IRENA
International Renewable Energy Agency

Energy Solutions for Cities of the Future: Facilitating the Integration of Low-Temperature Renewable Energy Sources into District Energy Systems.
Capacity building workshop

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

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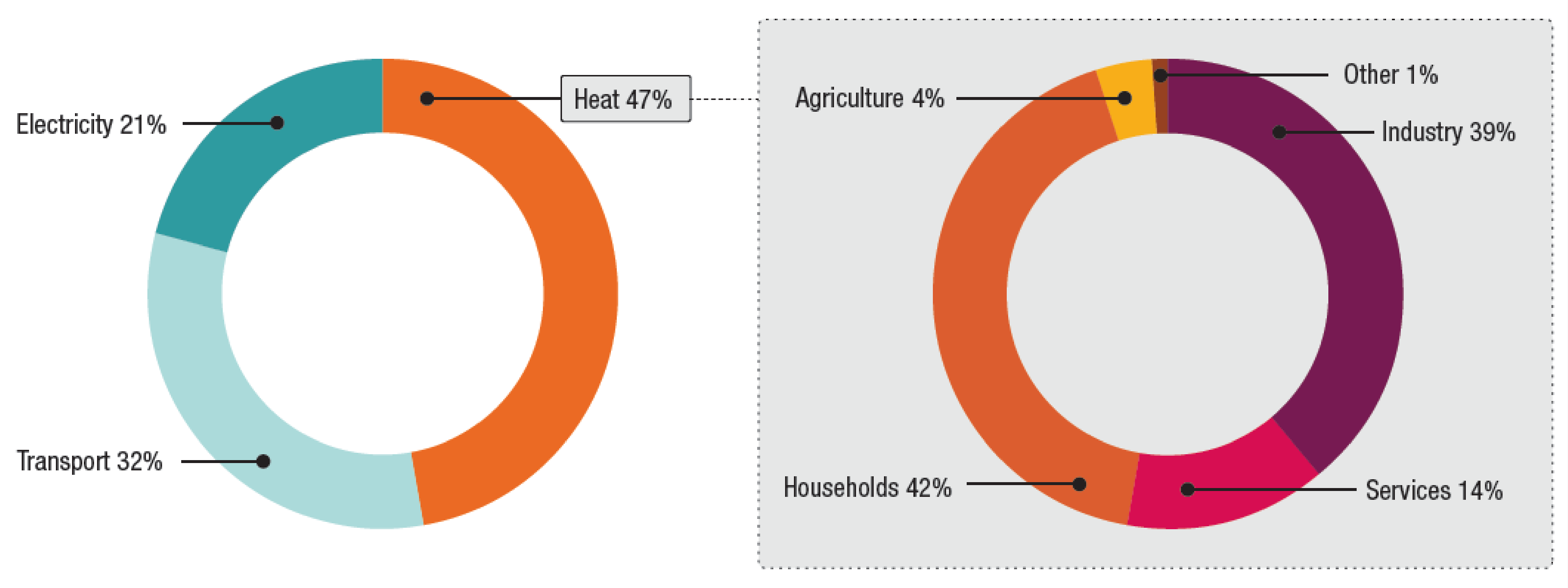
EGEC GEOTHERMAL

Outline

- EGEC market report on district heating in Europe
- ETIP DG vision on unlocking geothermal energy
- The Paris Basin GDH system
- Innovation: Subhorizontal well architectures
- Innovation: Anticorrosion well concept

GEOTHERMAL HEATING - HEAT DEMAND

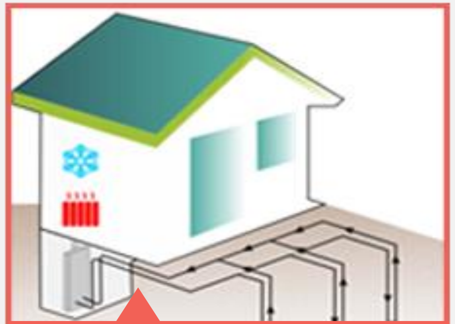
Why is heating so important - and where is it required ?



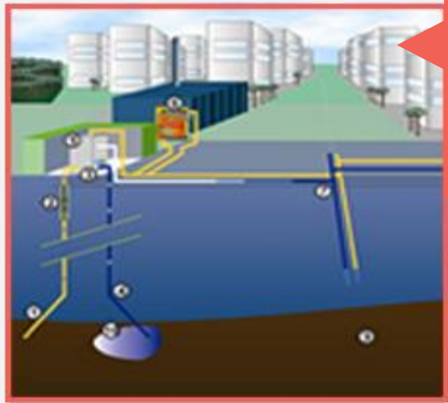
Graph from RHC-Platform – SRIA, 2013 (values for 2010)

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

Geothermal heating and cooling technologies



Heat pumps

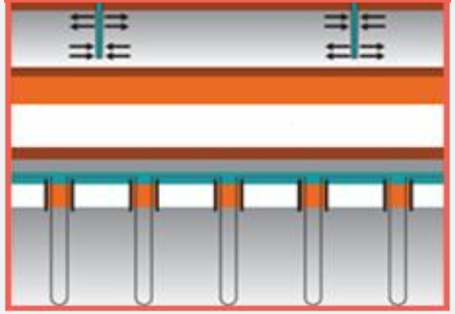


District heating and cooling

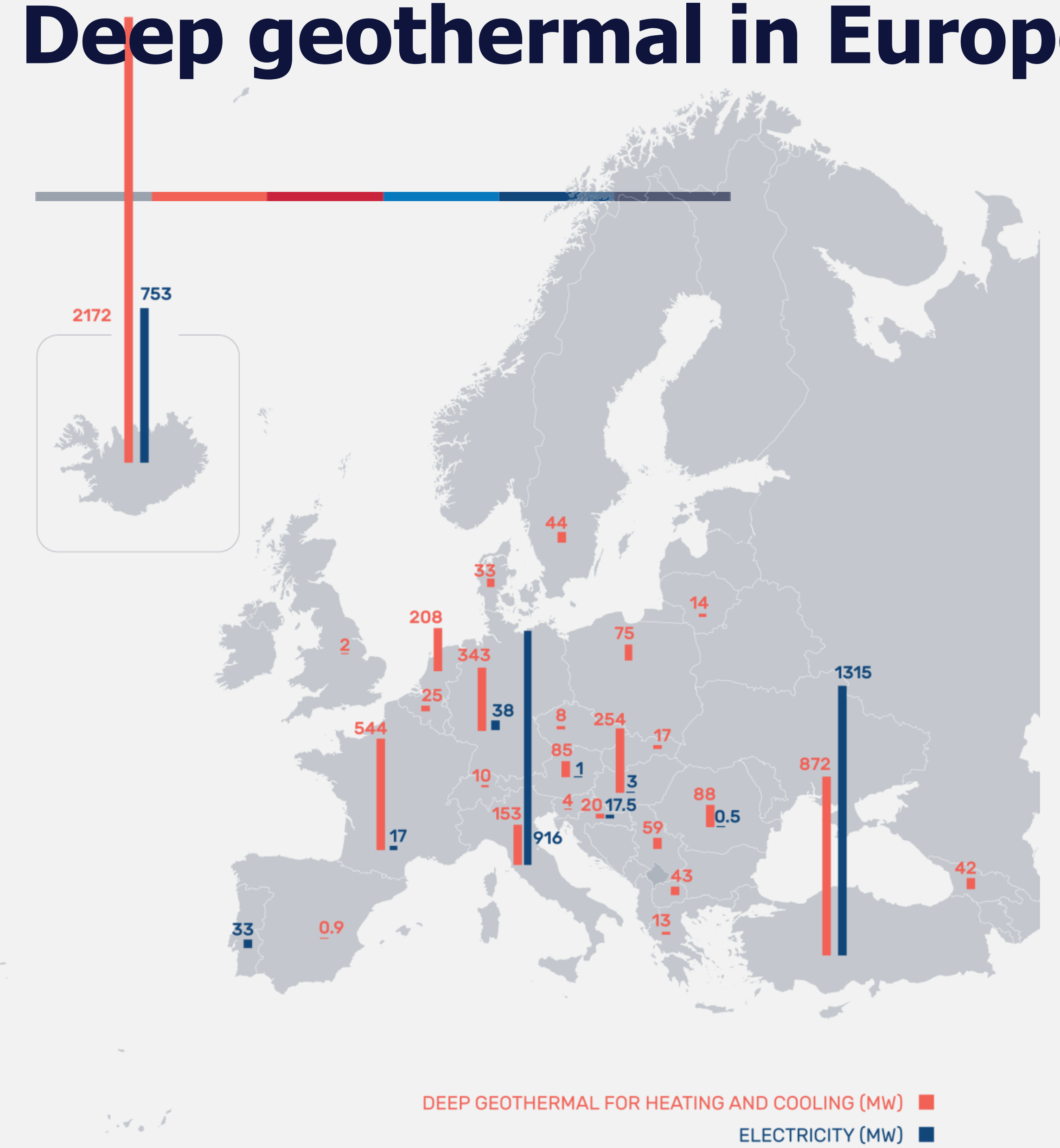
EGS and cogeneration

Underground thermal storage

Direct uses: e.g. in agro-industry



Deep geothermal in Europe: market overview



Installed capacity for geothermal electricity & district heating (2018, Mwe & MWth)

Two important milestones:

1) More than 3 GWe installed
2) More than 300 Geothermal DH in operation

….and soon 2 millions geothermal HPs !

Geothermal electricity in Europe:

- 3.1 GWe capacity
- 10% average annual growth rate over the last 5 years

Geothermal district heating in Europe:

- 5.1 GWth capacity

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District heating // Summary of key conclusions

State of Play in 2018

- Over 5 GWth of geothermal DH
- 12 new or renovated plants over the last year, 150MWth

300 Geothermal DH Plants

- 5 new project commissioned in the Netherlands
- 1 new and 3 renovated plants in France
- 1 new project in Serbia
- 1 new project in Belgium
- 1 new project in Germany

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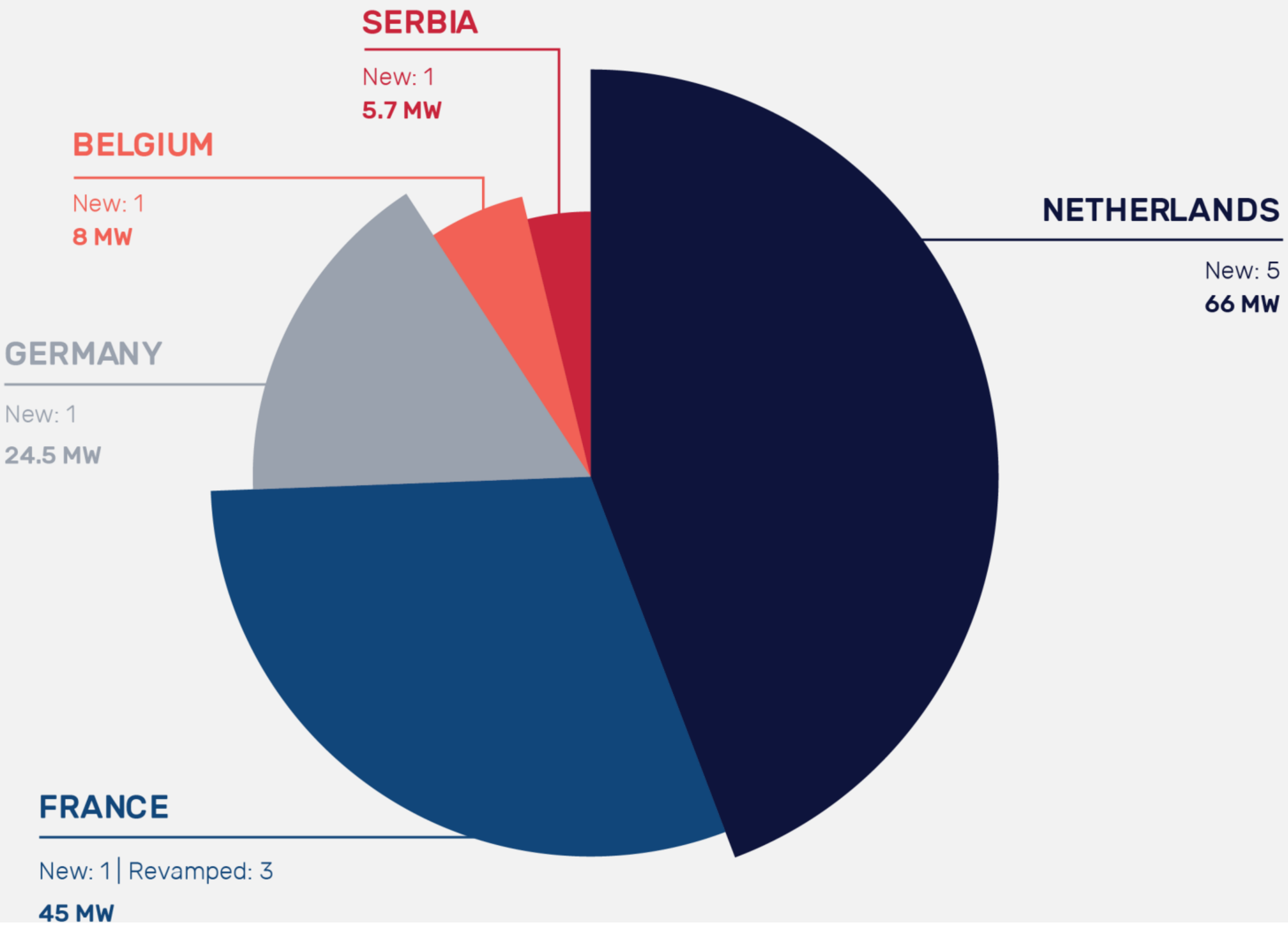
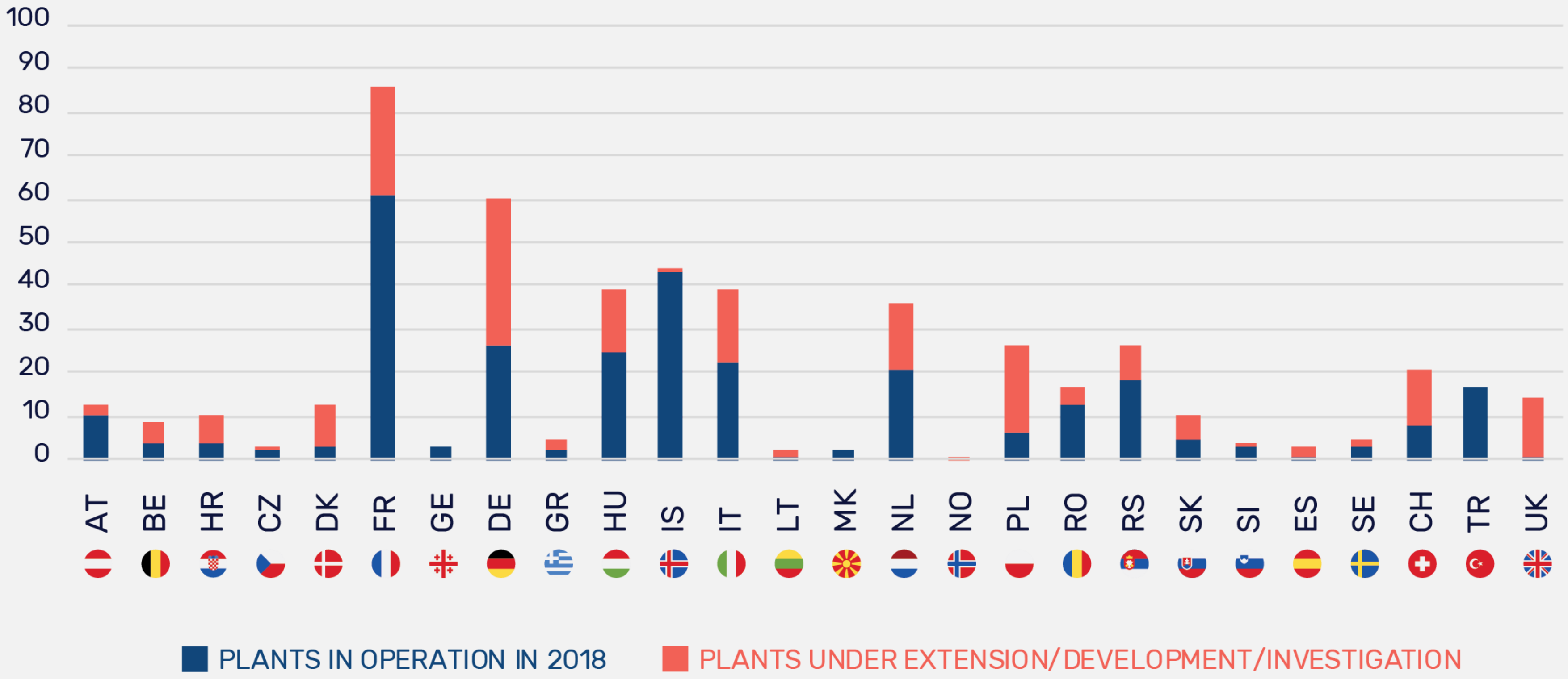
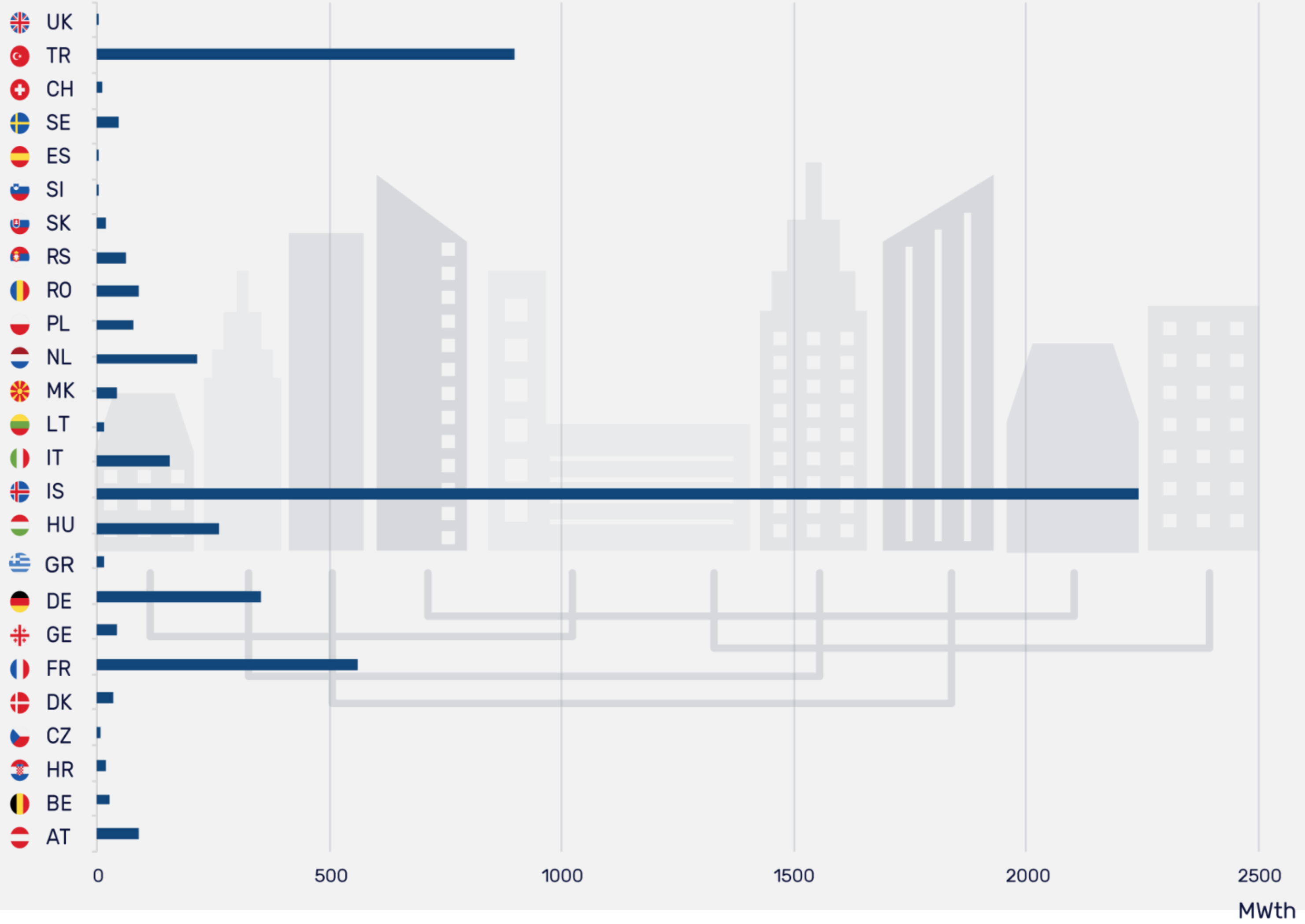
New plants for deep geothermal for heating and cooling in 2018 (capacity and number)



