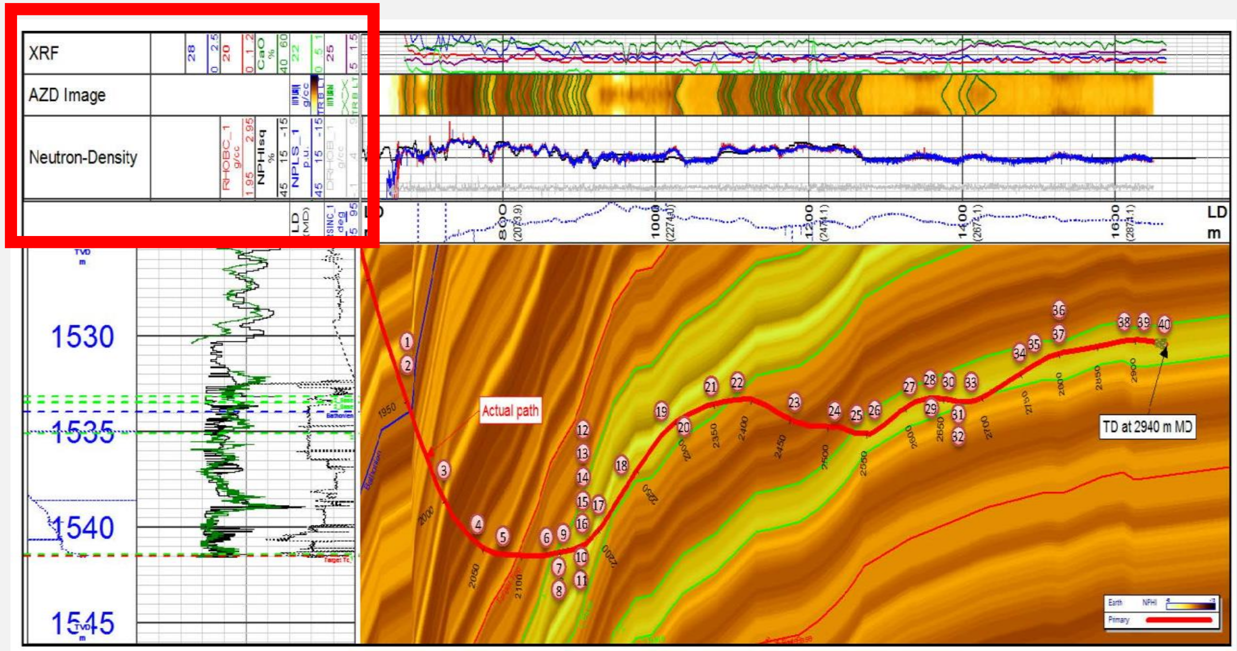


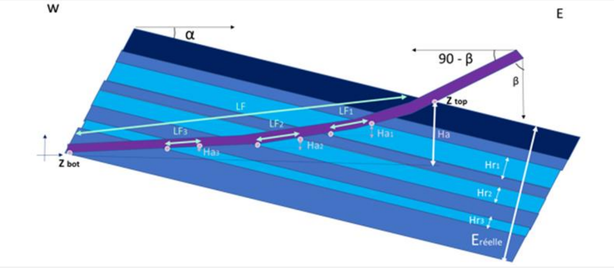
b) Well trajectories



c) SHW and candidature offset well trajectories

CHALLENGE. GEOSTEERING. WELL GCAH2
REAL TIME TRAJECTORY CORRECTIONS





α = 1°
β = 88°
E actual = 60 m
Then:
Ha : 40 m ;
LF : 1146 m

=> Well architecture similar to GCAH1 which intercepts all layers over large lenghts

α = 5°
β = 88°3
E actual = 20 m
Then:
Ha : 11 m ;
LF : 104 m

=> The whole reservoir is drilled where do we go next? upwards?

- **Challenge: Real time trajectory corrections**
  - 1 to 5° varying dips, impacting drain effetive length
  - Reconcile tracking of thin (#1 m) high porosity layers with target matching delays induced by high bit to RSS recording distance (#20 m)

