

Hydrogeologie · Geothermie



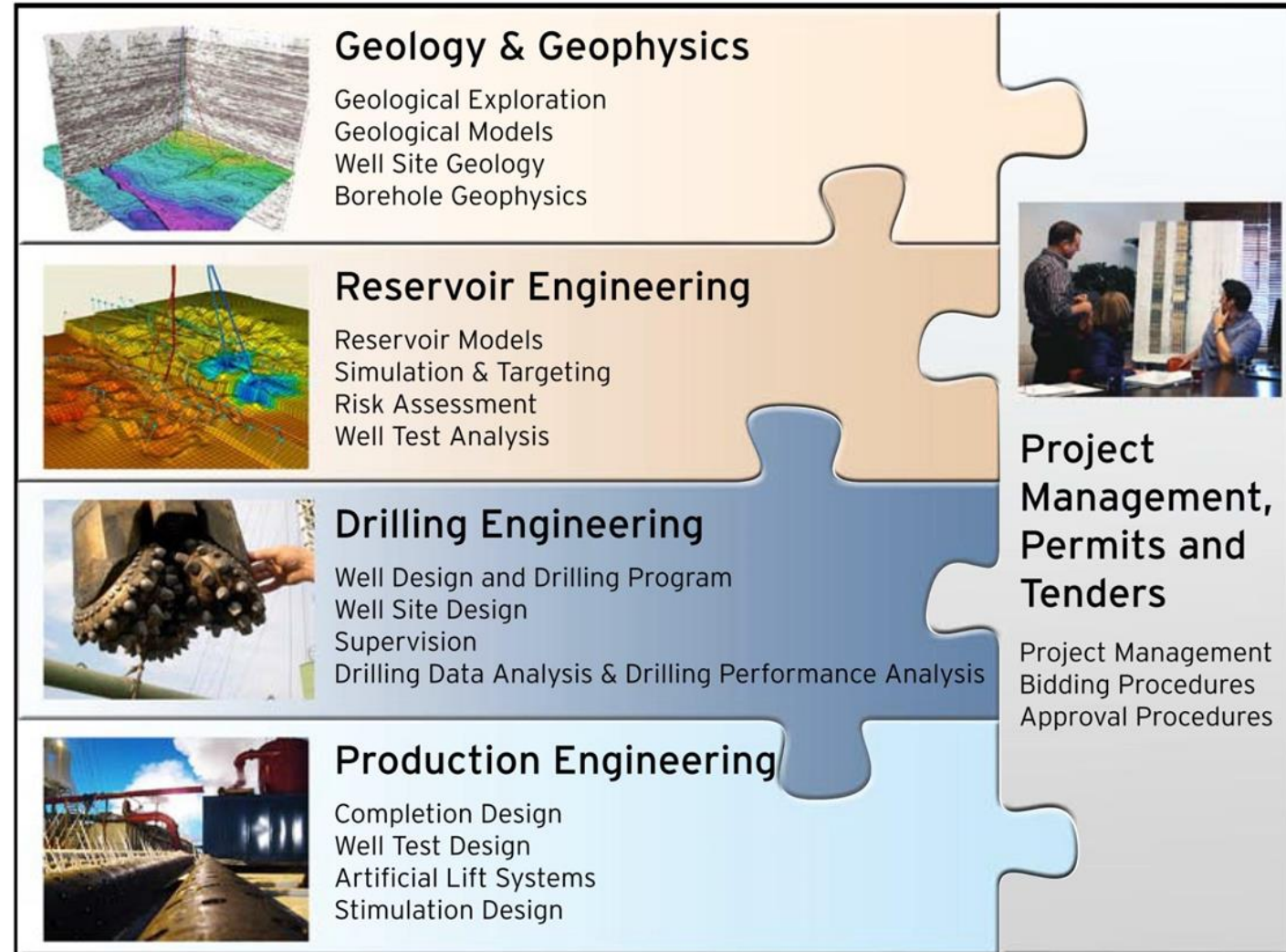
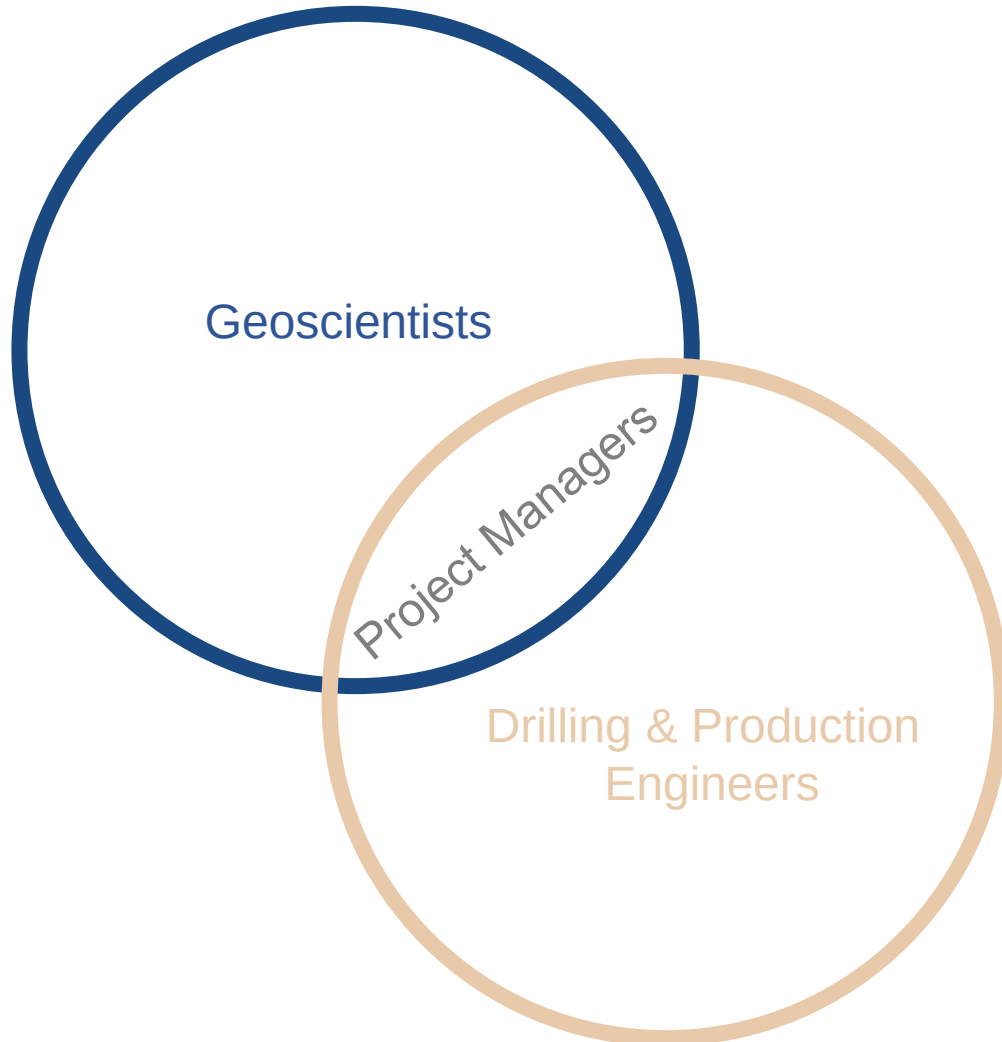
**Geothermal
Association
of Ireland**

From Vision to Reality: Unlocking the Geothermal Potential

Neil Farquharson
ERDWERK GmbH

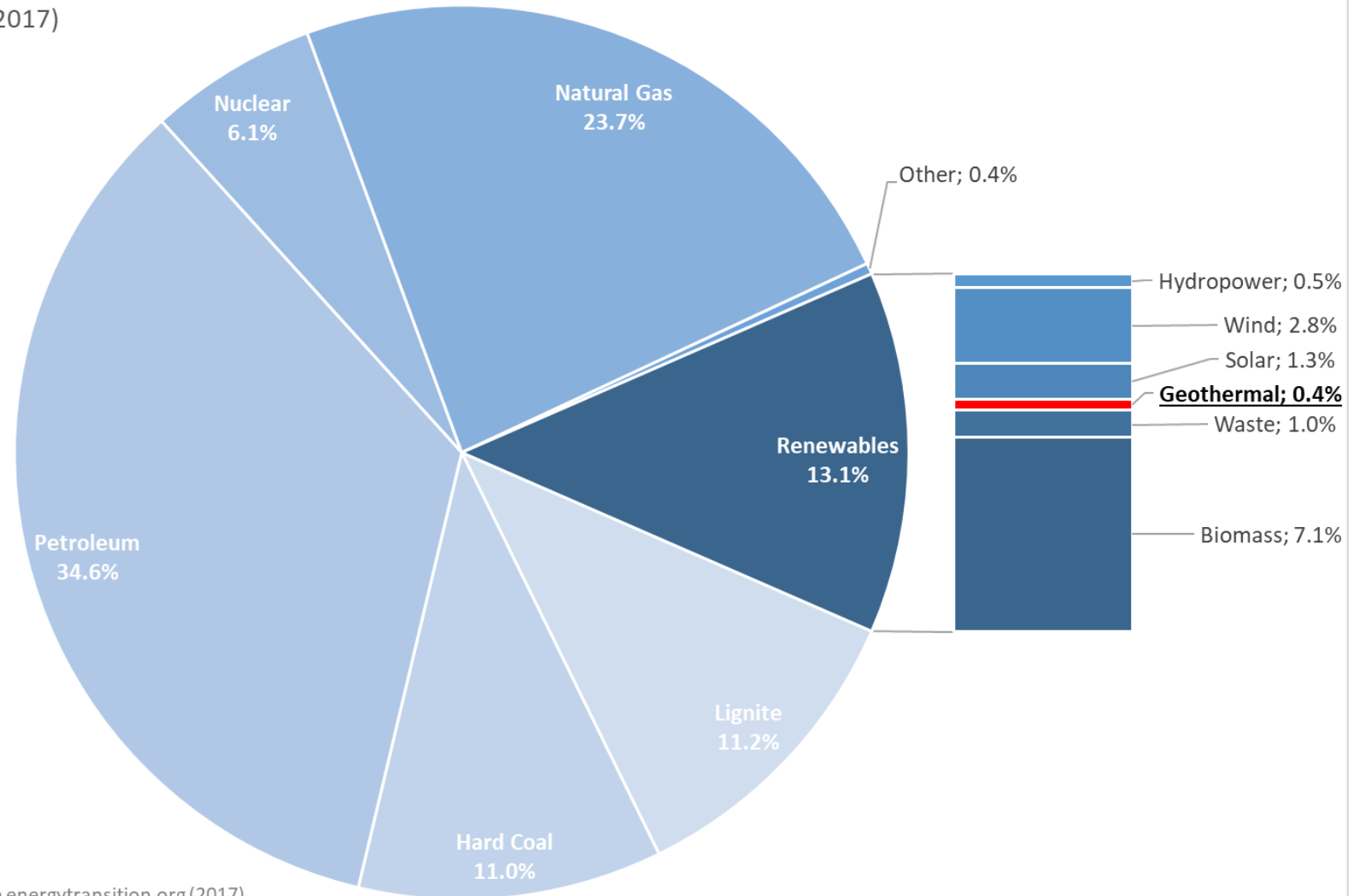
- ❖ Geothermal Development in Bavaria – Brief Overview
- ❖ Reasons for Success
- ❖ The Future
- ❖ Template for further Regions and Cities?