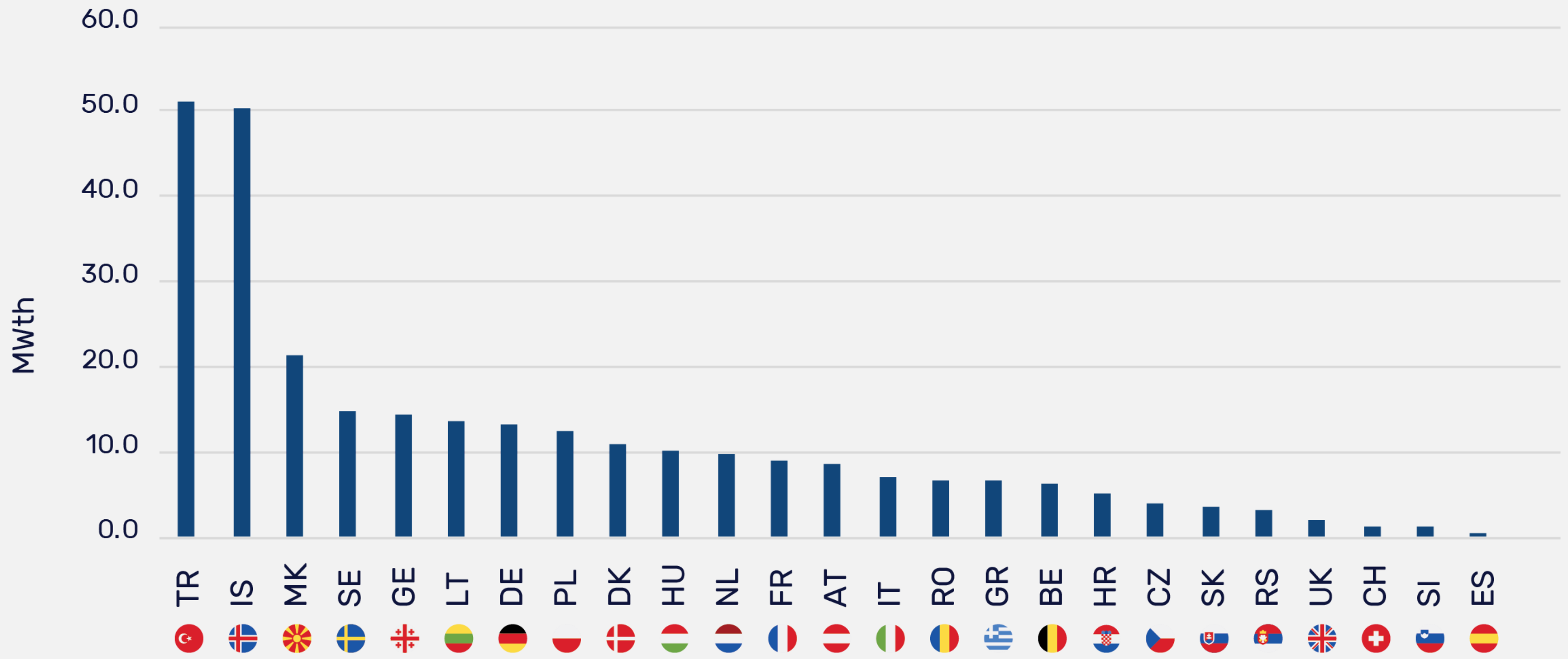
Number of GeoDH plants in operation and under development-investigation per country



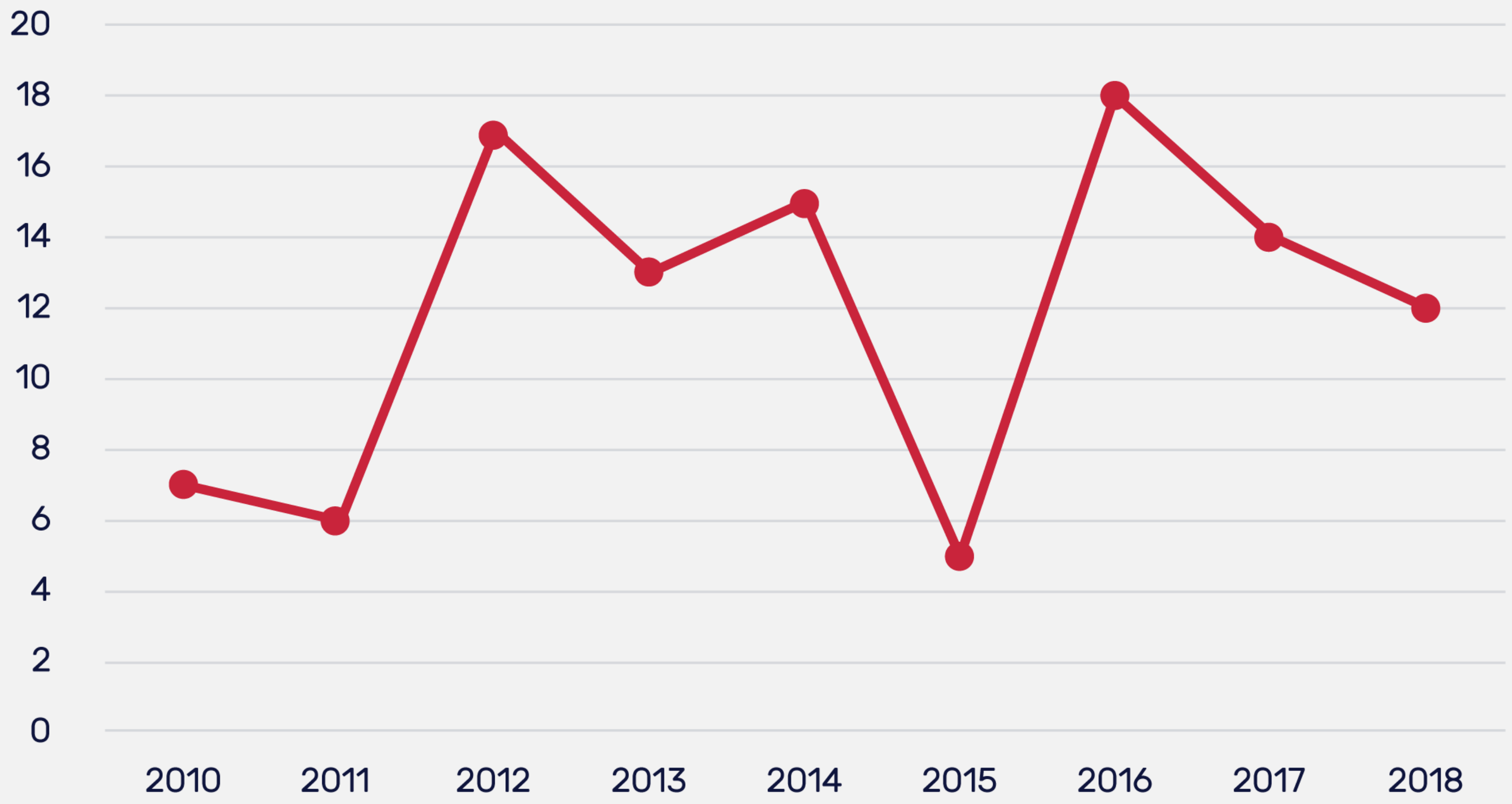
Deep geothermal for heating and cooling capacity per country (MWth)