ANTICORROSION WELL CONCEPT. BONNEUIL-SUR-MARNE

ANTICORROSION WELL CONCEPT

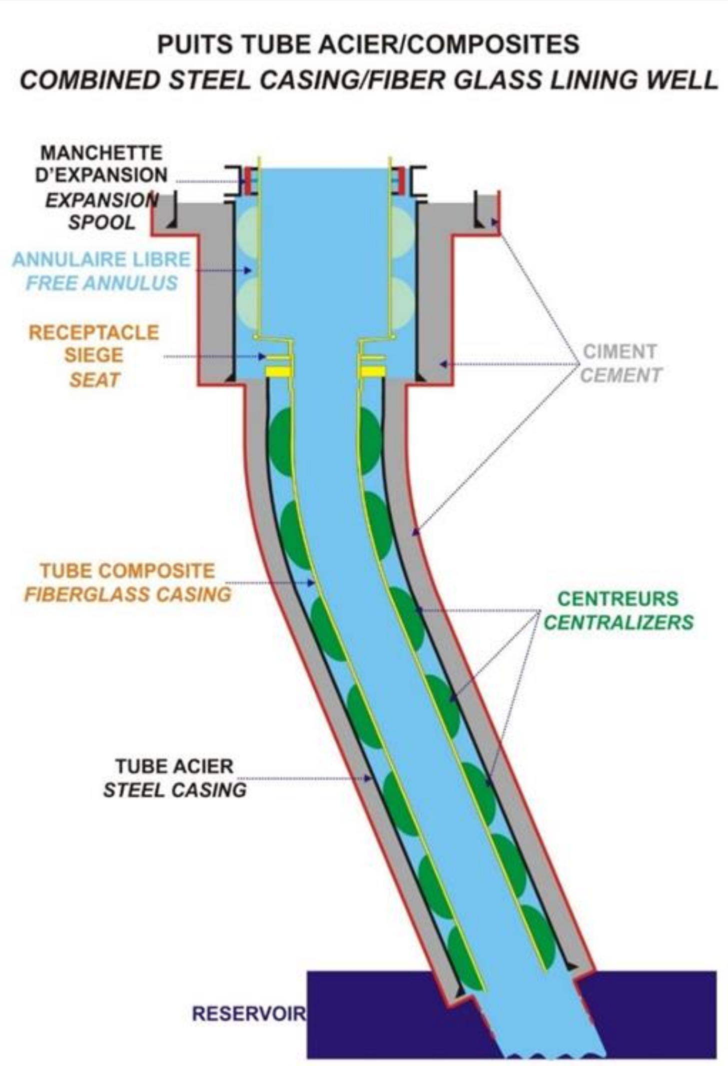
Present well architecture addresses an artificial lift, pump sustained, production, which implied significant design modifications, chiefly:
(i) an upper, wider (13"3/8OD -11.97” ID) liner section acting as a pumping chamber, sized to accommodate a 500 HP rated ESP, placed under compression between the wellhead and the lower section;

(ii) a lower and slimmer (9"5/8OD –7.74” ID), freely suspended production liner;

(iii) a (13"3/8x9"5/8) liner connecting system, placed at the (20"x13"3/8) casing interface, allowing for a free annular fluid (a make-up corrosion inhibitor agent) passage, indeed a key issue, and,

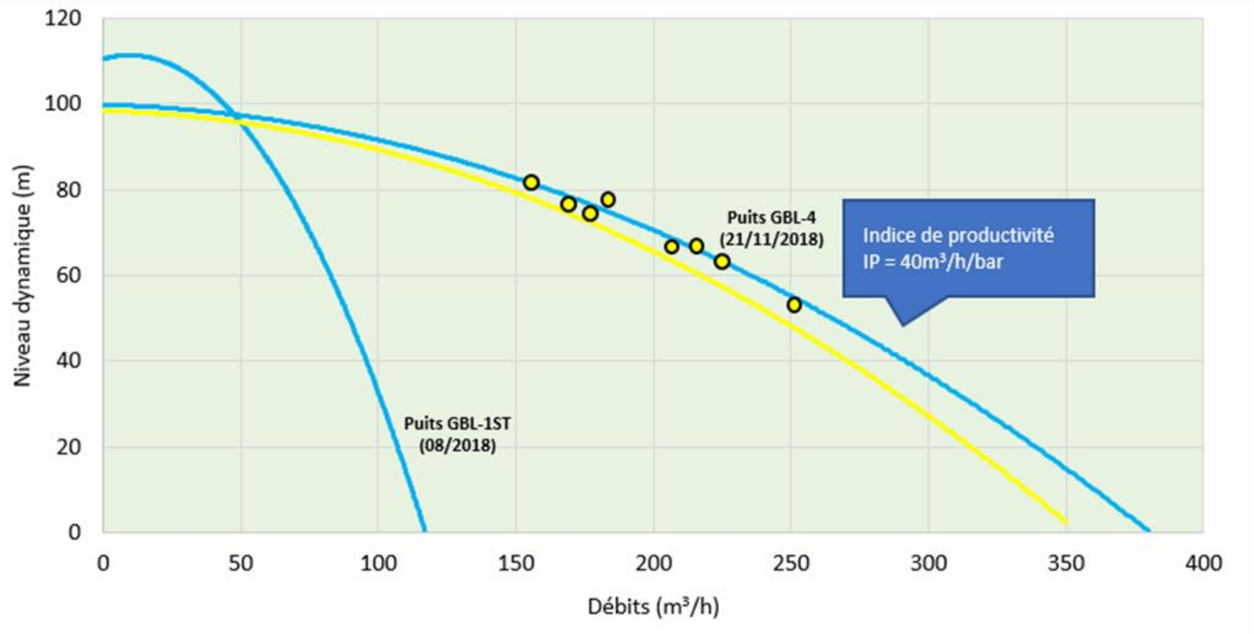
(iv) a wellhead expansion spool. The additional capital investment costs (ca 20% compared to a conventional 13"3/8x 9"5/8steel cased well architecture) will get payed back in less than eight years thanks to yearly OM costs savings.

Given the foregoing, itis expected this, smart well, material answer to thermochemically hostile corrosive fluid environments, elsewhere securing well longevities and low operation/maintenance (OM) costs, raises due interest among geothermal operators and stakeholders.



EGEC GEOTHERMAL

ANTICORROSION WELL CONCEPT. IMPLEMENTATION AND RESULTS



THANK YOU FOR YOUR ATTENTION

Geothermal Energy:
renewable-sustainable-proven-achievable-realistic

WWW.EGEC.ORG