Introduction

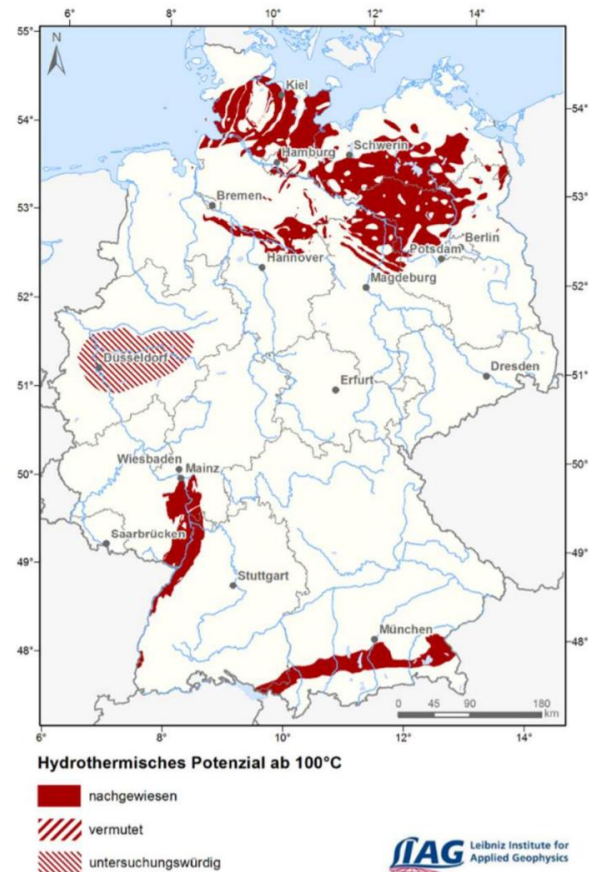


Geothermal Development in Bavaria – Brief Overview

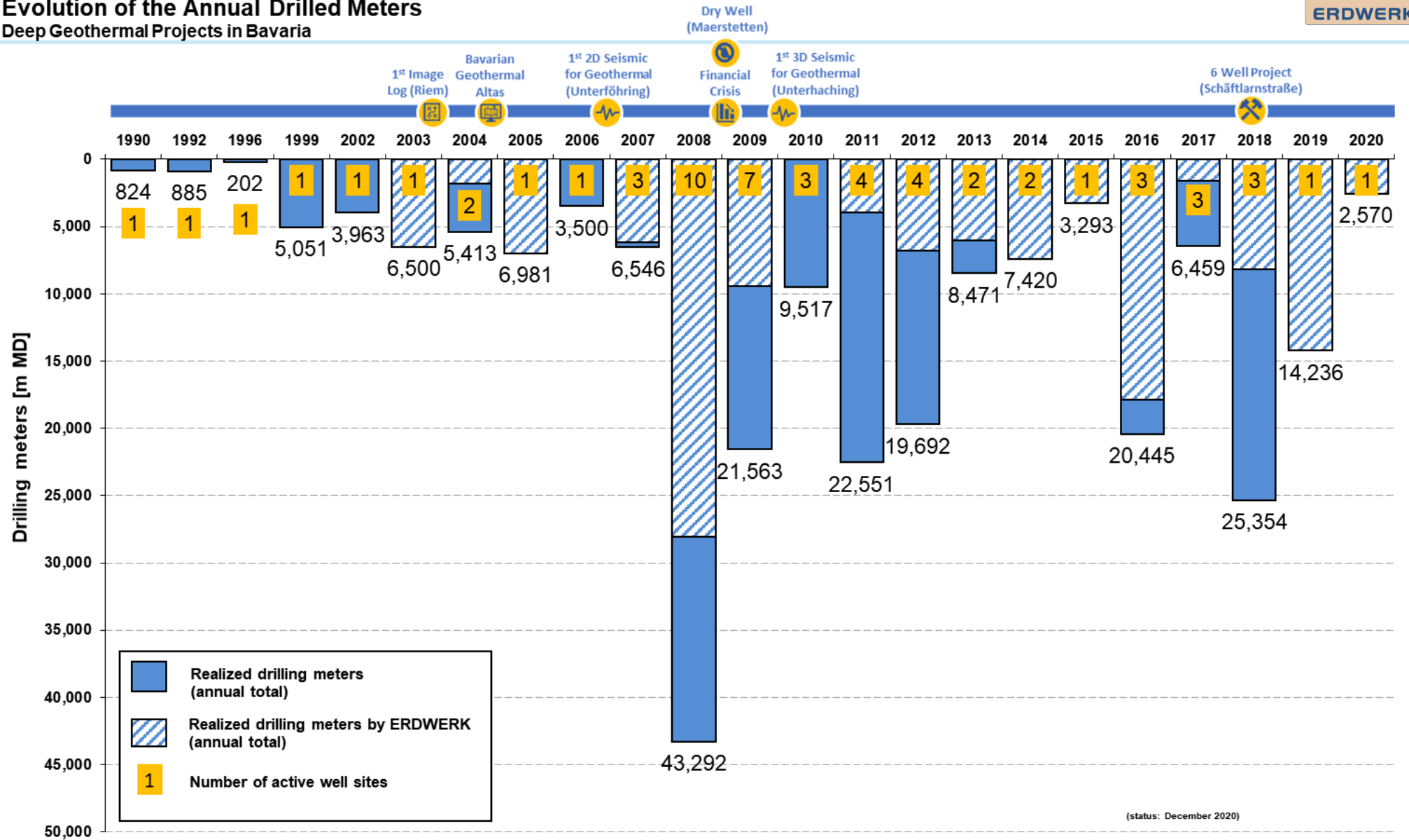
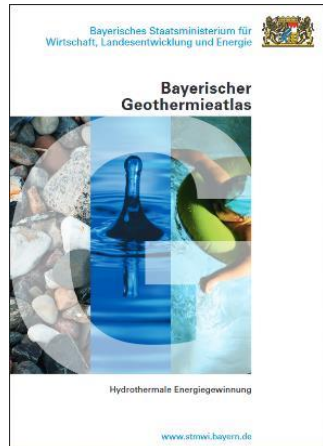
Primary Consumption Energy Mix
Germany (2017)



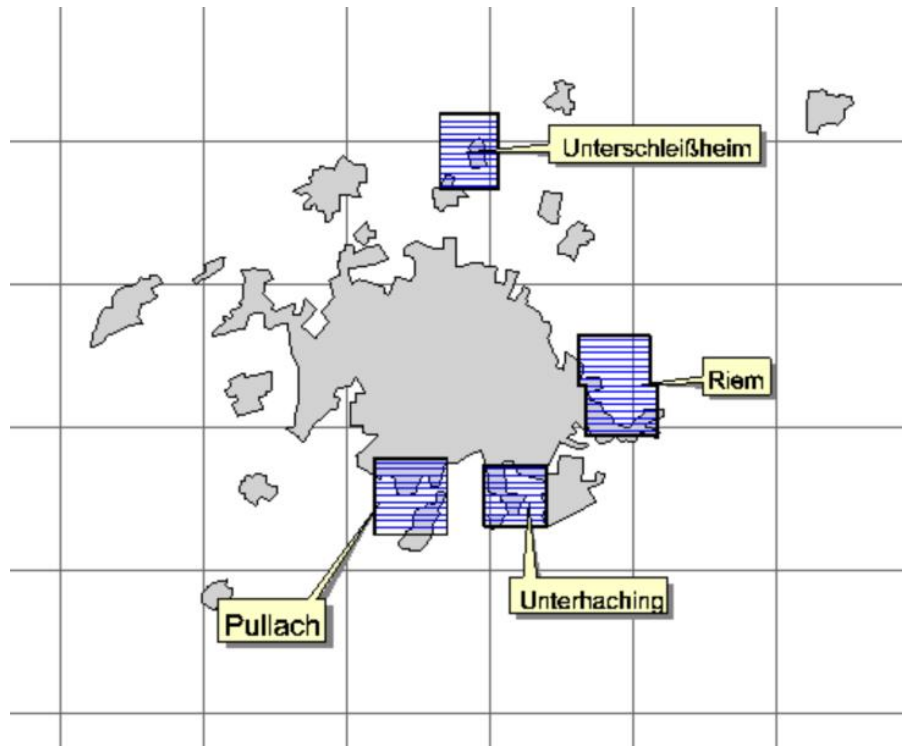
Adapted from energytransition.org (2017)