Average size of deep geothermal heating and cooling plant per country



Number of new geothermal plants commissioned per year



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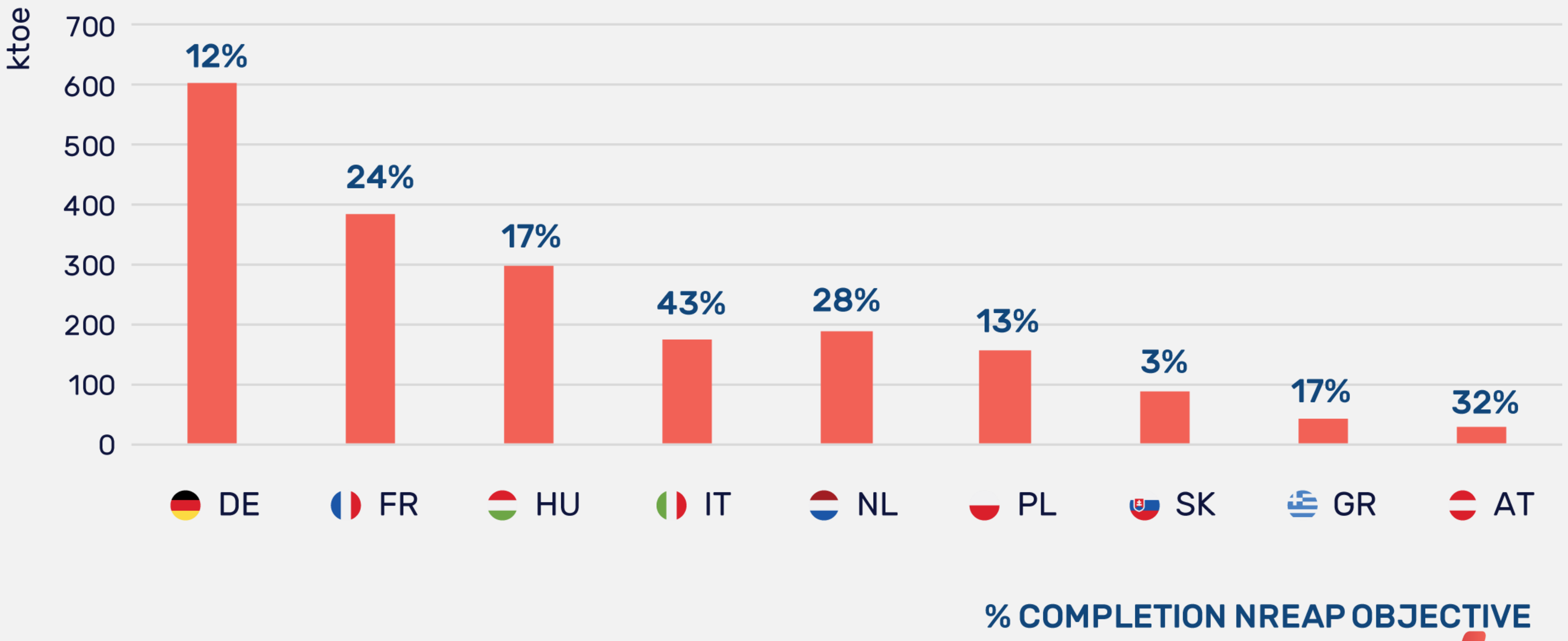
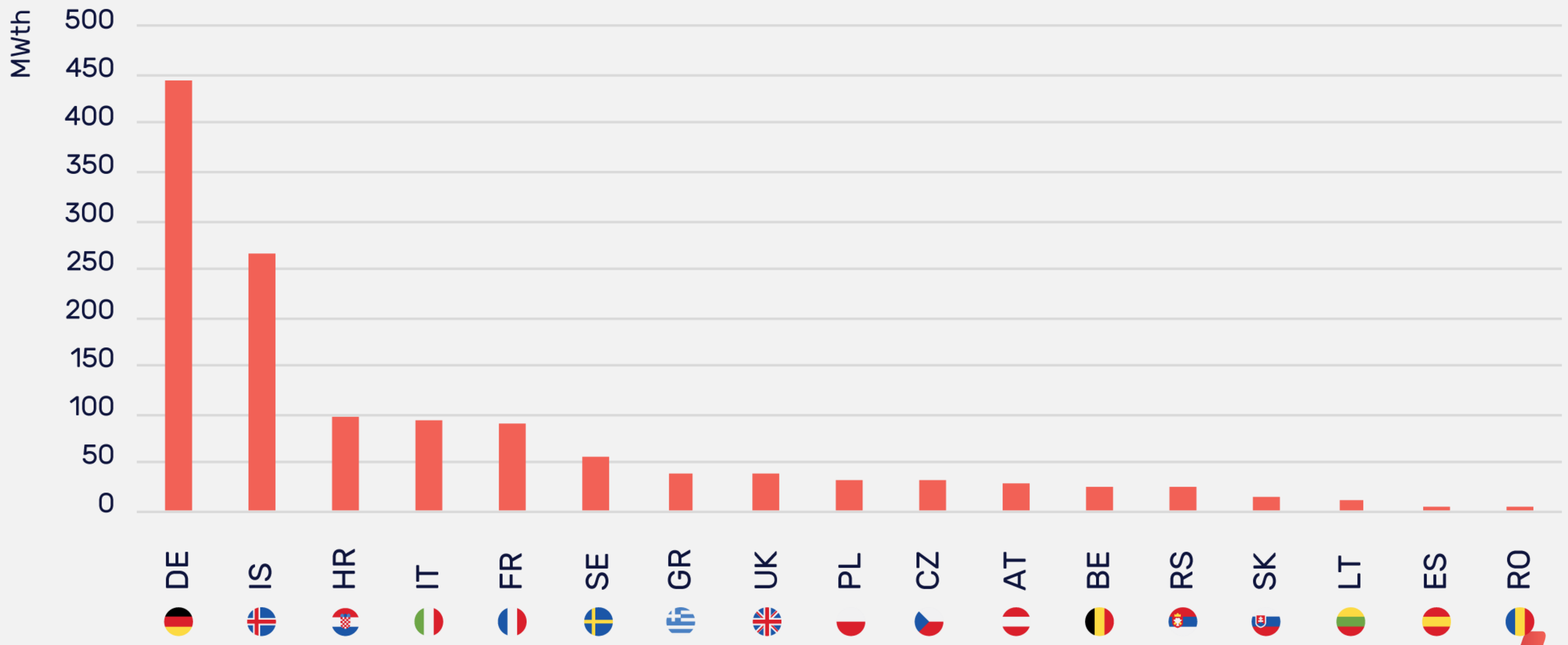
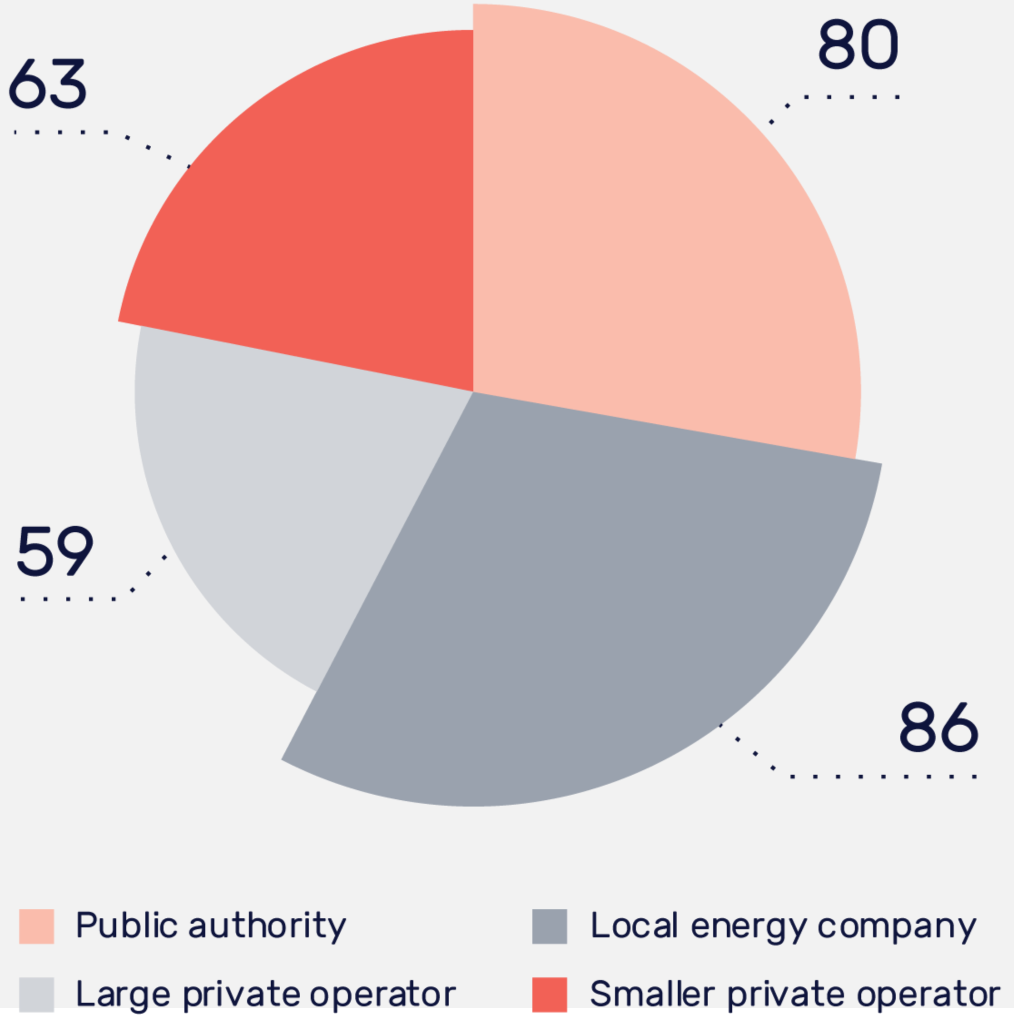
Gap to deep geothermal heating and cooling objectives in NREAPs



Geothermal planned capacity per country (when data is available)



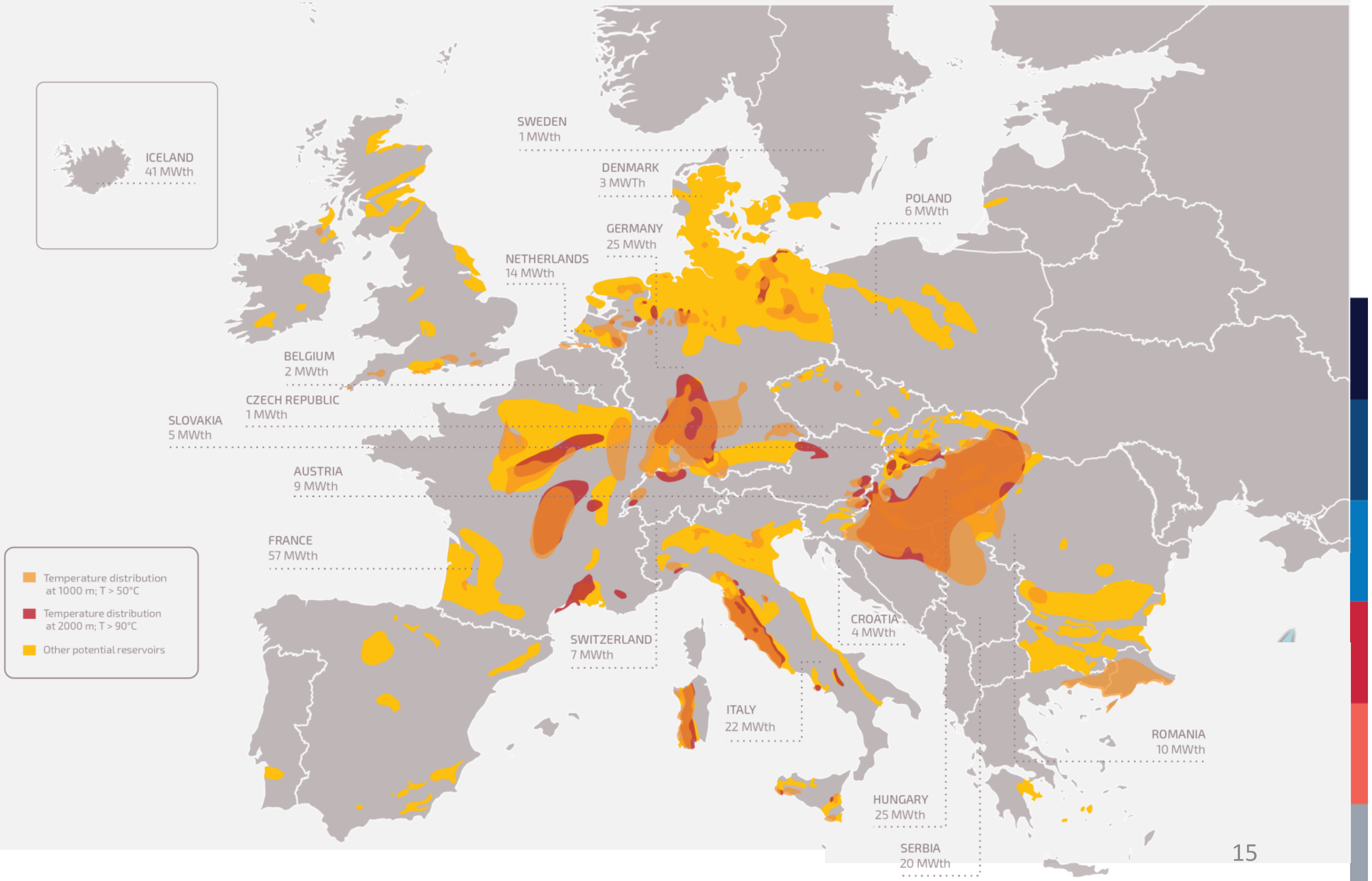
Typology of geothermal heating and cooling projects operators in Europe



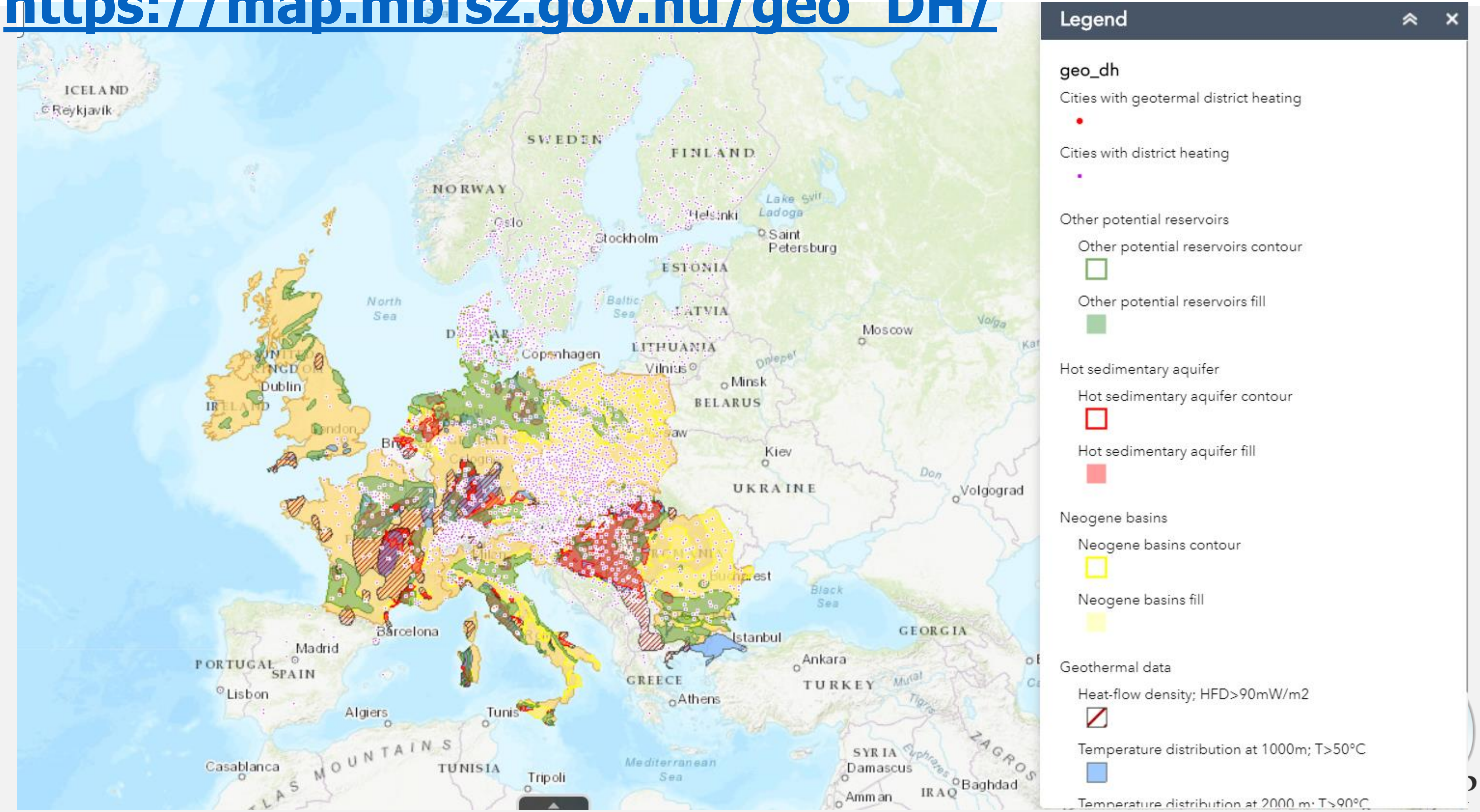
More than 25% of the EU population lives in areas directly suitable for geothermal district heating