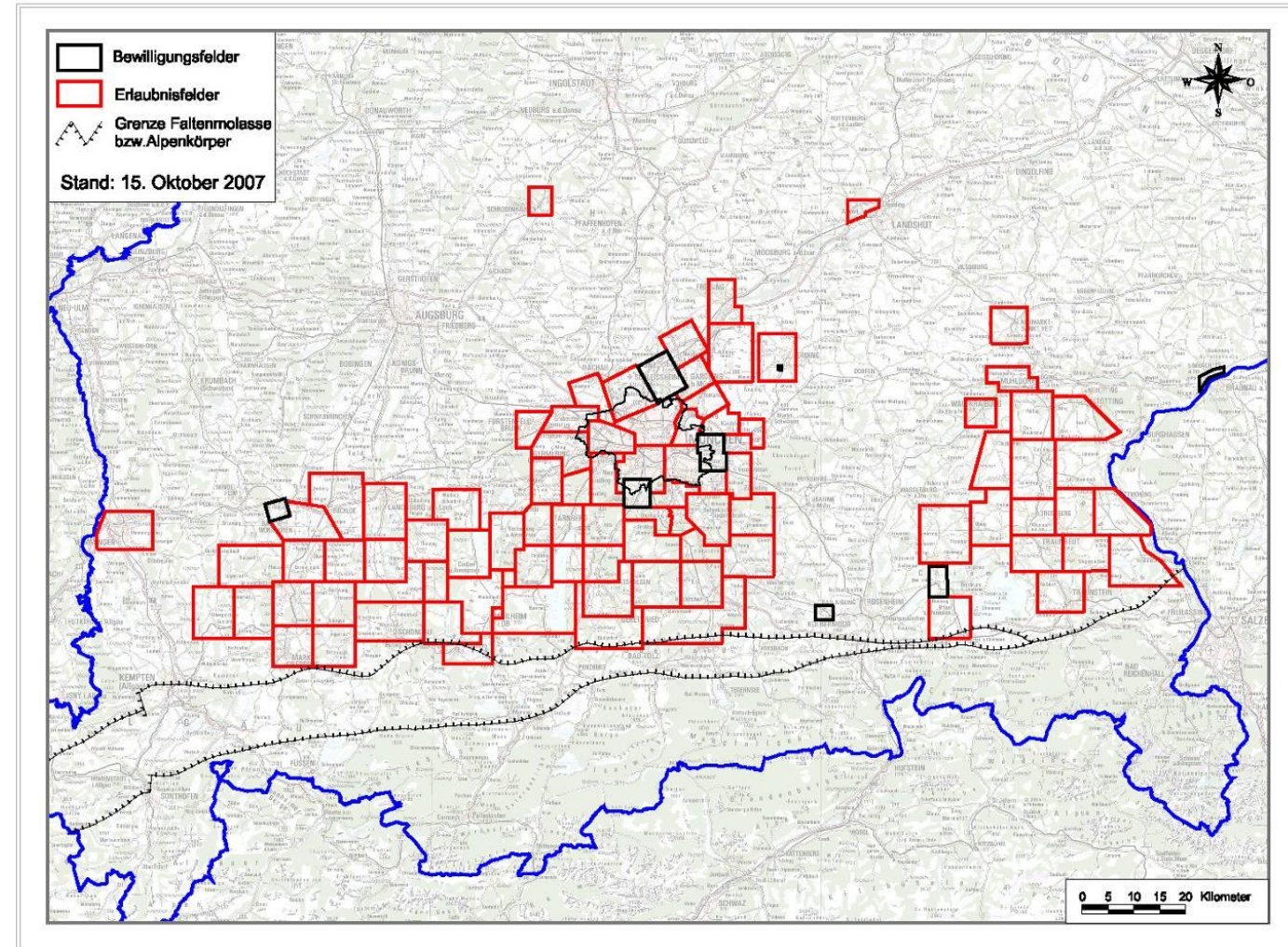
Evolution of the Annual Drilled Meters Deep Geothermal Projects in Bavaria



Geothermal Development in Bavaria – Brief Overview



2002



2007

Geothermal Development in Bavaria – Brief Overview



Geothermal Concession Fields

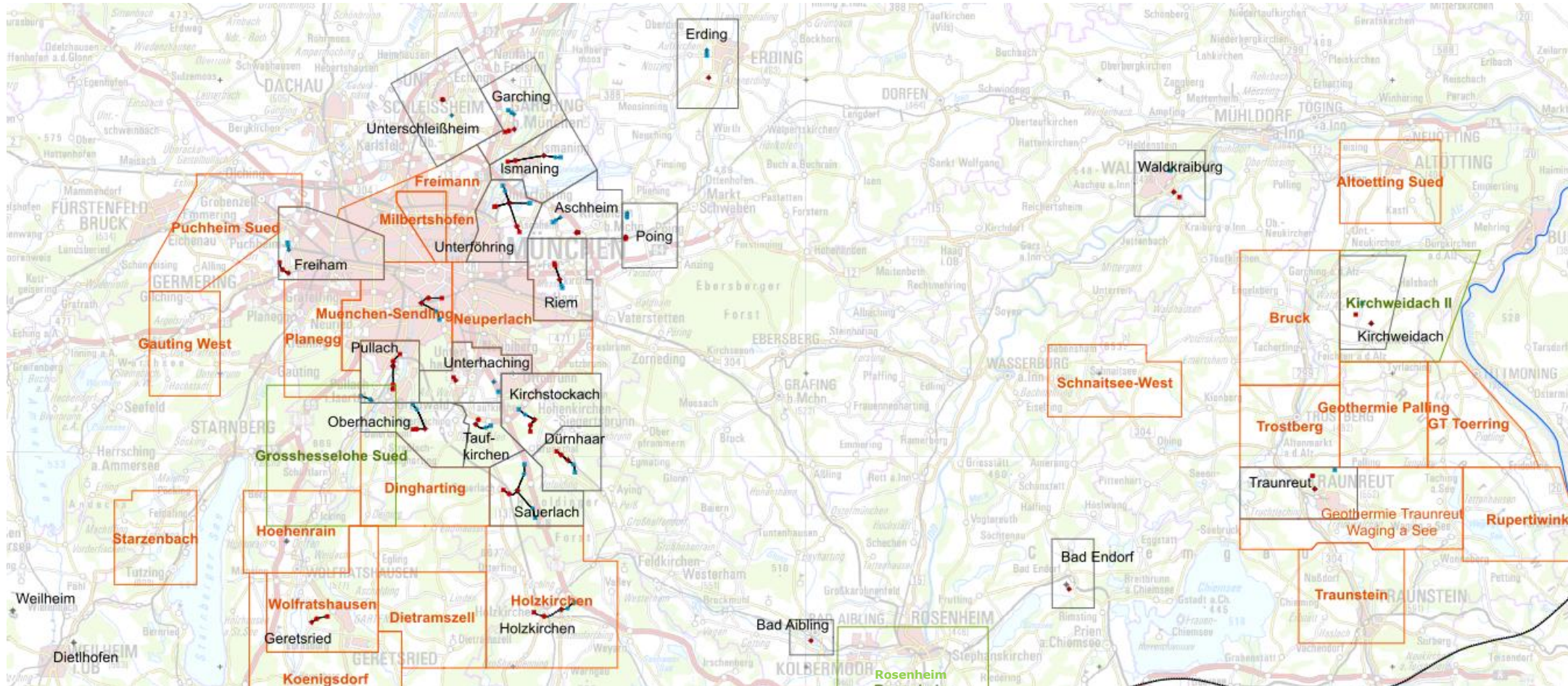
- Production Permit
- Exploration Permit
- Large-Scale Permit

Geothermal Wells

- ◆ Production Well
- ◆ Injection Well

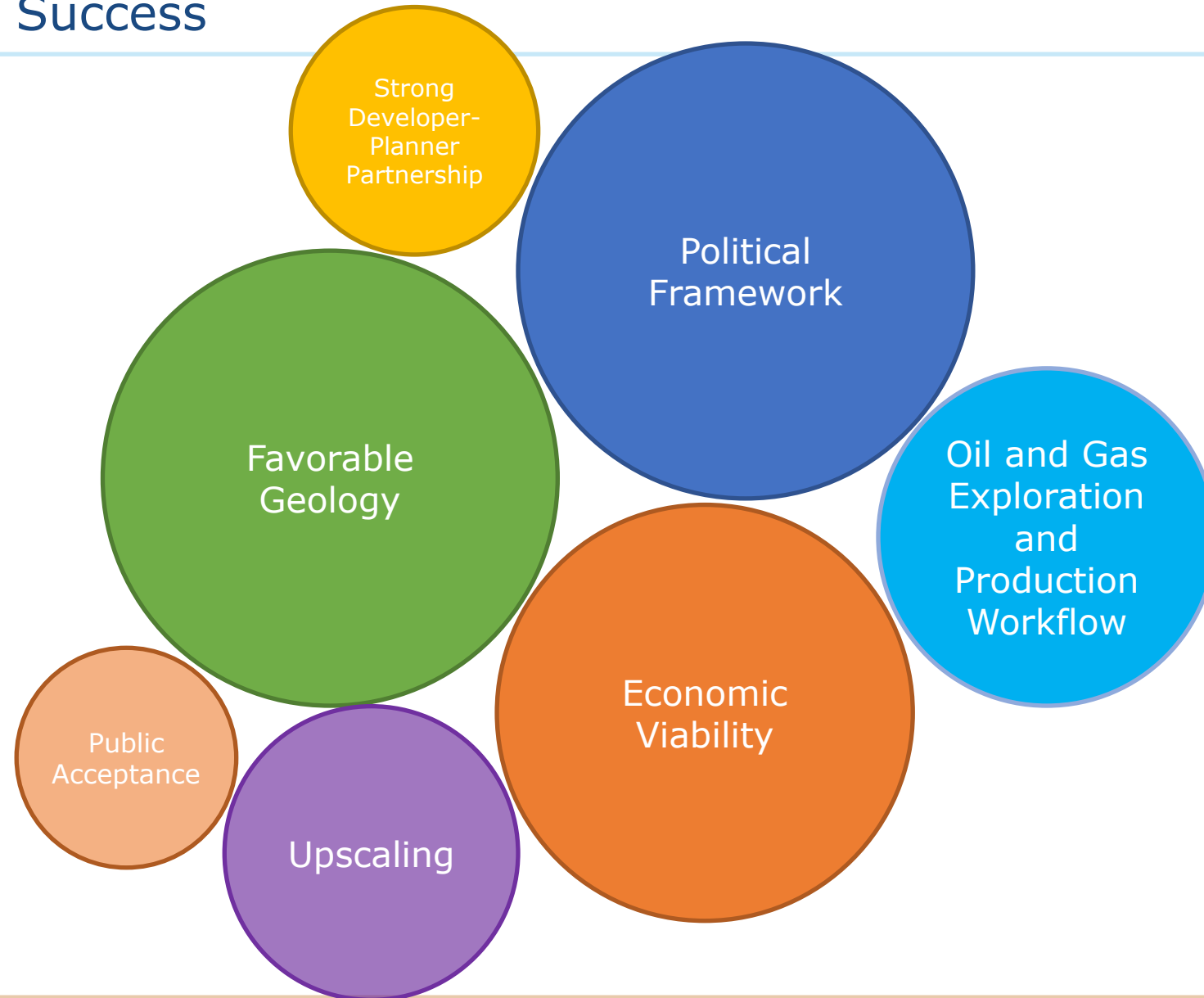
Development of the Concessions Fields in Bavaria