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

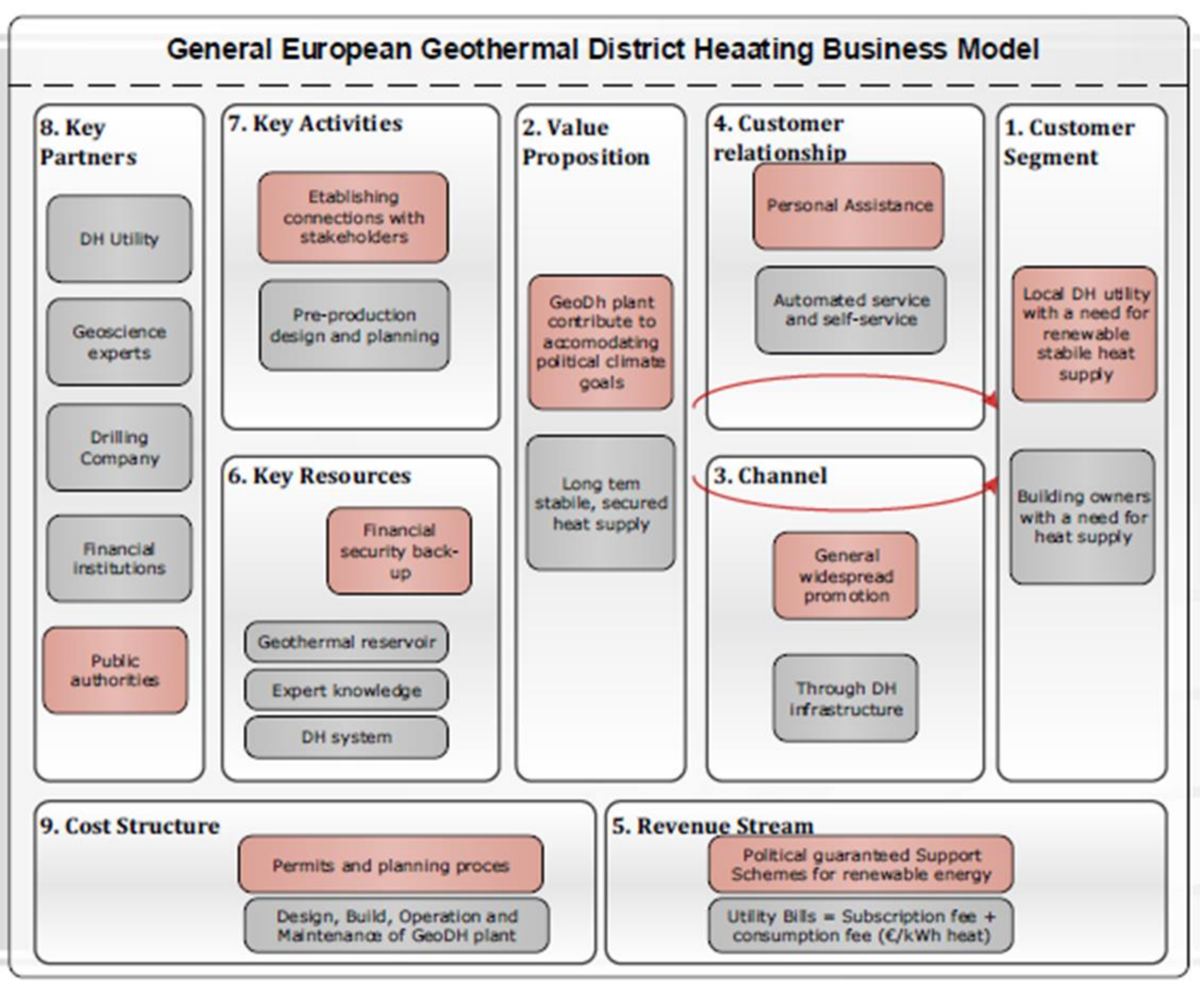


https://map.mbfsz.gov.hu/geo_DH/

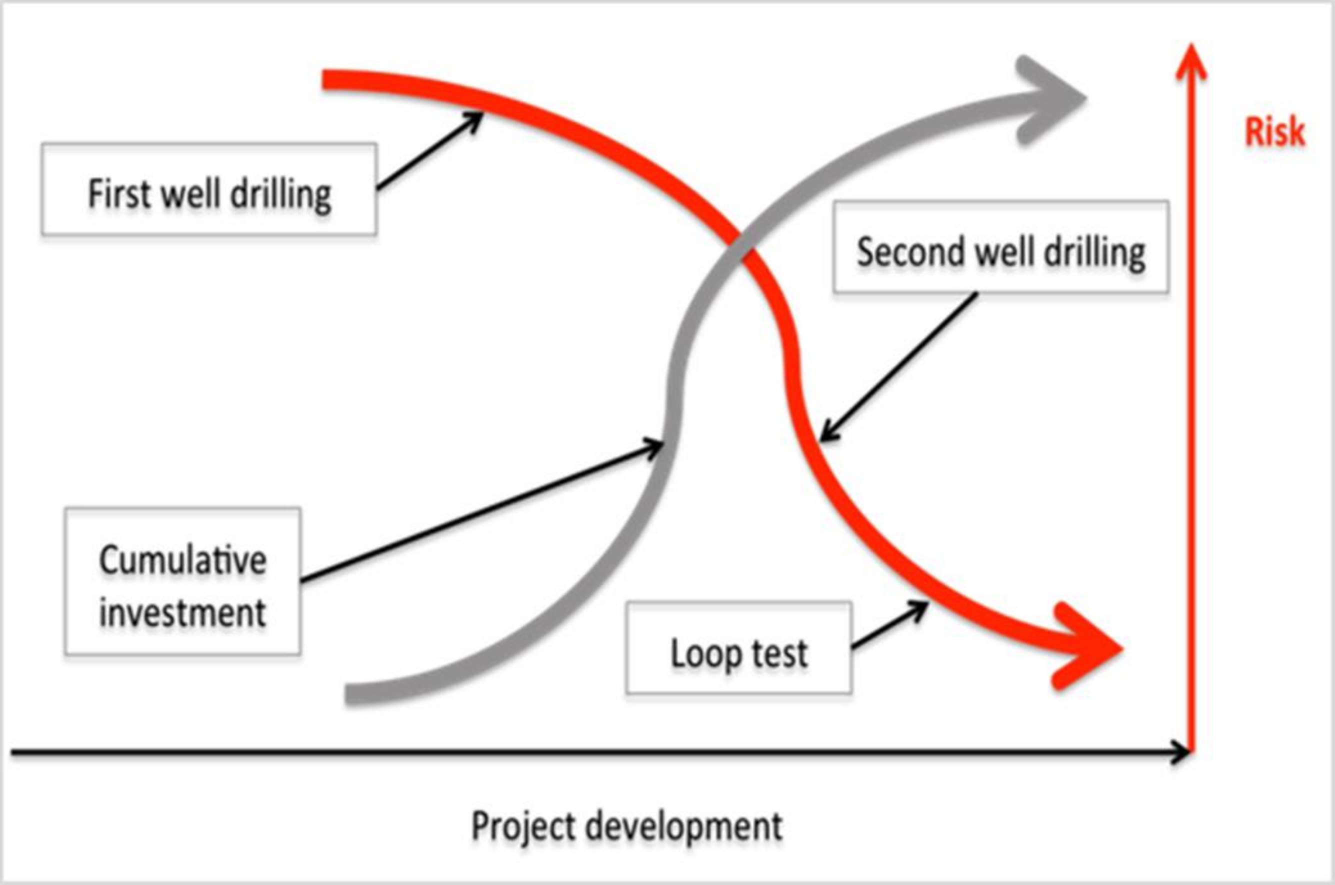


Challenges

- Demand for Heat supply
- Firmness of electricity supply



Risks in investments

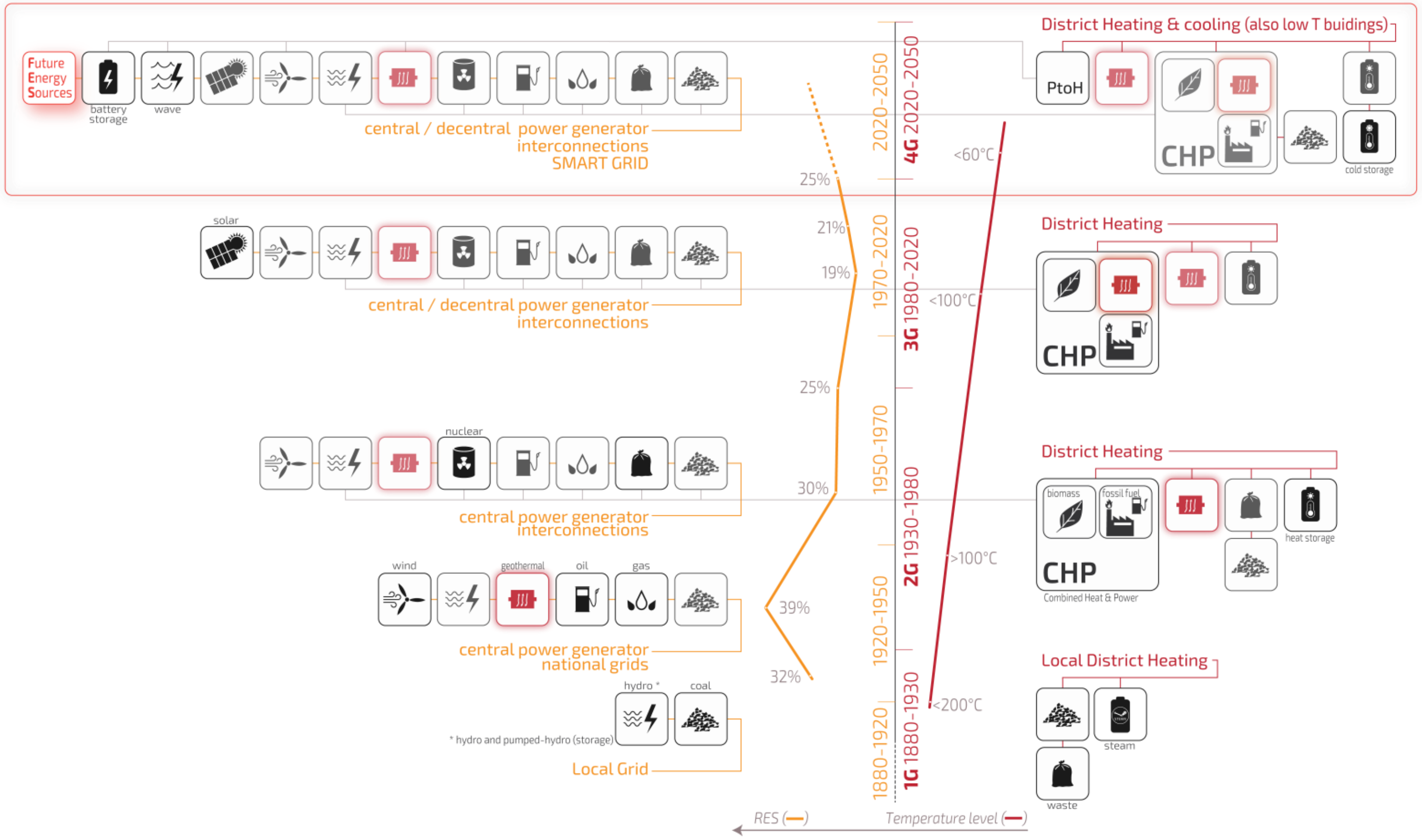


Two important news:

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

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: Power development

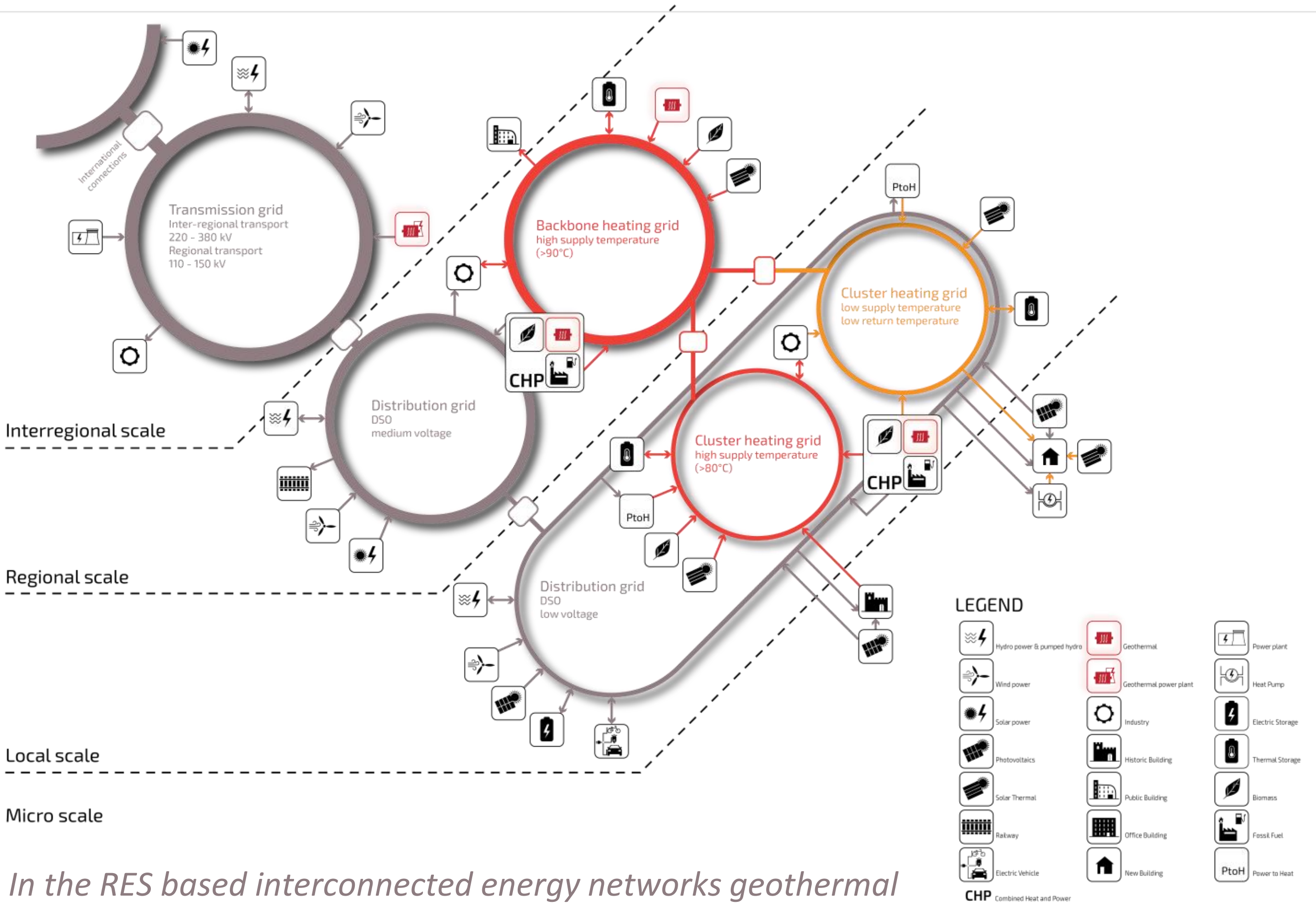
Combined biomass and geothermal plant in Cornia, Italy

> Improved efficiency, optimization of material, processes, cycle design

> Hybrid, proper combination

> Cutting edge technologies for any kind of resource (super-hot, off-shore, geopressurized) and any place (from remote islands to urban areas)

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

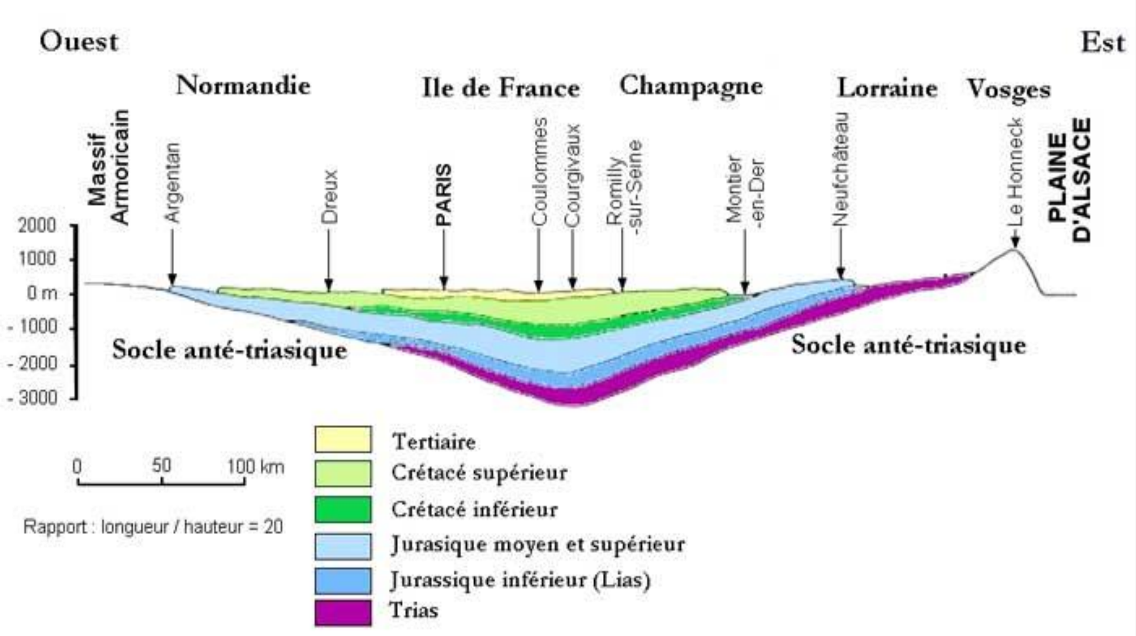
> Consumer-producer-prosumer perspectives