Year	Concessions
2002	4
2004	>40
2013	>80
heute	ca. 50

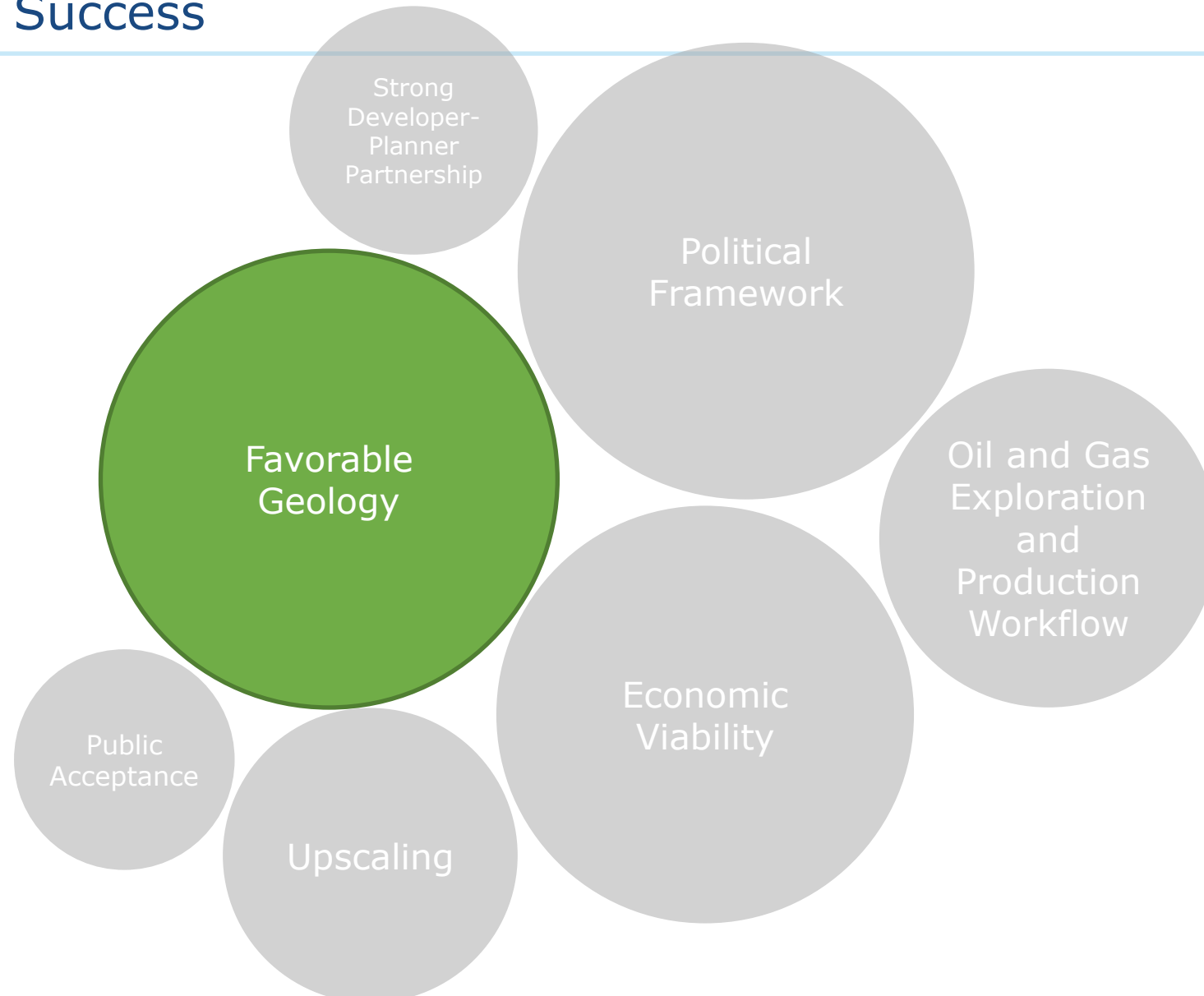


Stand: 02/2019

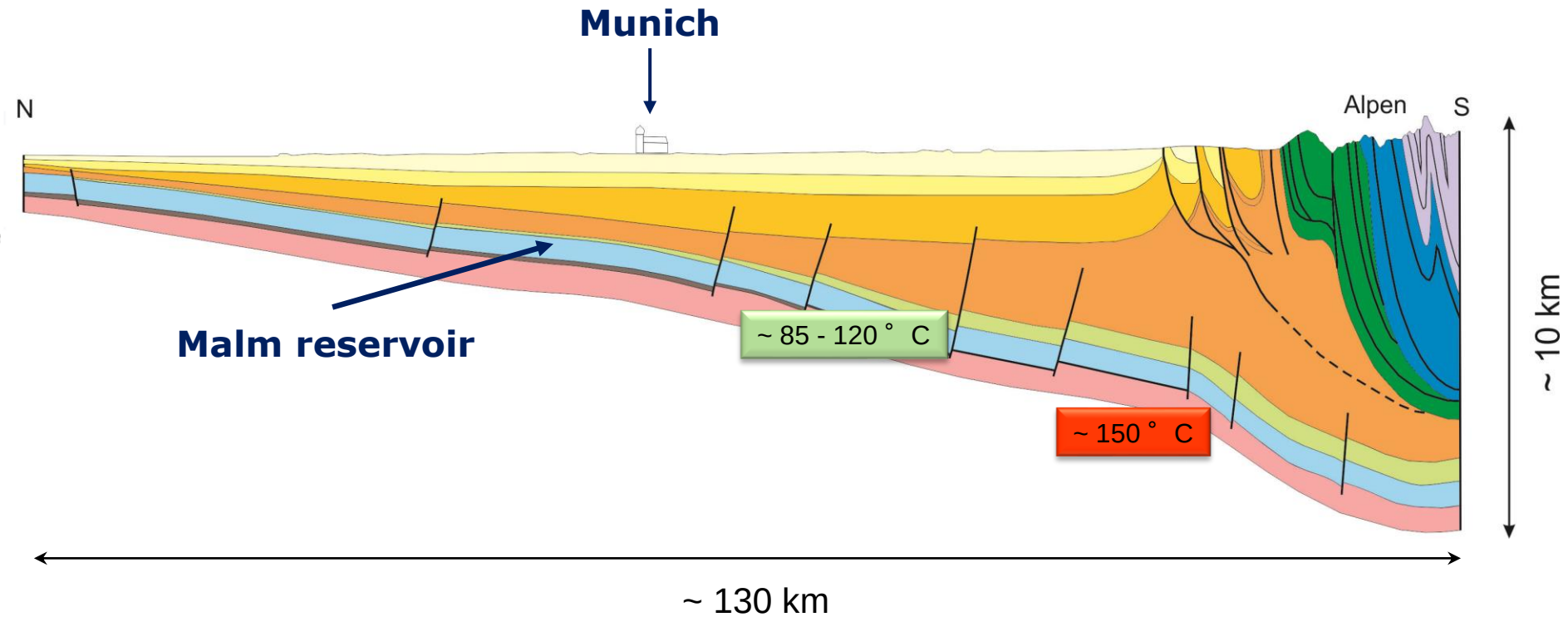
Reasons for Success



Reasons for Success

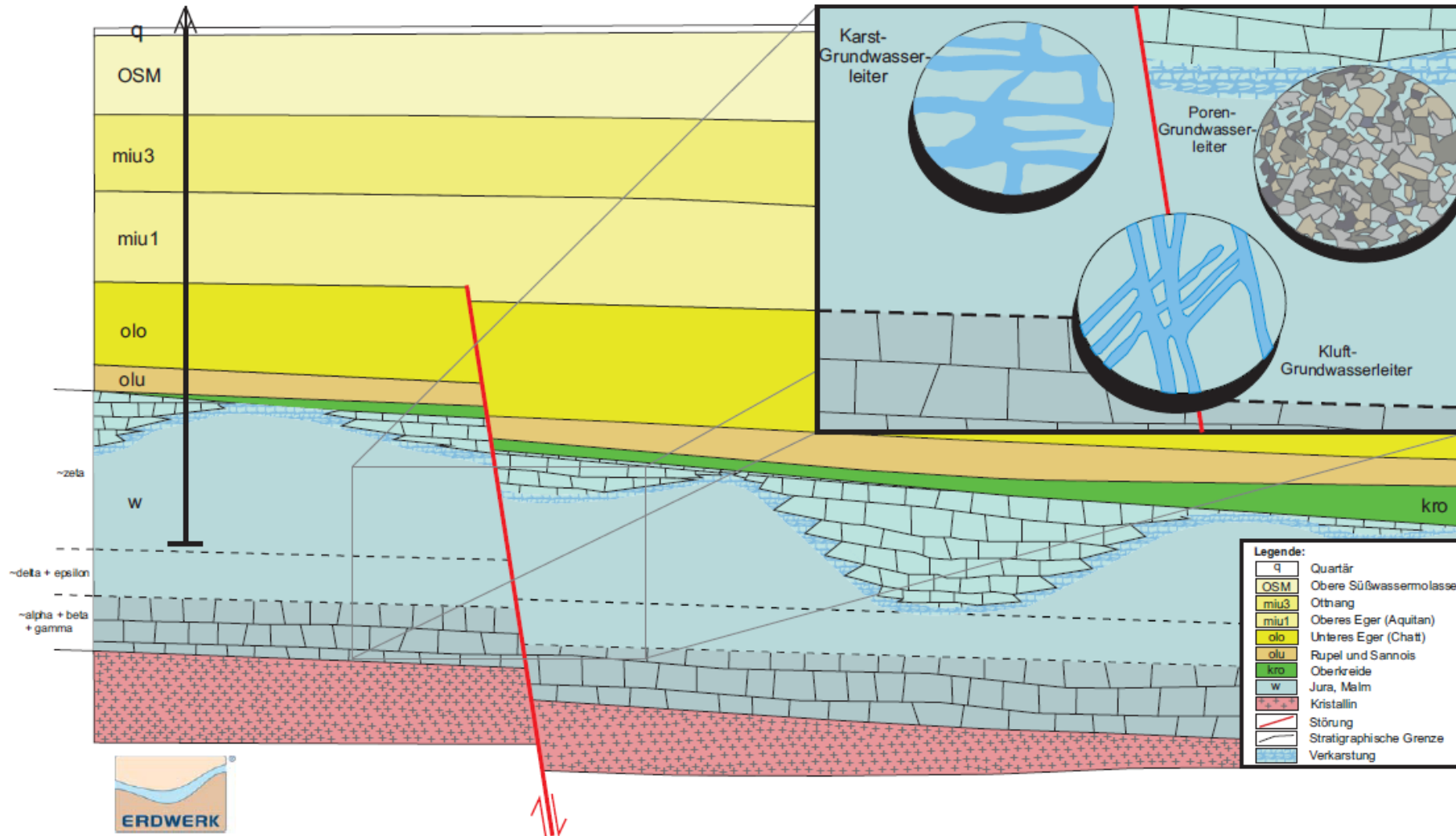


Reasons for Success: Favourable Geology

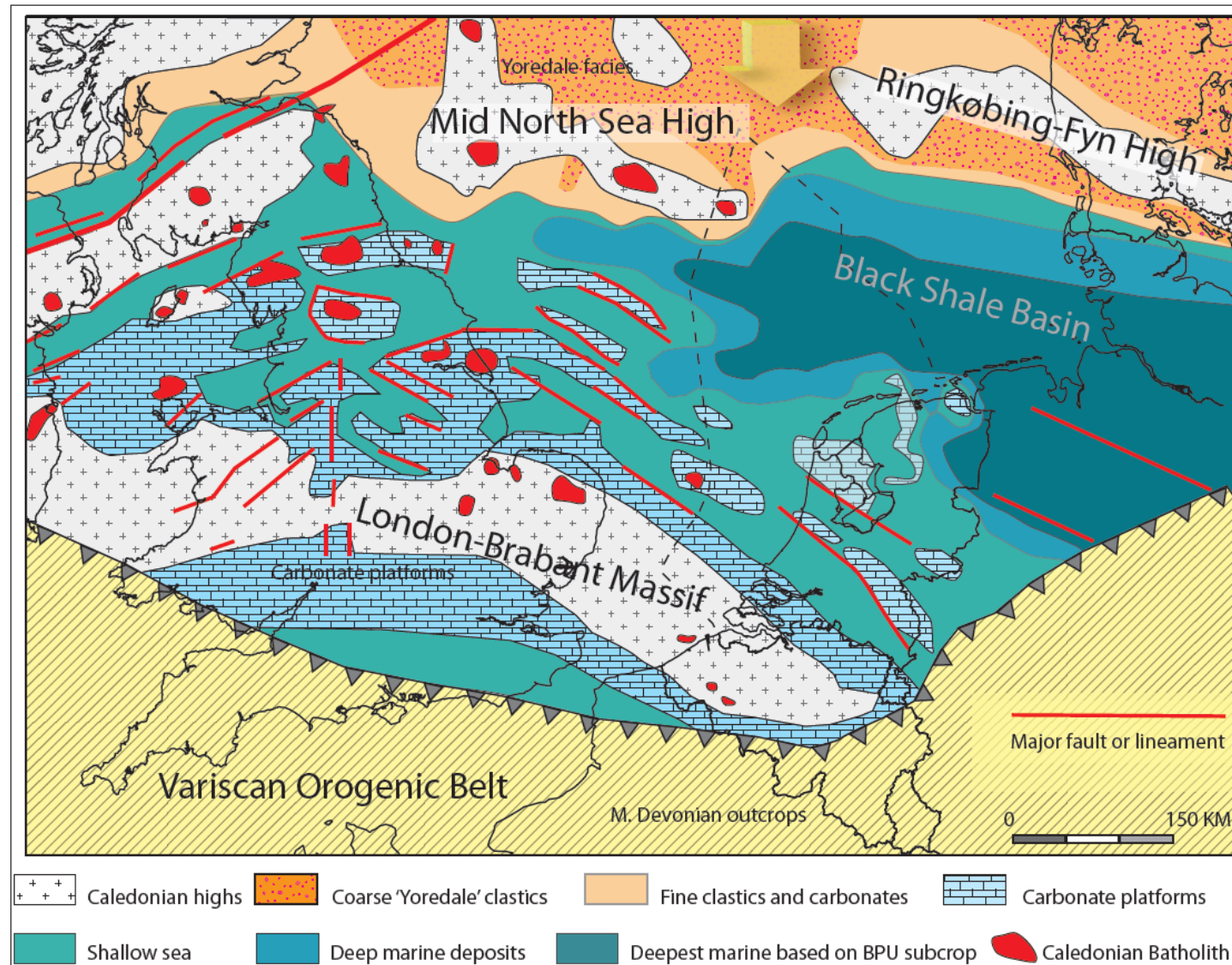


After: „Geologische Karte von Bayern 1:50000“, Bayerisches Geologisches Landesamt, 1996

Reasons for Success: Favourable Geology



Reasons for Success: Favourable Geology

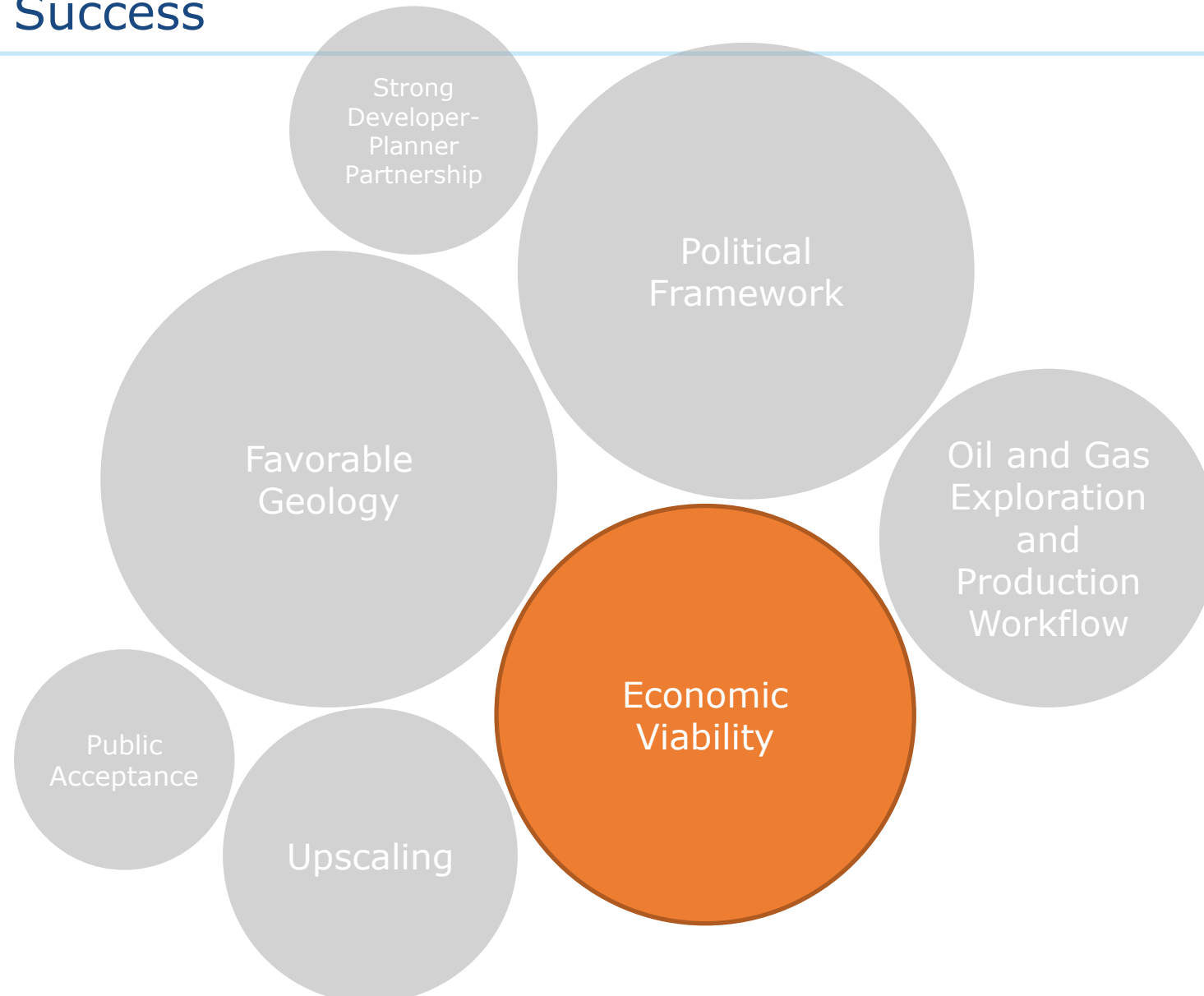


van Hulten et al. (2012)

Reasons for Success: Favourable Geology

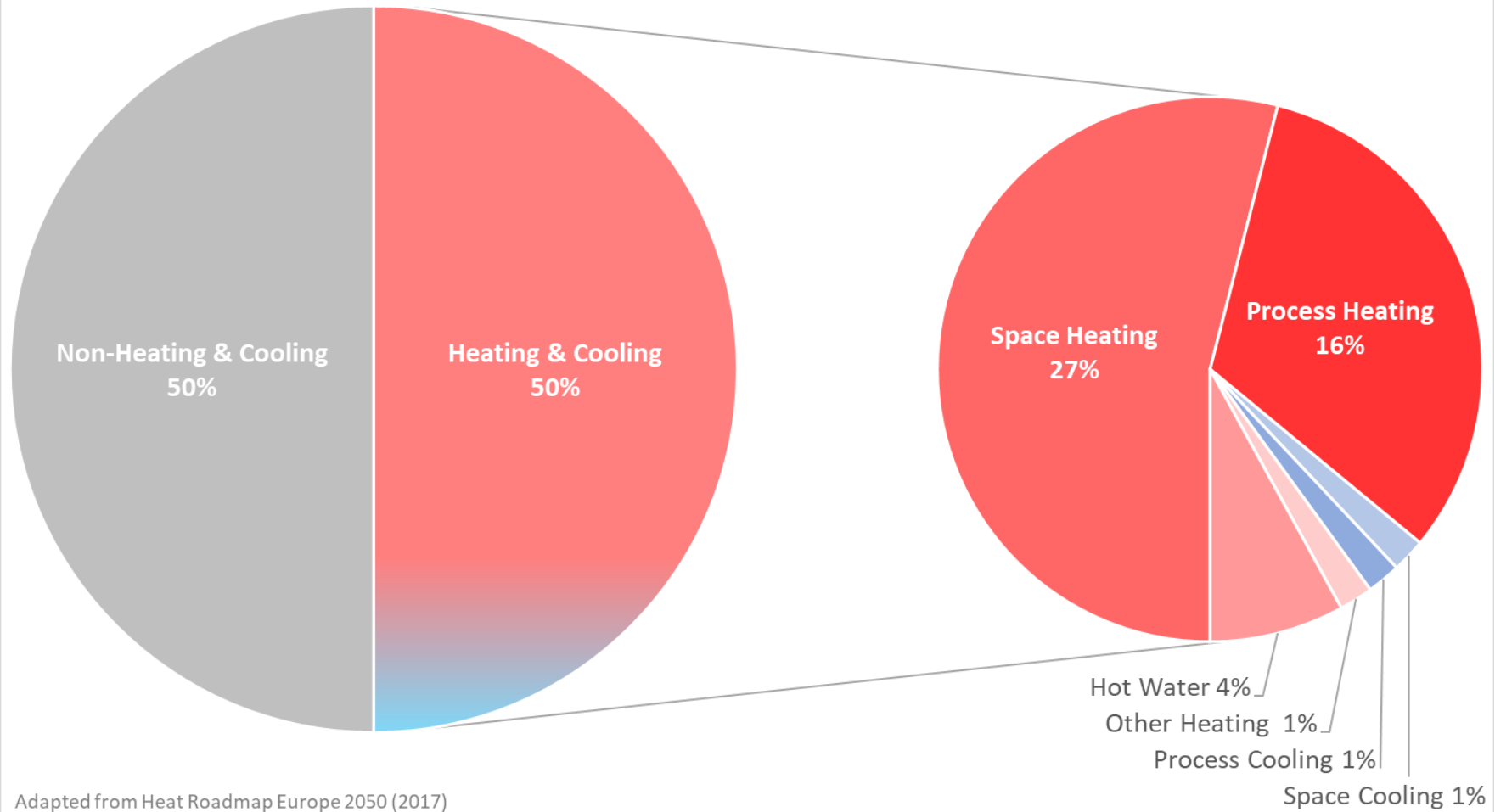
	Dinantian	Malm	+/-
Age	c. 300 Ma (Lower Carboniferous)	c. 150 Ma (Upper Jurassic)	-
Climate	Tropical, warm		+
Depositional Environment	Epicontinental – Shallow Marine		+
Lithology	Carbonates (Limestone, Dolomite, Marls)		+
Diagenesis	Partial Dolomitization?	Dolomitization	+/-
Post-depositional Structural Setting	Foreland basin		+
Formation Fluid	High Salinity (radioactive)	Low Salinity (almost fresh)	-
Geothermal Gradient	30 – 40 ° C/km (Some high temp anomalies)		+
Porosity (deep)	(Intergranular) (Karstic) Fractures	Intergranular Karstic (Fractures)	+/-