> Thermal storage to help balance and to optimize production

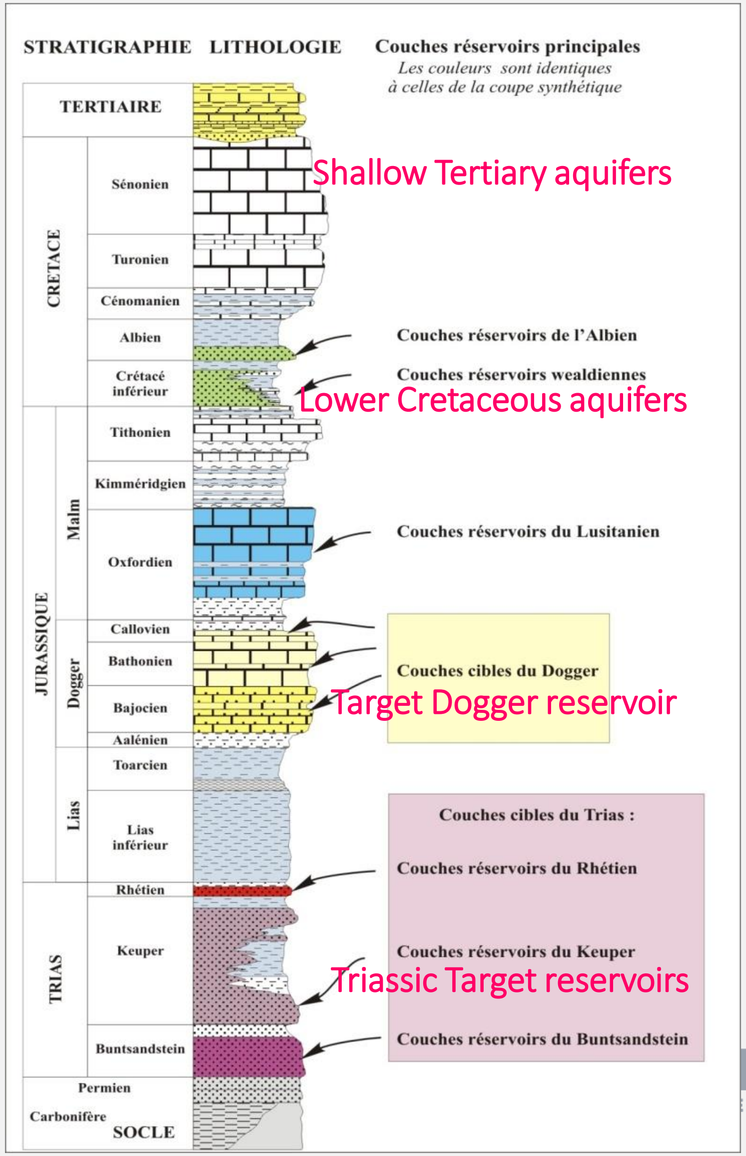
> Cascade, hybrid, synergy (e.g. geothermal-algae-biofuels-transport)

PARIS BASIN - GEOLOGICAL SKETCHES

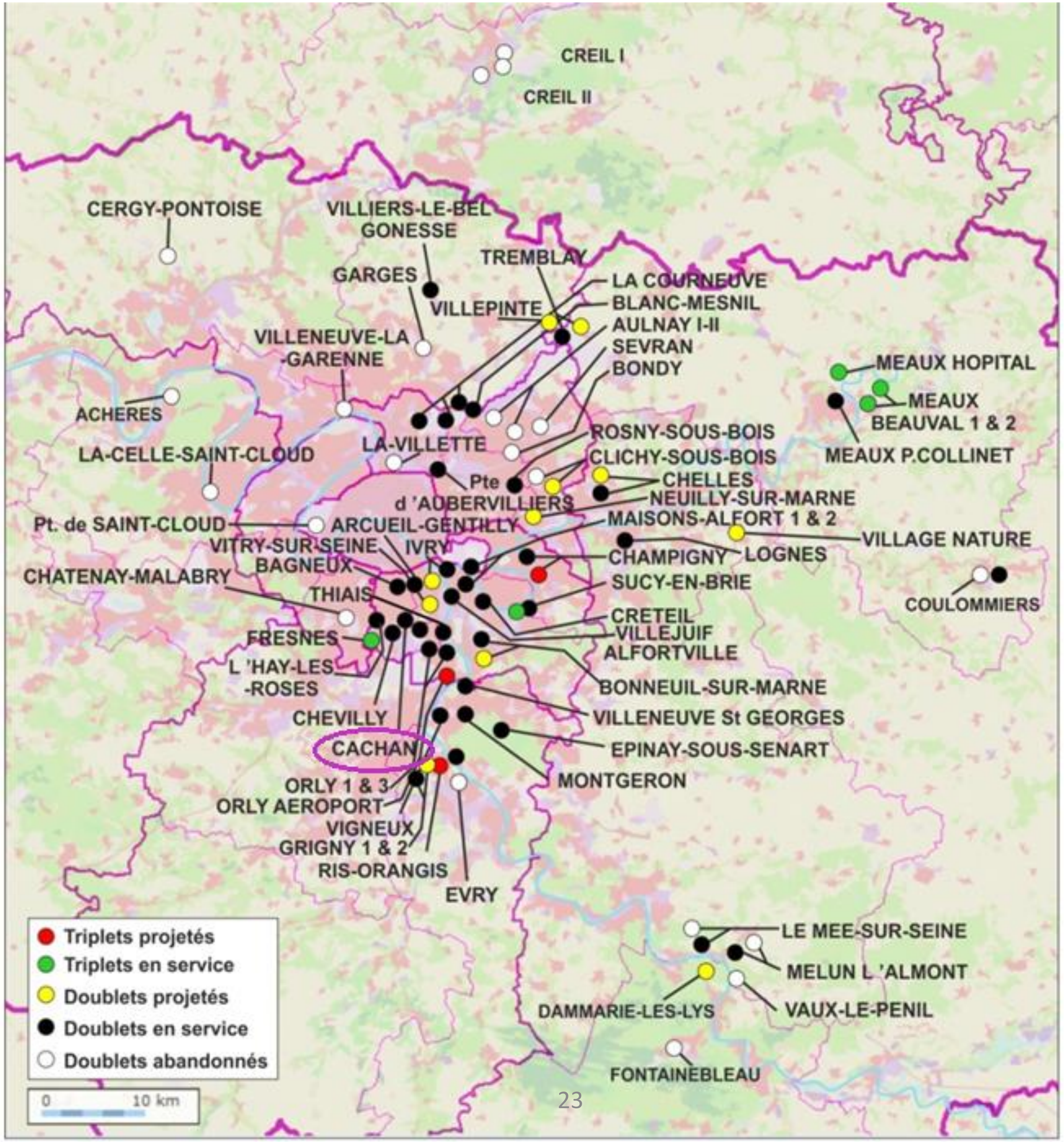
West East Cross Section



Lithostratigraphic column and target reservoir horizons



PARIS BASIN GDH STATUS



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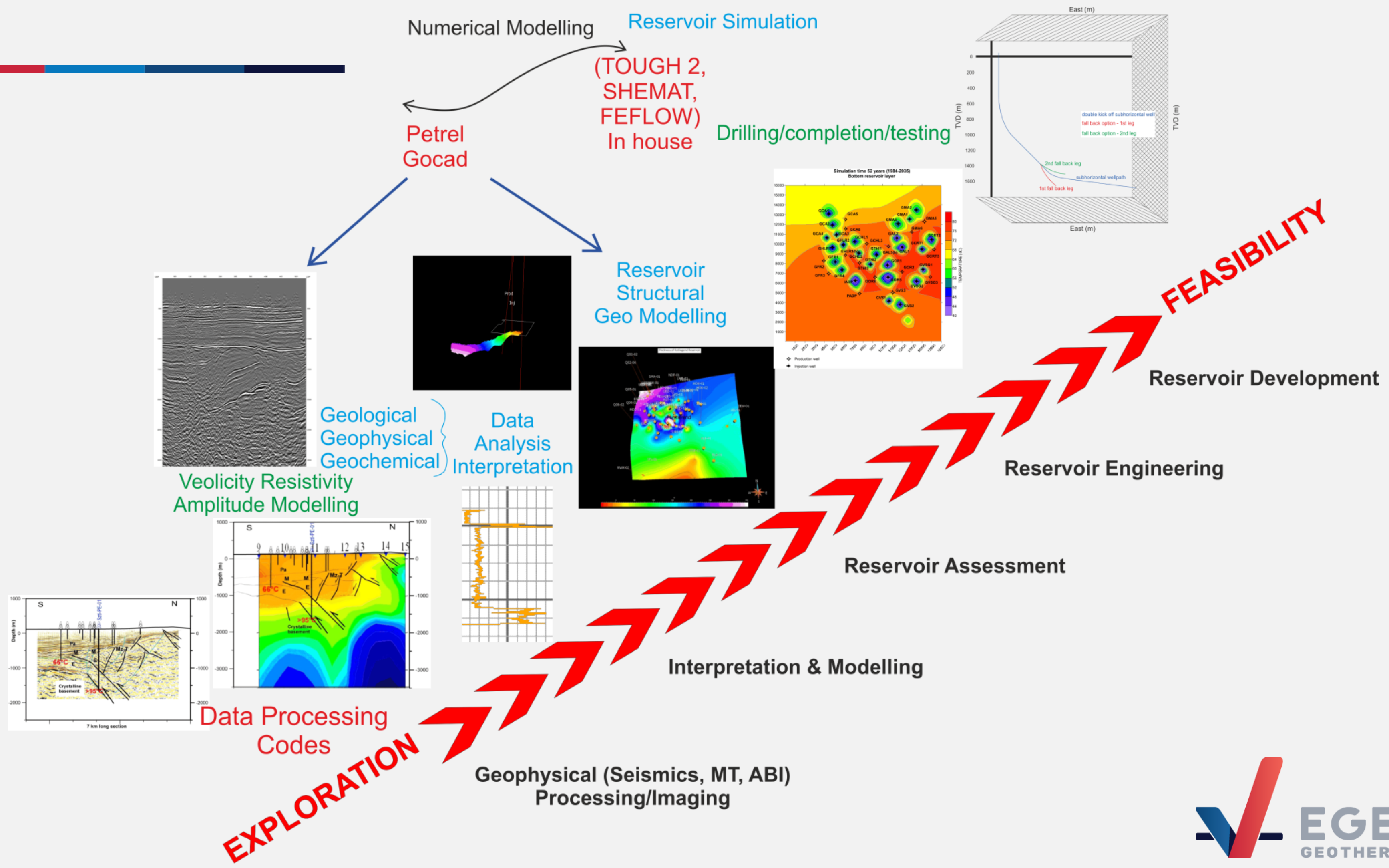
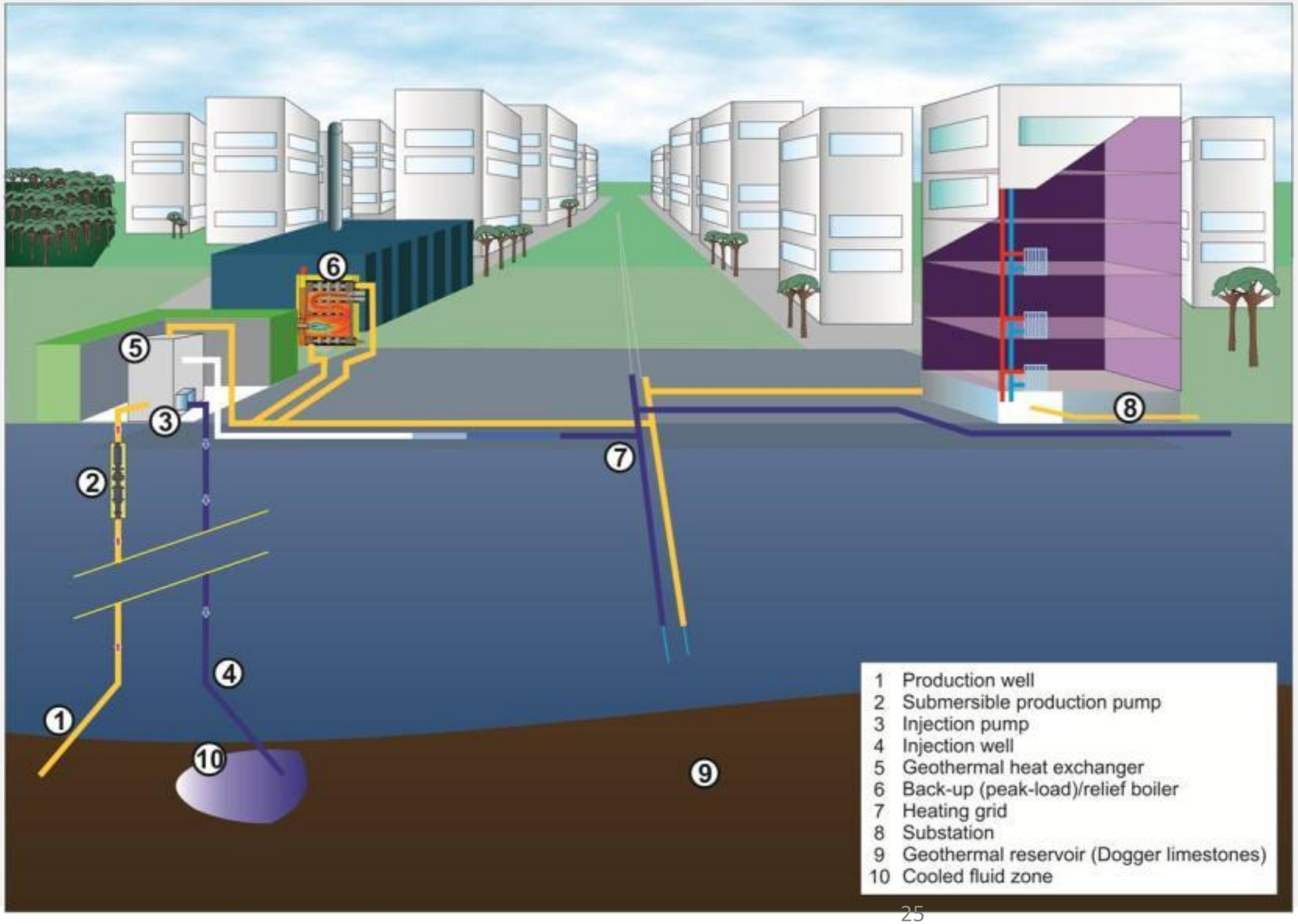
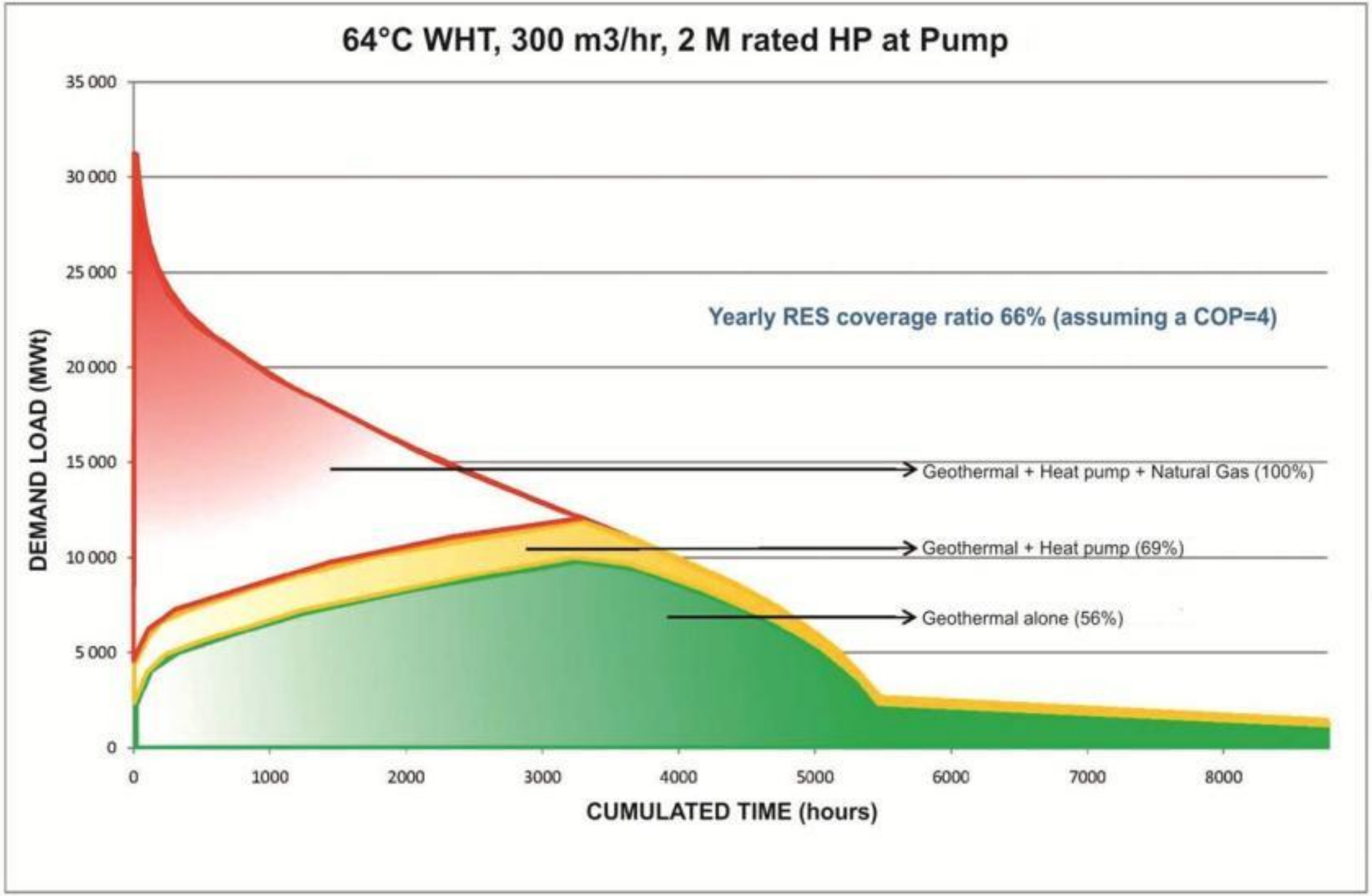
RESERVOIR ENGINEERING AN INTEGRATED APPROACH