Reasons for Success



Reasons for Success: Economic Viability - Heat Demand

EU28 Energy Demand(2015)
(Household and Industry)



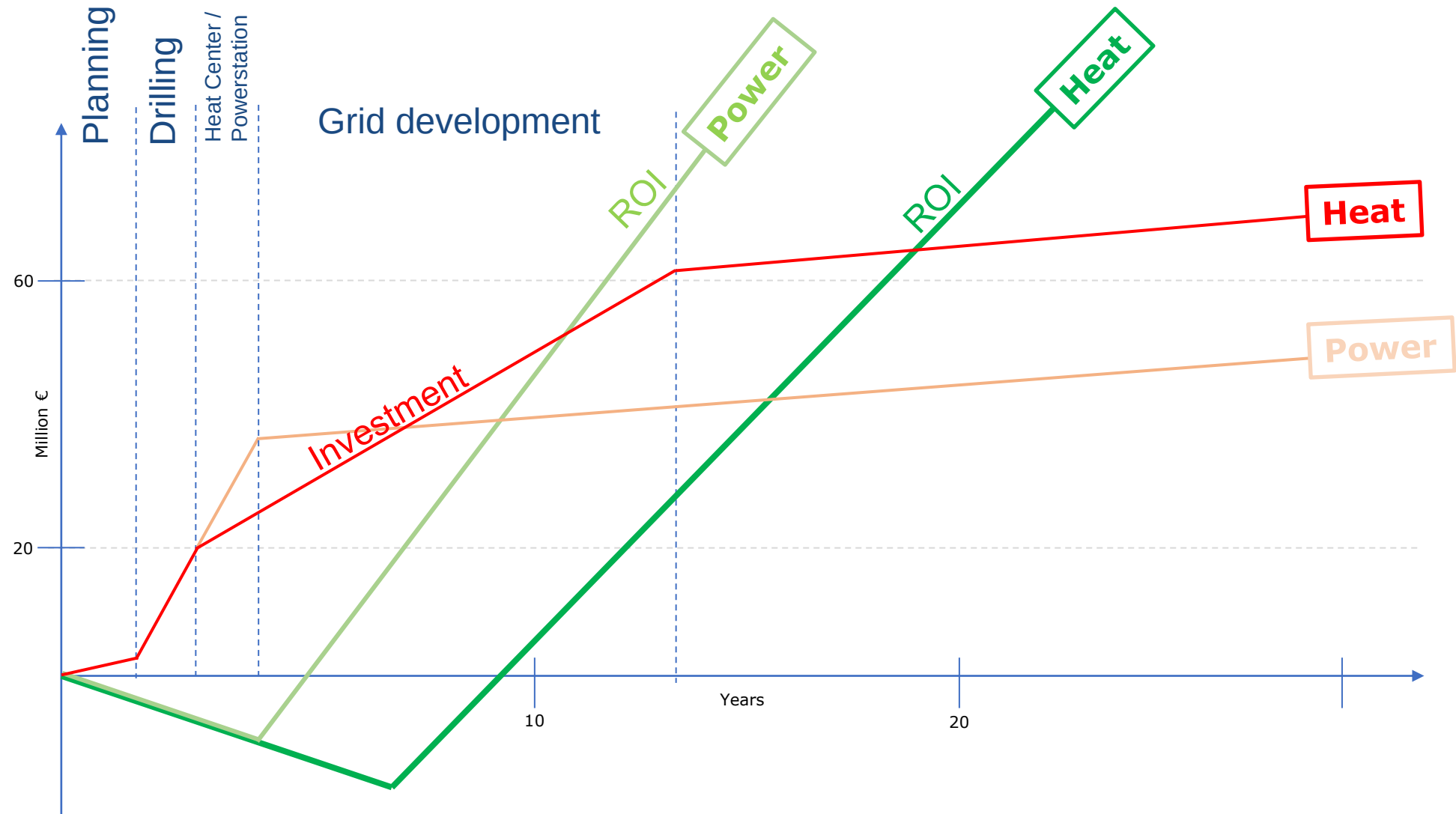
Adapted from Heat Roadmap Europe 2050 (2017)

Reasons for Success: Economic Viability - Heat Demand

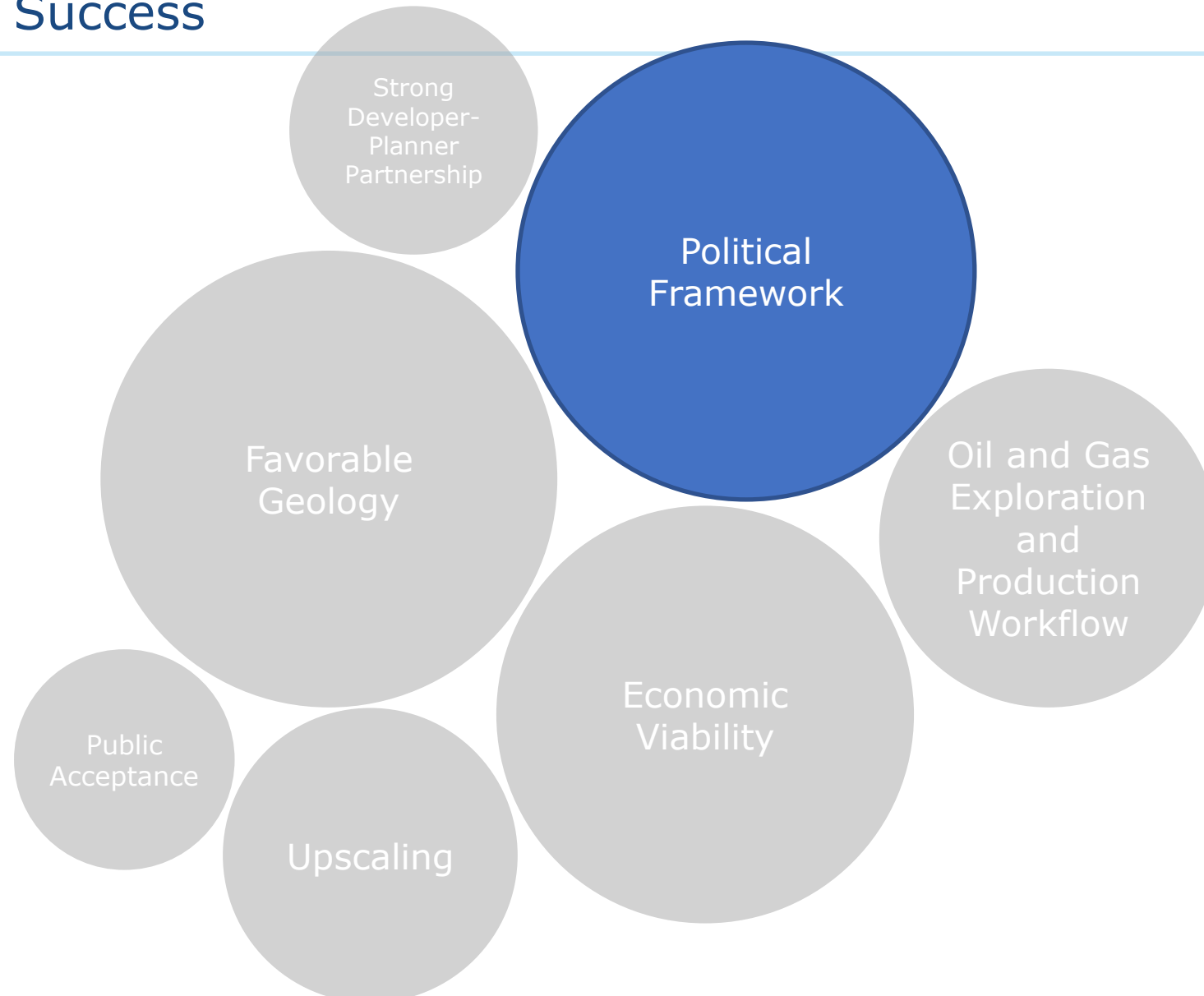


• Wells	10.8 Mio. Euro (Th1a/Th2) 7.3 Mio. Euro (Th3)
• Energy Center	3.7 Mio. Euro
• DHN Pt1	ca. 16.8 Mio. Euro
• DHN Pt2	ca. 28.0 Mio. Euro
• Extension of Energy Center	ca. 2.9 Mio. Euro
• Reinjection Pipework	ca. 2.9 Mio. Euro
• Total Investment to 2054	ca. 76.0 Mio. Euro