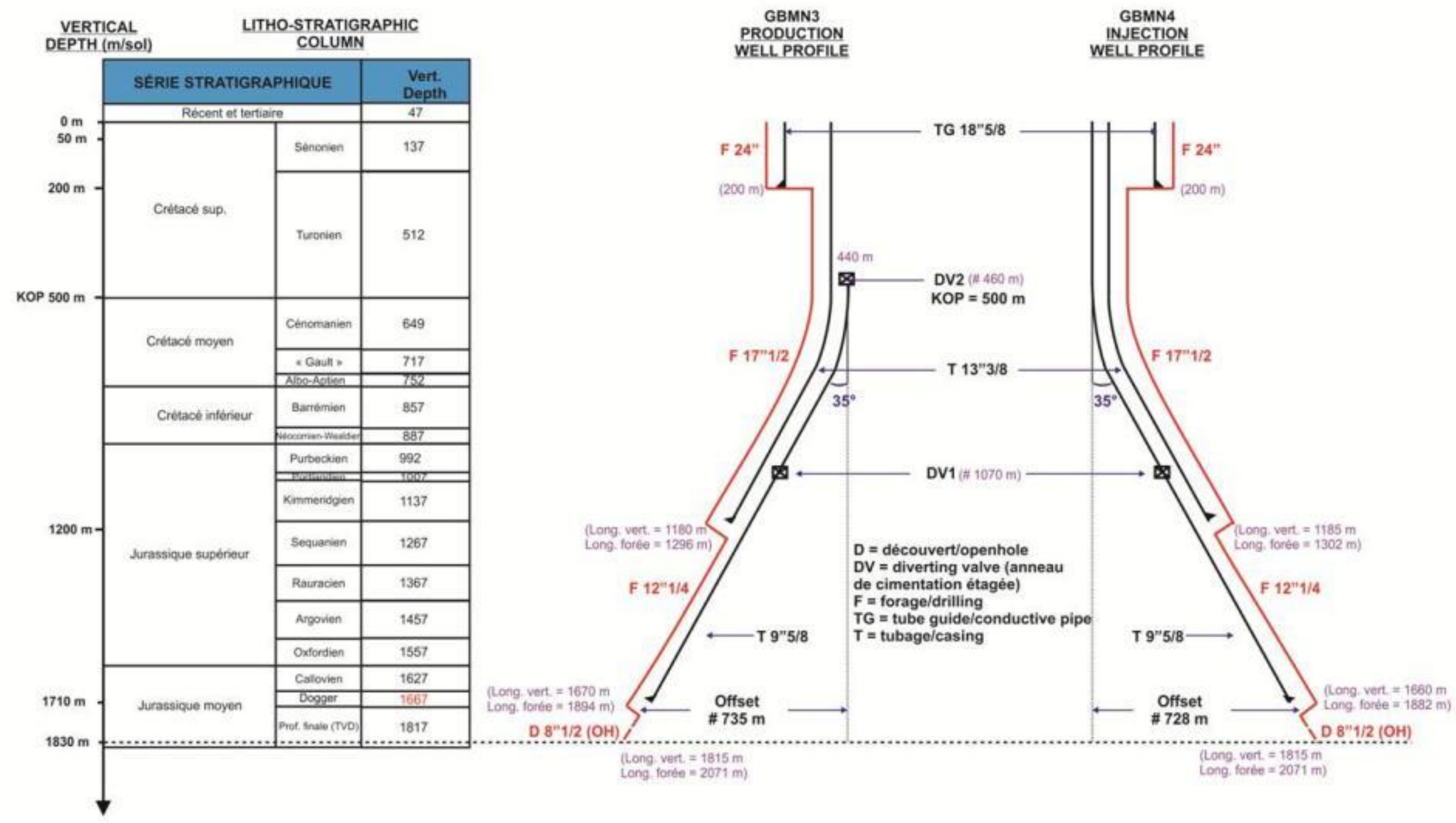
PARIS BASIN GDH SCHEME



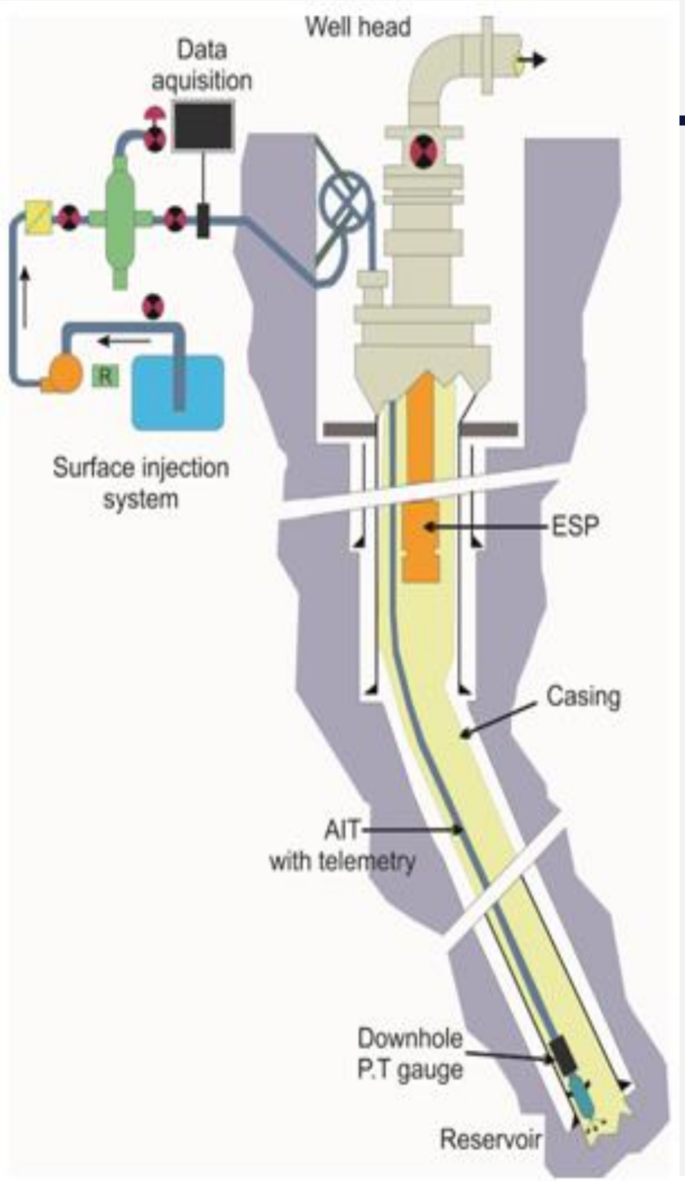
TYPICAL LOAD DURATION CURVE

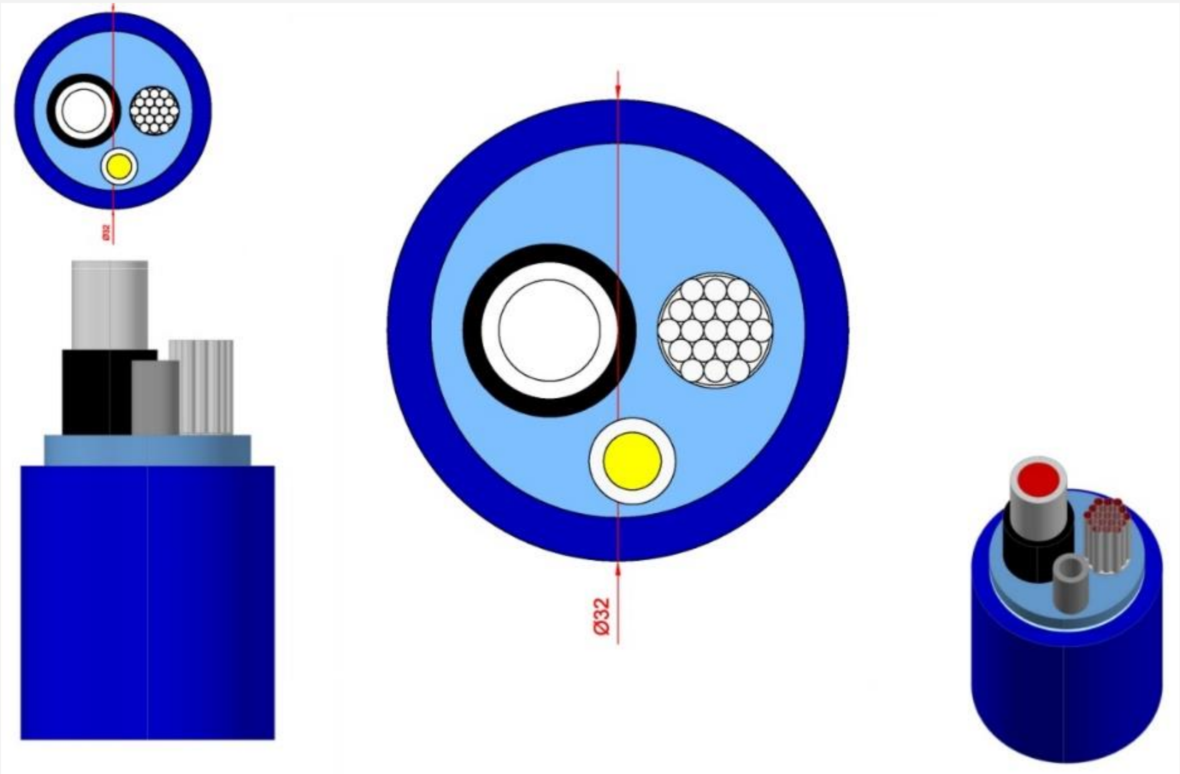


TYPICAL GDH WELL ARCHITECTURE

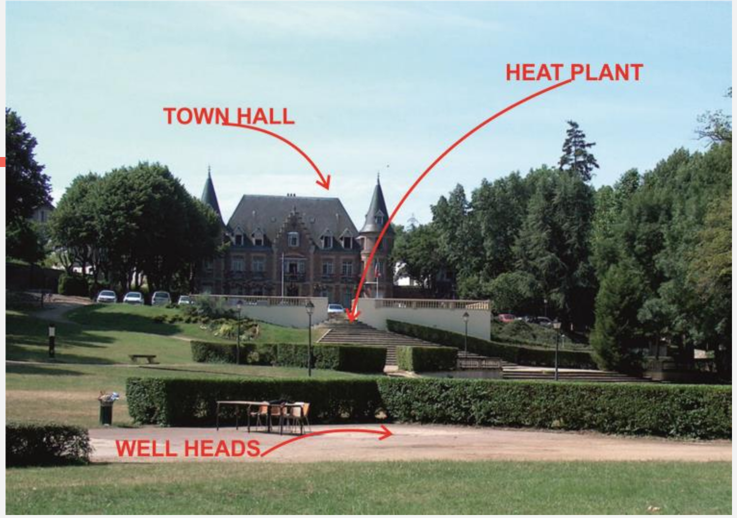


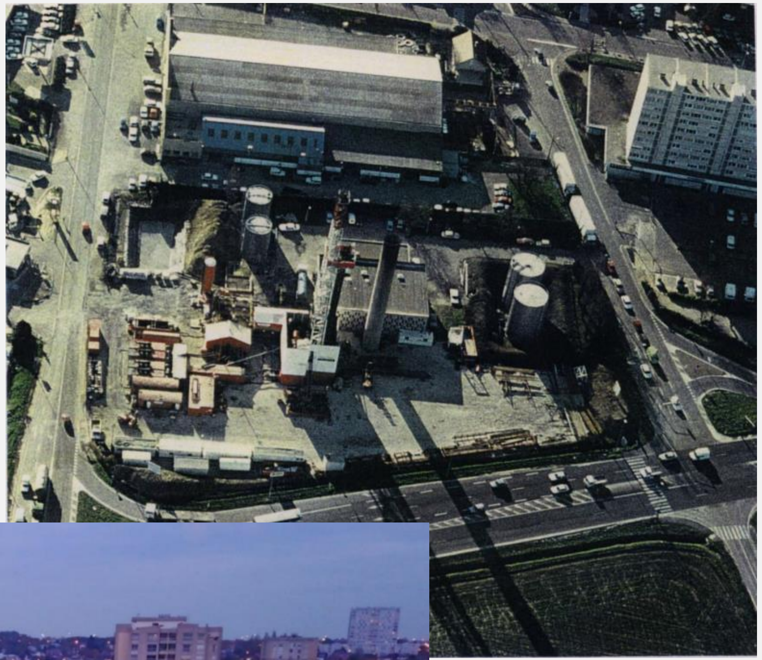
CORROSION AND SCALING ABATMENT. AUXILIARY INJECTION TUBING WITH FO



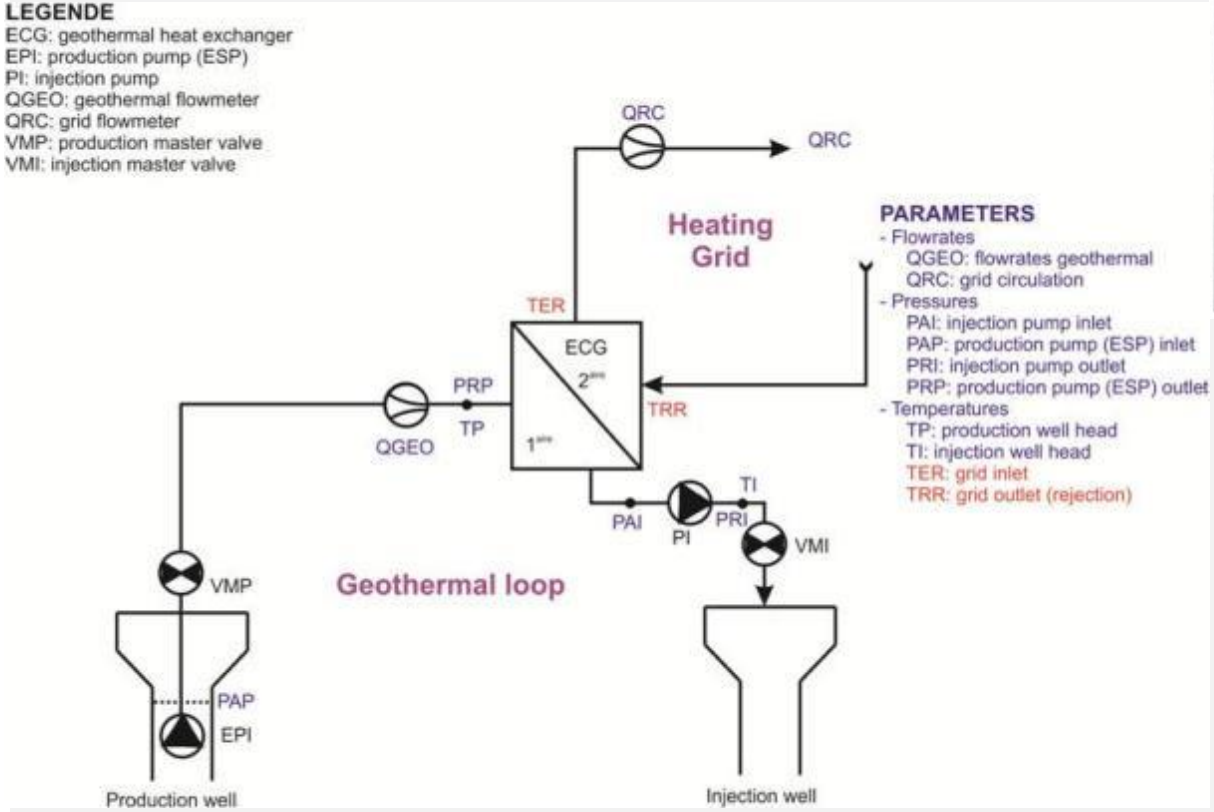


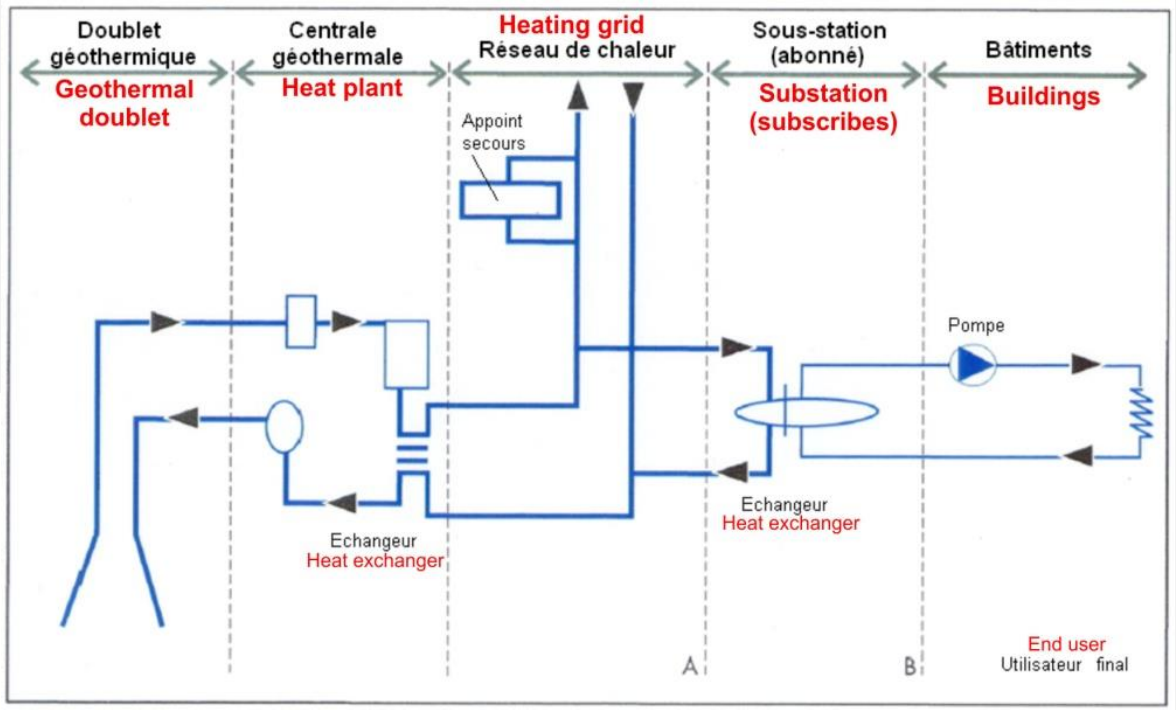
PARIS BASIN. TYPICAL GEOTHERMAL SITES



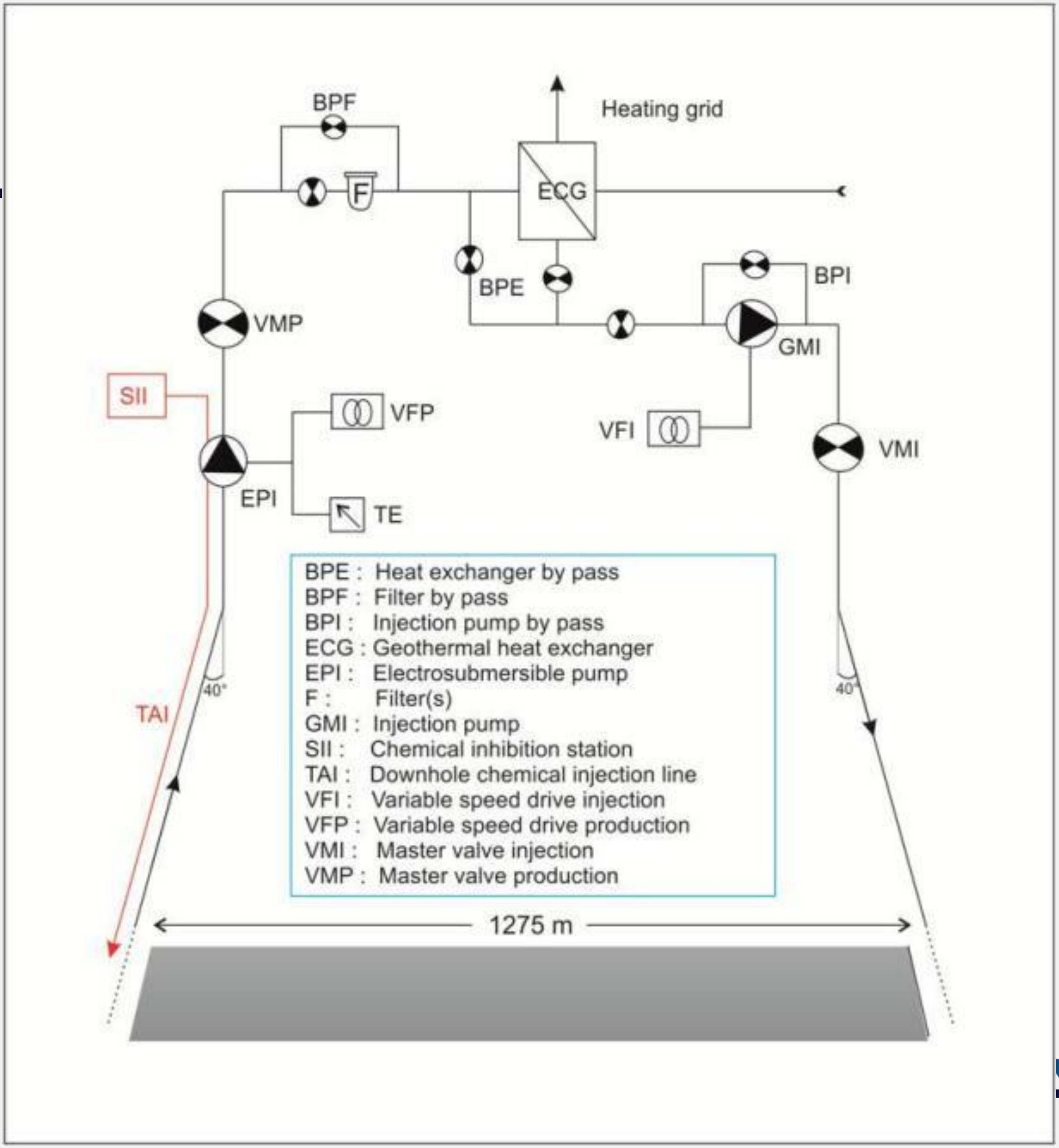


GDH DESIGN AND MONITORING

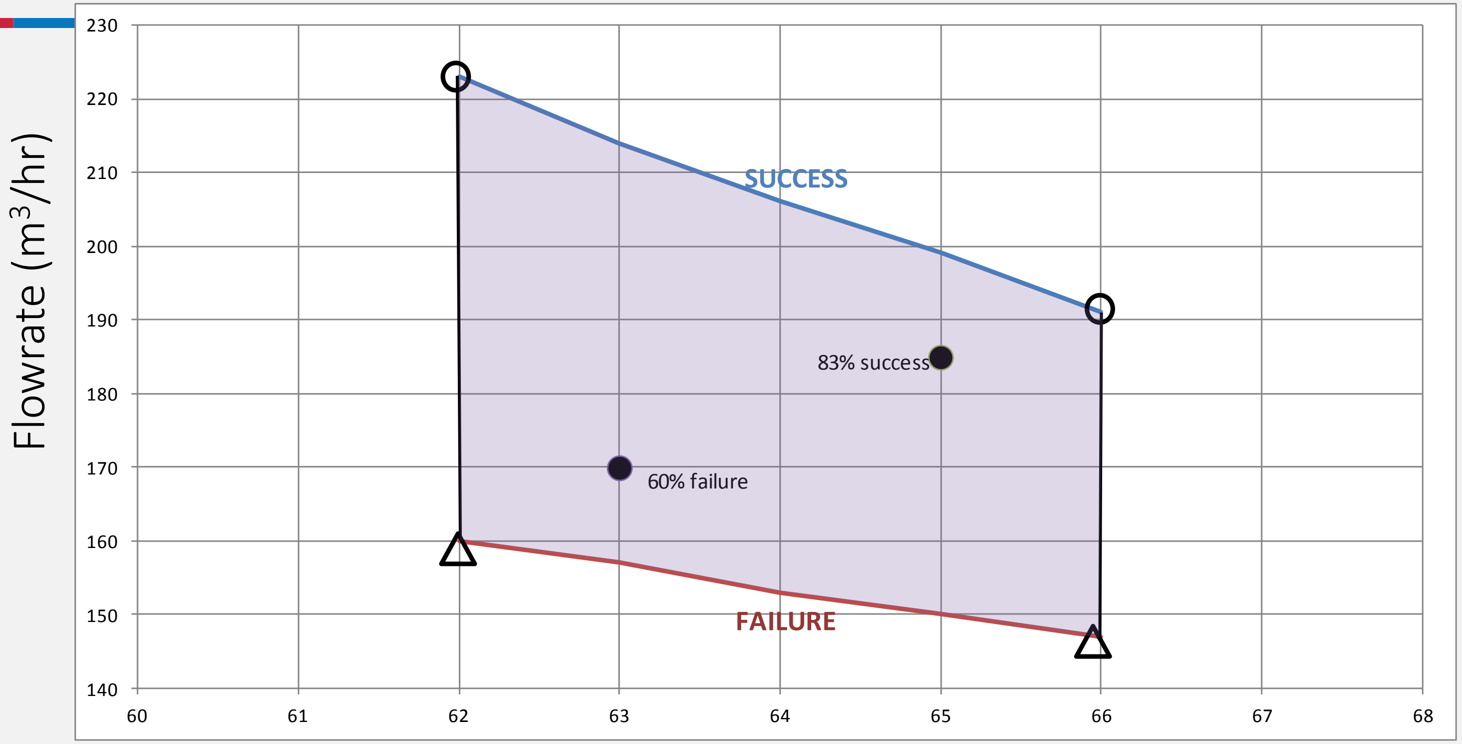




GEOTHERMAL LOOP DESIGN



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

TYPICAL COST BREAKDOWN (103 €)

CAPEX				OPEX		
Mining	min	max		**Mining**	min	max
Well drilling/completion	8500	9000		P1 Power, chemicals, consummables	200	250
Primary (geothermal) loop	1200	1300		P2 Monitoring, light maintenance	75	90
Geothermal heat exchanger	300	400		Heavy duty maintenance, well workover, on duty call	250	300
Total	10000	10700		Miscellaneous	30	50
				Total	555	690
Surface				**Surface**		
Secondary (grid) loop	600	700		P1 Power, chemicals	40	50
Heat plant	800	900		P2 Heat plant/grid monitoring/maintenance	400	450
Grid (piping)	8000	10000		P3 Provisions for depreciation	250	350
Grid (substations)	2500	3000		Miscellaneous	40	60