Reasons for Success: Economic Viability - Heat Demand



Reasons for Success



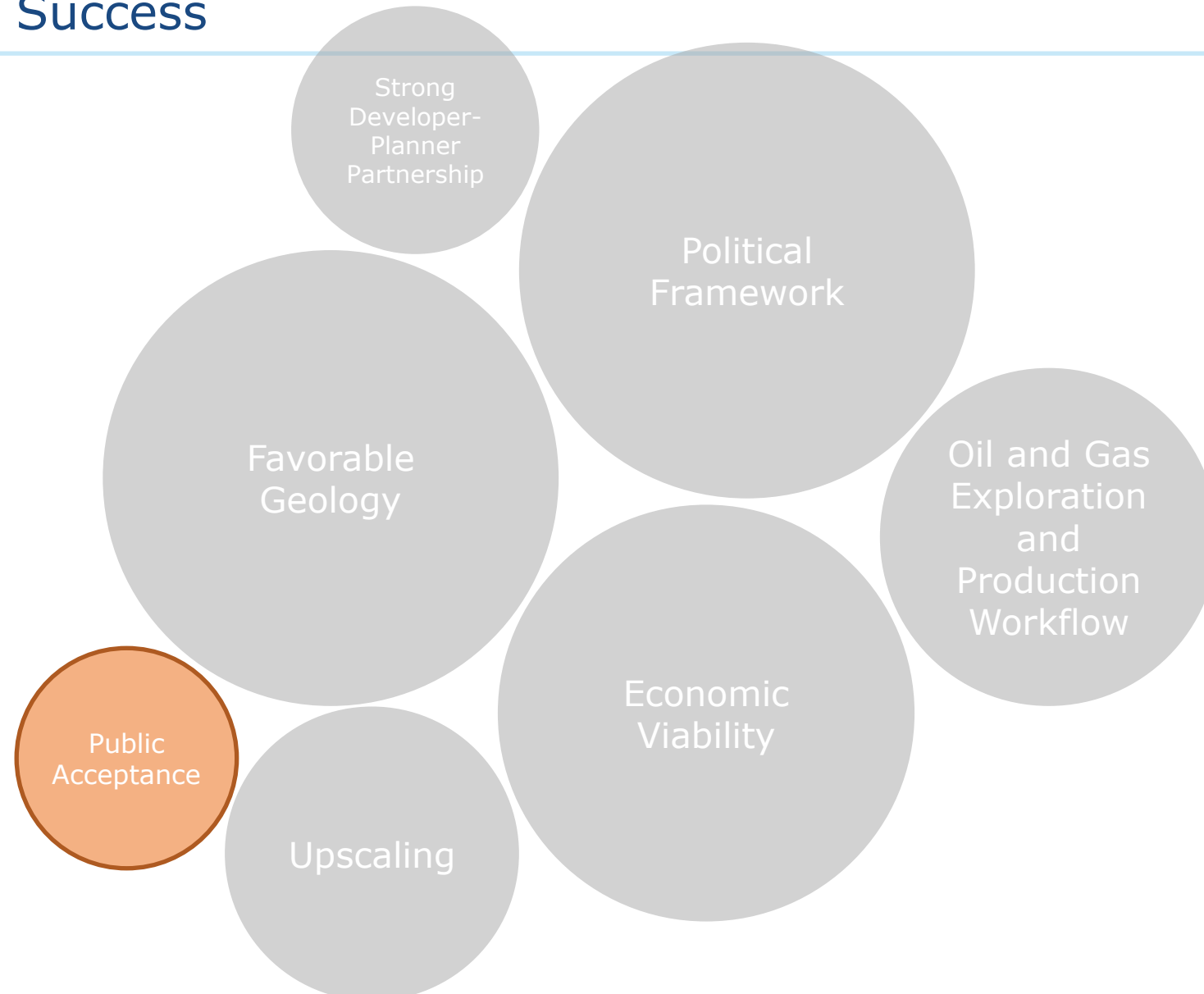
Reasons for Success: Political Framework

National Funding (Kreditanstalt für Wiederaufbau (KfW))			
Plant Subsidies	200 €/kW ^(nominal heat output) Max. €2 million		
Deep Geothermal Wells (heat)	400 m to 1,000 m TVD: 375 €/m TVD	1,000 m to 2,500 m TVD: 500 €/m TVD	>2,500 m TVD: 750 €/m TVD
	Max €5 million per doublet Additional work due to unforeseen technical risks, up to 50% of costs, max €1.25 million per well-		
District Heating Network (DHN)	60 €/m (new sections) Max €1.5 million Repayment Subsidies: €1,800 per household connection		
Bavarian Funding (LfA Förderbank Bayern)			
District Heating Network (DHN)	Max €0.5 million per project from the LfA Förderbank		
Municipal Infrastructure Projects	loans at reduced interest rates granted by LfA Förderbank		

[https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/Erneuerbare-Energien-Tiefengeothermie-\(272-282\)/](https://www.kfw.de/inlandsfoerderung/Unternehmen/Energie-Umwelt/F%C3%B6rderprodukte/Erneuerbare-Energien-Tiefengeothermie-(272-282)/)

***However, there is no state exploration insurance!**

Reasons for Success



Reasons for Success: Public Acceptance

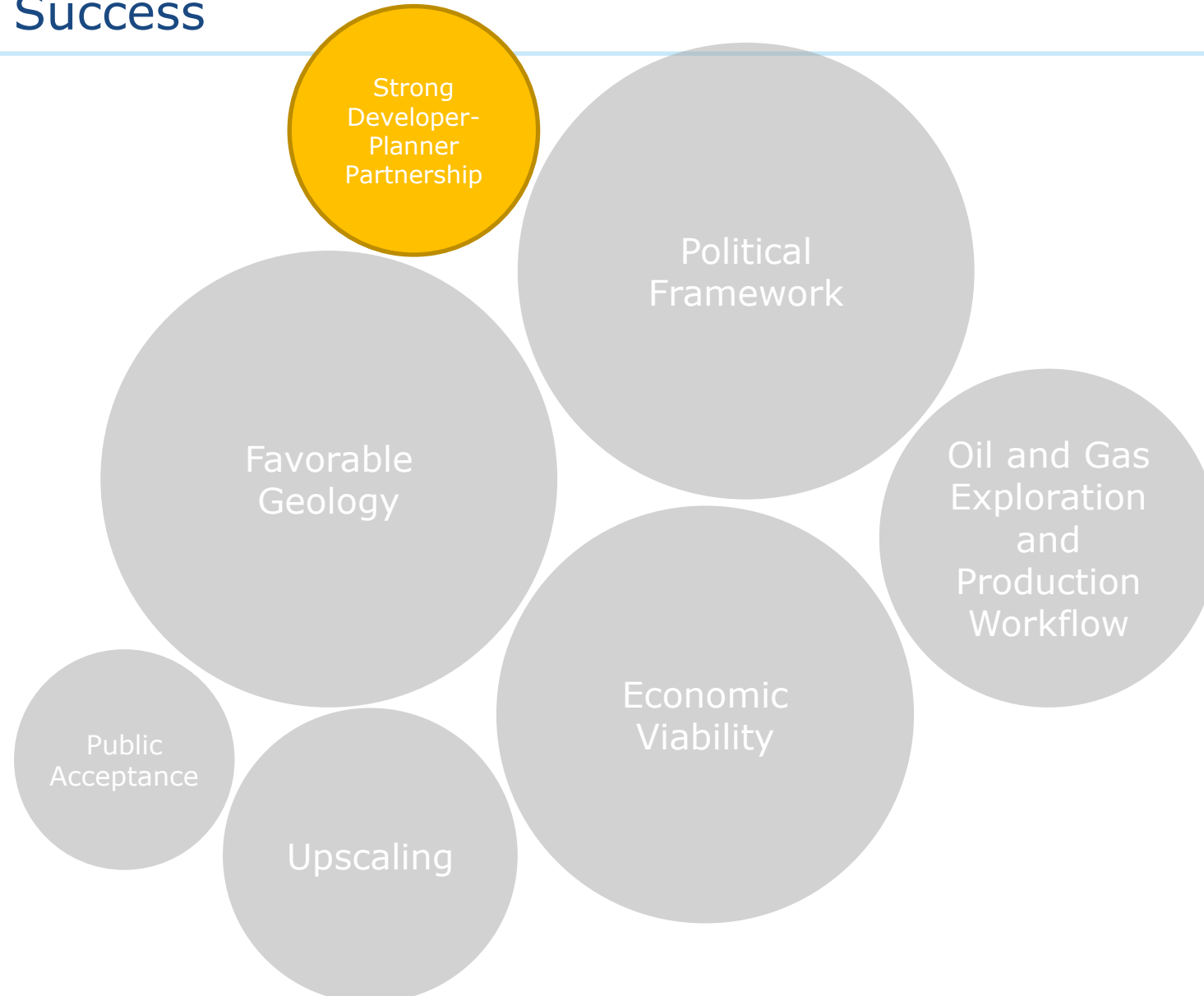
- 93% of German citizens support the development of green energy*
- Project Success = Positive Reporting
- Transparent approach of Municipal Projects
- PR work & Education
- Accept that sometime there isn't a fit.