Total	11900	14600		Total	730	910
GRAND TOTAL	21900	25300		**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**

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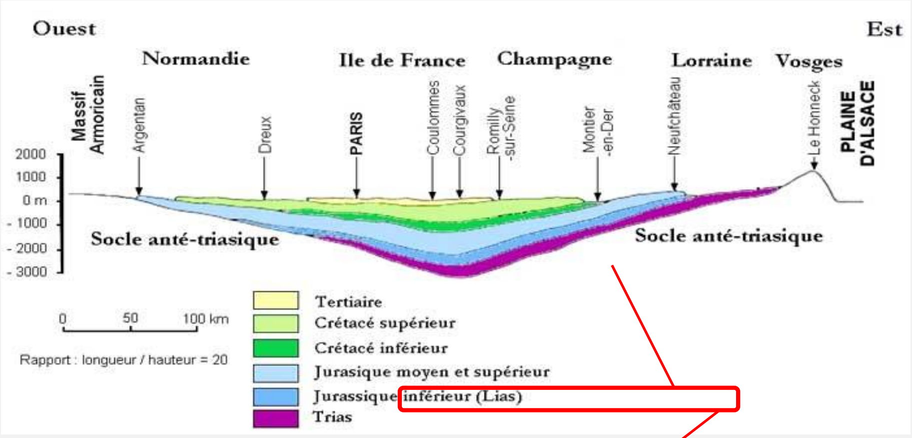
FROM COMMISSIONING TO START UP
TYPICAL GDH COMPLETION SCHEDULE

Nom de la tâche	Début	Fin
START	Lun 01/11/10	Ven 26/11/10
Project Commissioning	Lun 01/11/10	Ven 21/01/11
Feasibility study	Mar 01/02/11	Lun 07/11/11
Exploration permit	Ven 01/07/11	Jeu 03/05/12
Land acquisition	Mar 01/11/11	Lun 28/11/11
Budget setup	Jeu 01/12/11	Ven 27/01/12
Negotiation of EUR/National support	Mer 01/02/12	Mar 22/05/12
Call for tenders (TOR)	Mer 01/02/12	Mar 22/05/12
Tendering	Ven 01/06/12	Jeu 07/03/13
Site preparation. Well drilling/completion	Ven 01/11/13	Lun 30/03/15
Surface works. Heating grid & substations	Ven 01/11/13	Jeu 19/02/15
Geothermal & Back-up/relief heat plant	Mar 01/04/14	Mar 30/06/15
Start up	Mer 01/07/15	Ven 31/07/15

INNOVATION: SUBHORIZONTAL WELL ARCHITECTURES

WEAST EAST CROSS SECTION

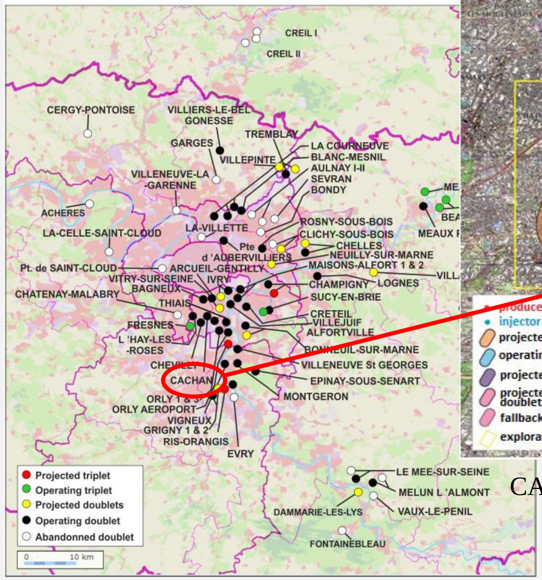


The Dogger (Bathonian member) target reservoir is hosted by the Upper part of the carbonate platform.

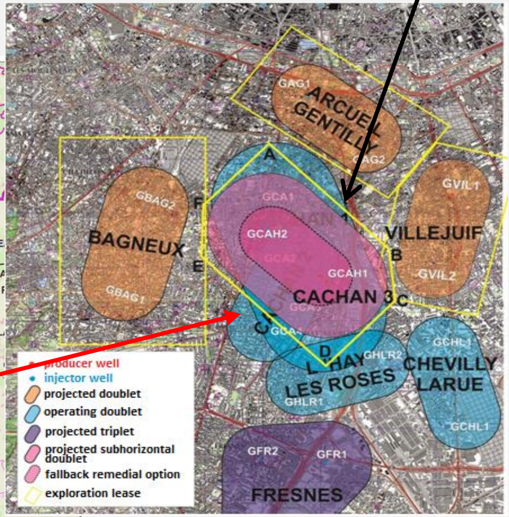
Within the platform oolithic limestone sequences exhibit high connected porosities and related permeabilities portraying a dependable multilayered reservoir structure.

LOCATION

Target area



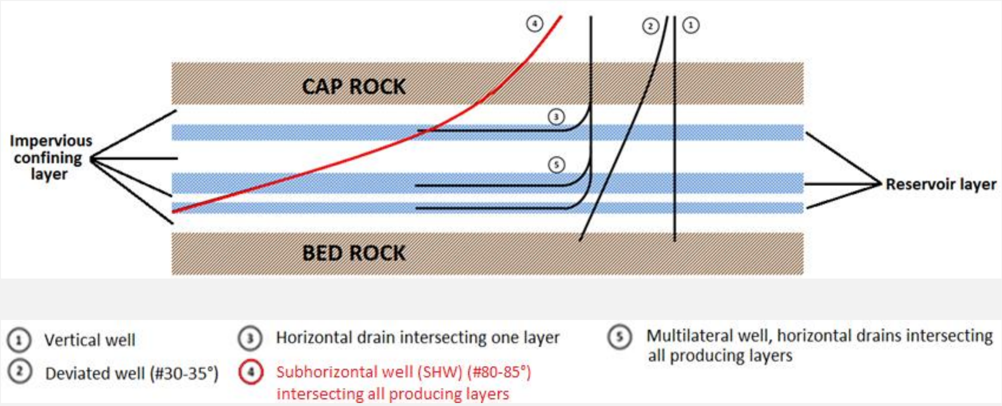
PARIS BASIN GEOTHERMAL DISTRICT HEATING (GDH) STATUS



CACHAN SITE AND SURROUNDING DH DOUBLETS/TRIPLET

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

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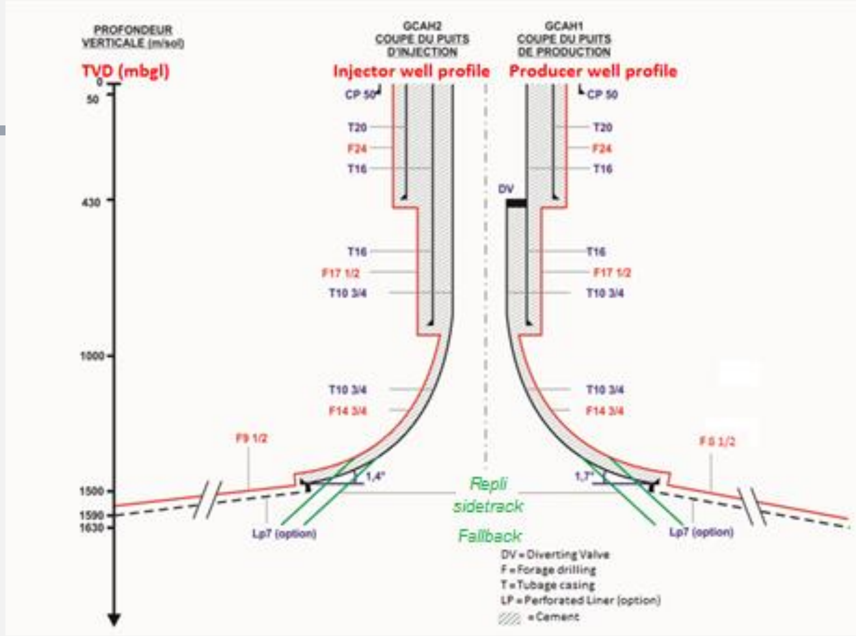
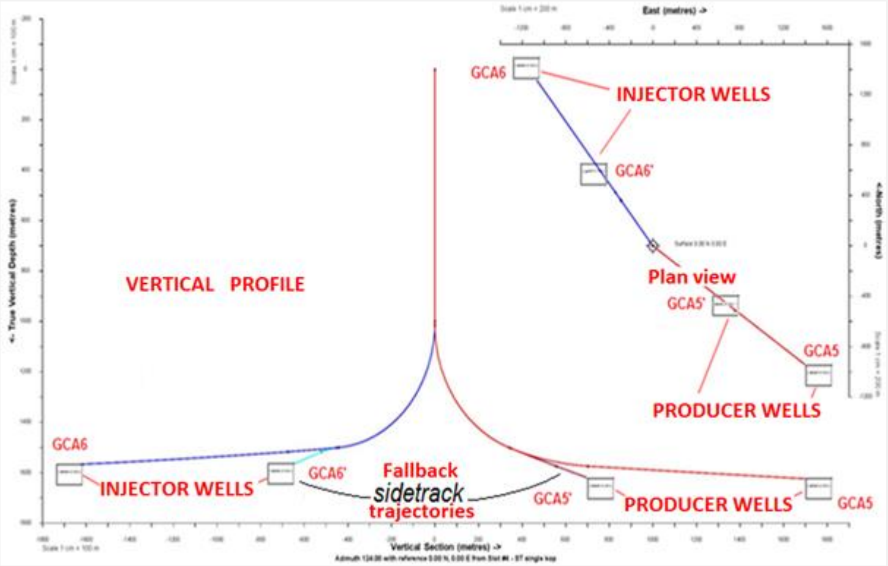
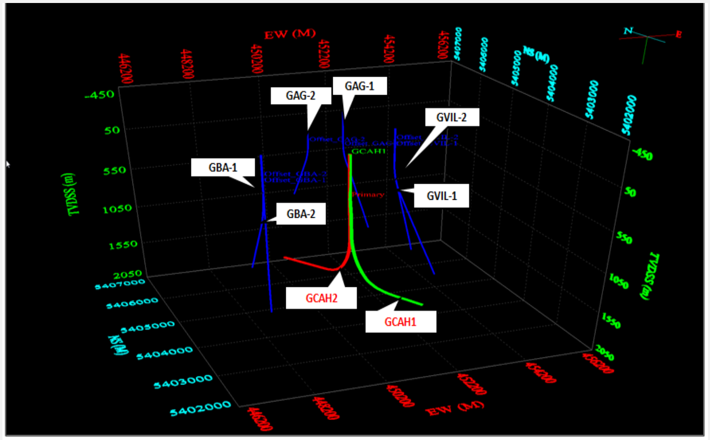
SHW DOUBLET ARCHITECTURE AND OFFSET WELL TRAJECTORIES



a) Well architectures

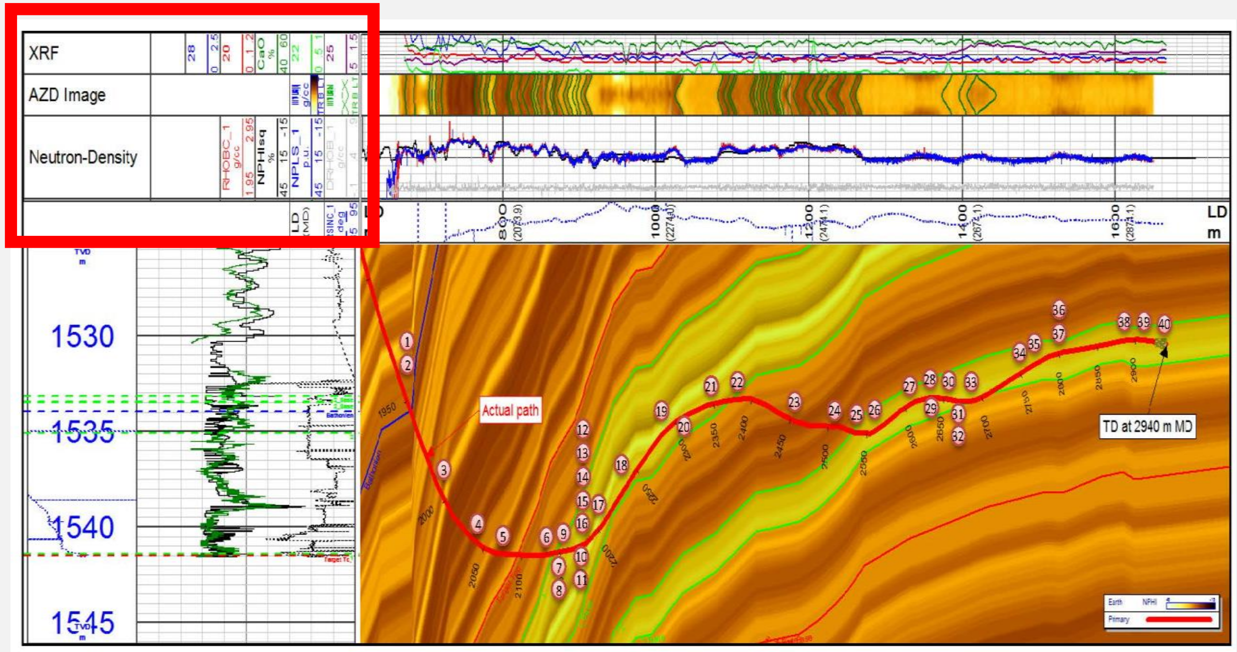


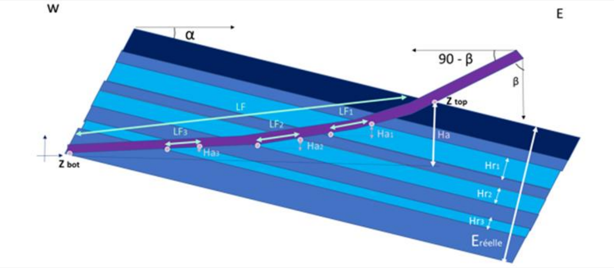
b) Well trajectories



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

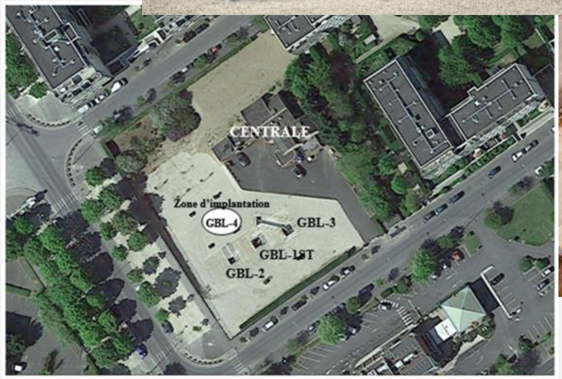
=> Well architecture similar to GCAH1 which intercepts all layers over large lenghts

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

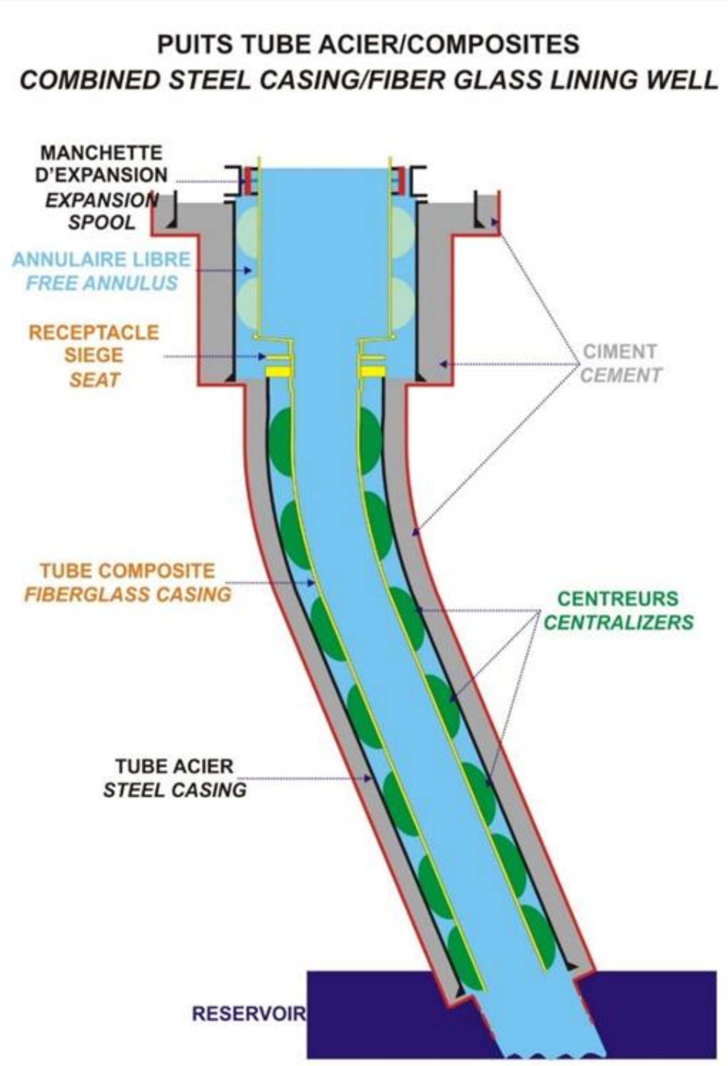
Present well architecture addresses an artificial lift, pump sustained, production, which implied significant design modifications, chiefly:
(i) an upper, wider (13"3/8OD -11.97” ID) liner section acting as a pumping chamber, sized to accommodate a 500 HP rated ESP, placed under compression between the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

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

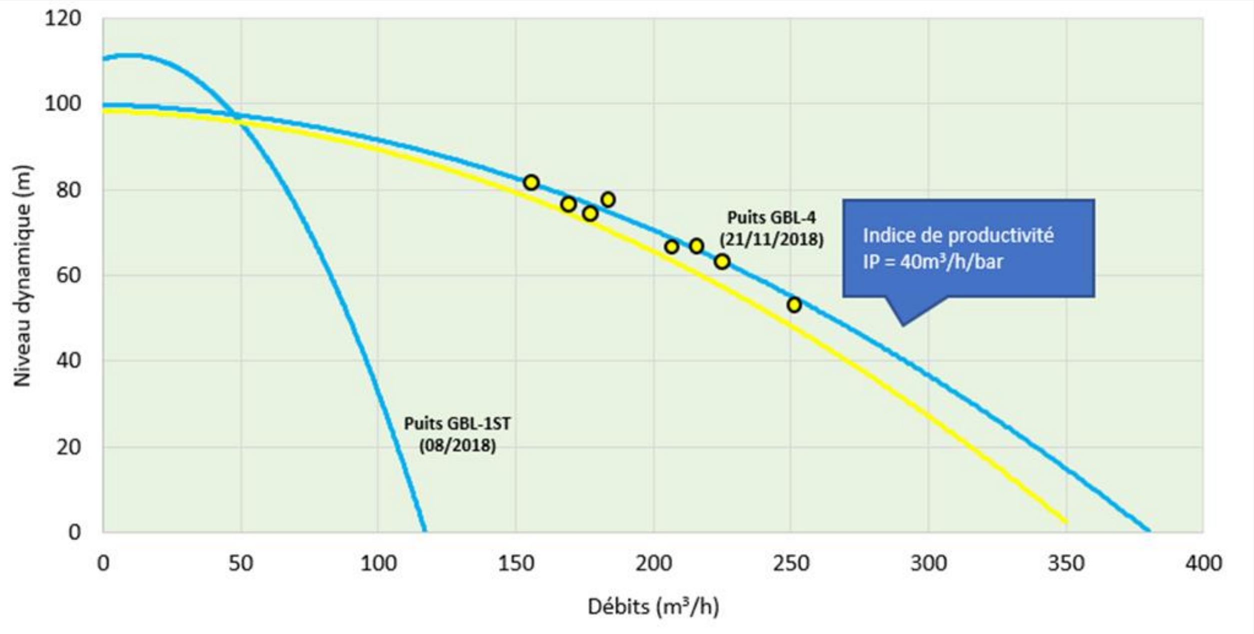
(iii) a (13"3/8x9"5/8) liner connecting system, placed at the (20"x13"3/8) casing interface, allowing for a free annular fluid (a make-up corrosion inhibitor agent) passage, indeed a key issue, and,

(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.



ANTICORROSION WELL CONCEPT. IMPLEMENTATION AND RESULTS



THANK YOU FOR YOUR ATTENTION