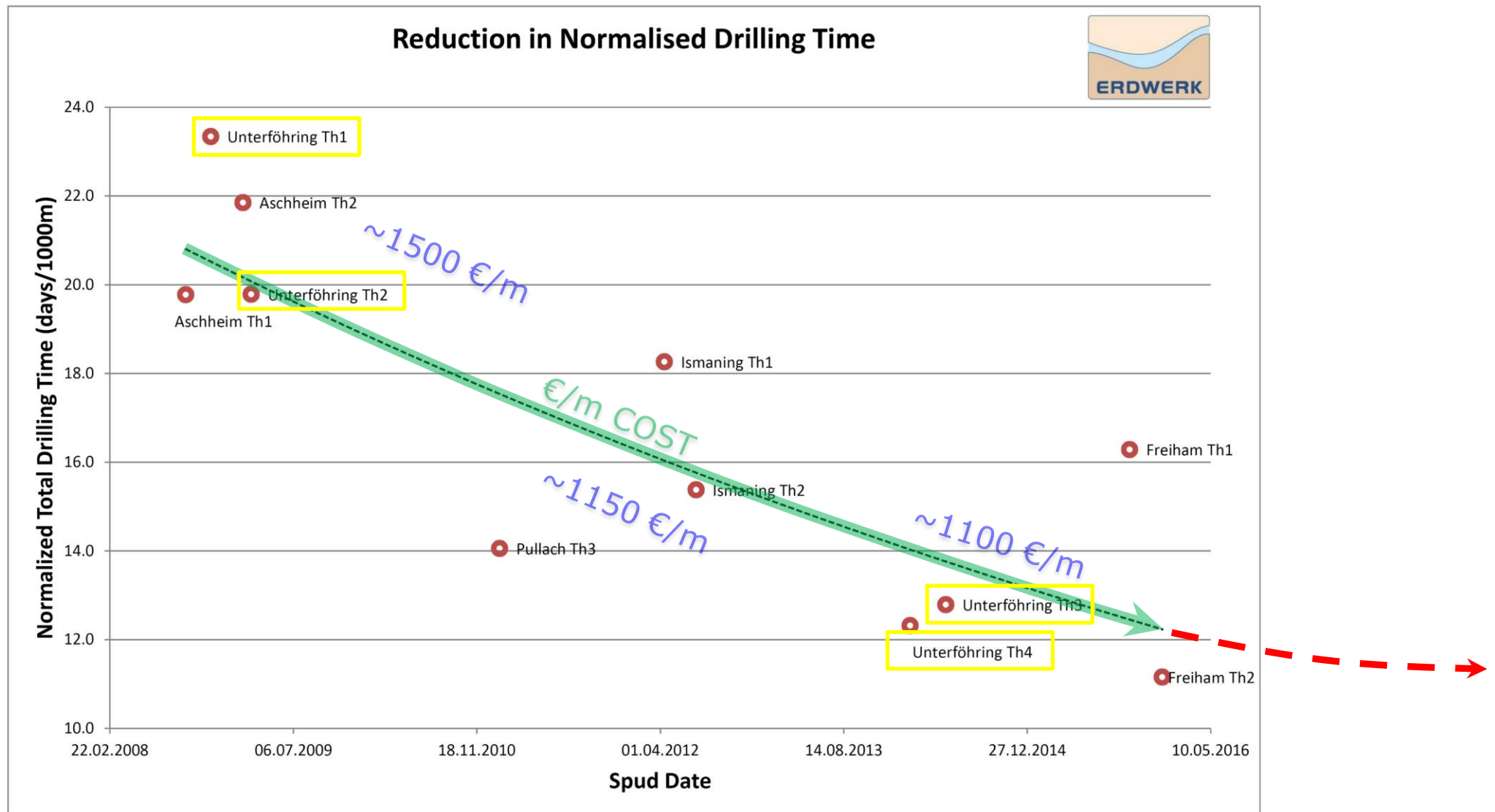
*Agentur für Erneubare Energien, 2018

Site	First detection	Strongest event / Event number	Description
Unterhaching (UH)	10.02.2008	M_L 2.4 / 657	27 events $M_L \geq 1.0$, six events $M_L \geq 2.0$, near inj. well, decreasing
Taufkirchen (TK)	19.07.2012	M_L 0.3 / 11	During circulation test at inj. well
Kirchstockach (KS)	23.08.2012	M_L 0.8 / 33	30 microseismic events $M_L \leq 0.8$ near inj. well
Sauerlach (S)	19.06.2014	M_L 1.2 / 2	M_L 0.7 and M_L 1.2, big location error
Pullach (Pu)	21.02.2015	M_L -0.4 / 1	Near inj. well
Oberhaching (OH)	01.02.2016	M_L 0.5 / 3	Near inj. well
Duerrnhaar (DH)	31.07.2016	M_L 1.3 / 10	Big location error
Poing (PO)	19.11.2016	M_L 2.1 / 21	18 microseismic events, two events $M_L = 2.1$, near inj. well

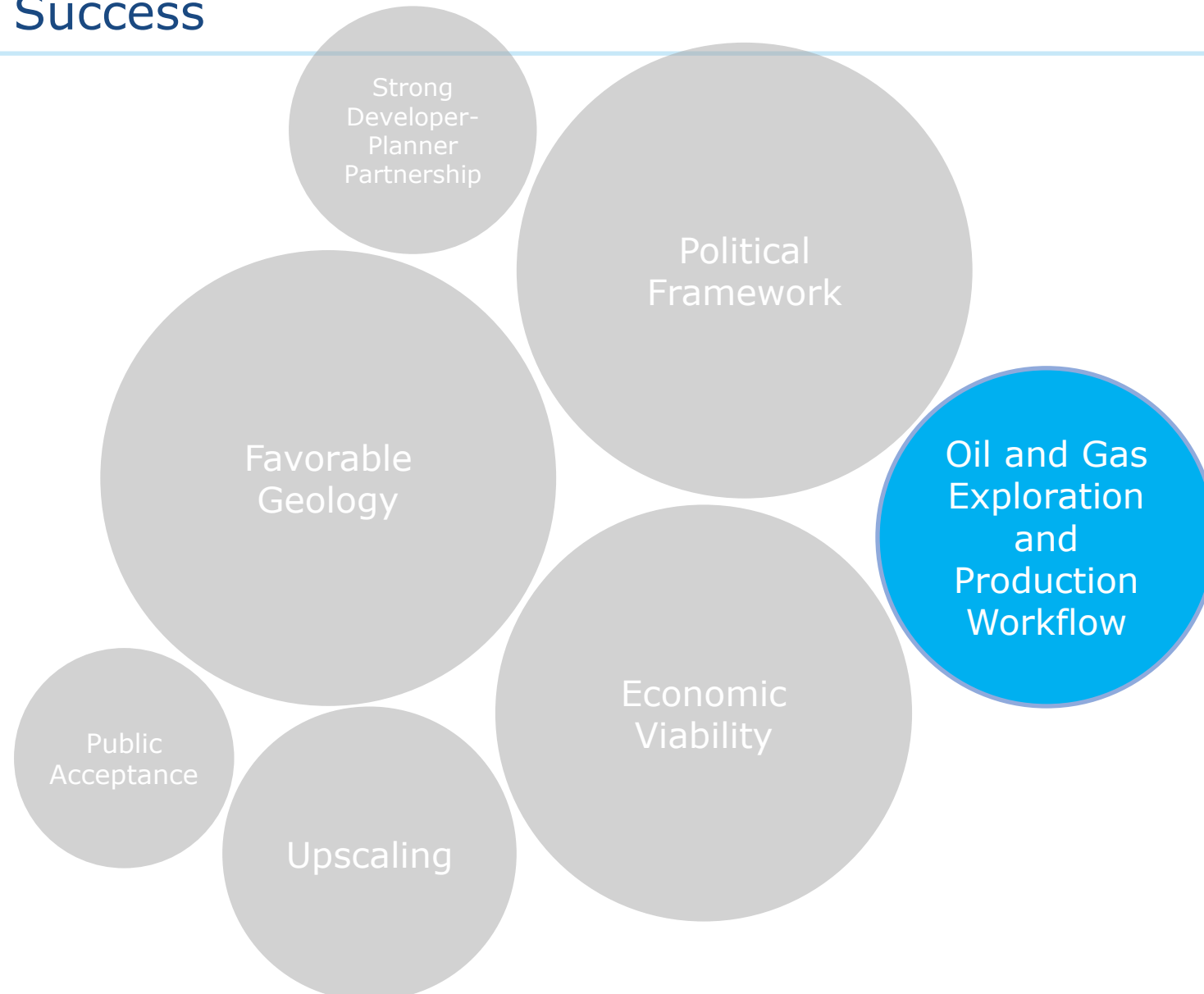
Reasons for Success



Reasons for Success: Strong Developer – Planner Partnership



Reasons for Success



Reasons for Success: Oil and Gas Exploration and Production Workflow

- Technology
 - Seismic Profiles 2D to 3D
 - Petrel & Eclipse, Landmark
 - Modern RSS & Multilateral Completions
- HSE (More than just water wells)
- Human Resources
- Industry Cross Over
- Large Operator Approach
- Upscaling

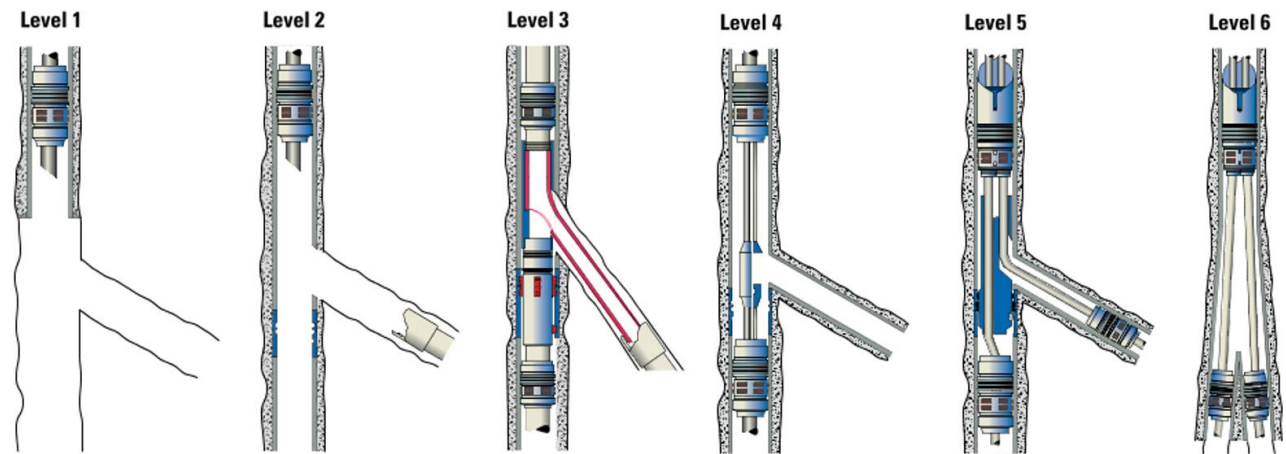
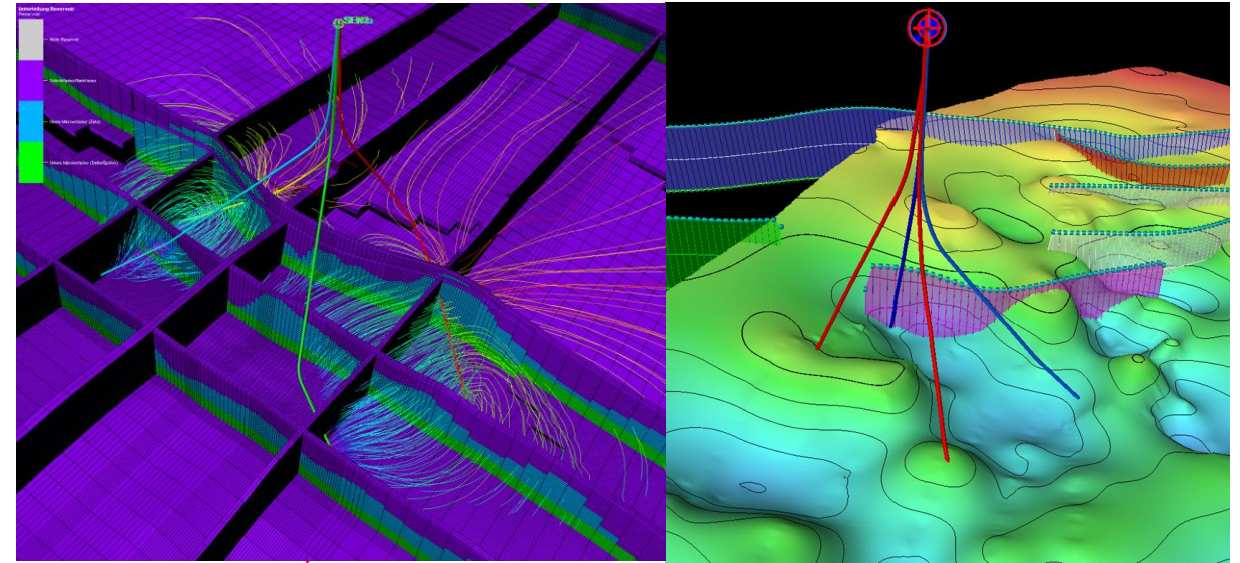
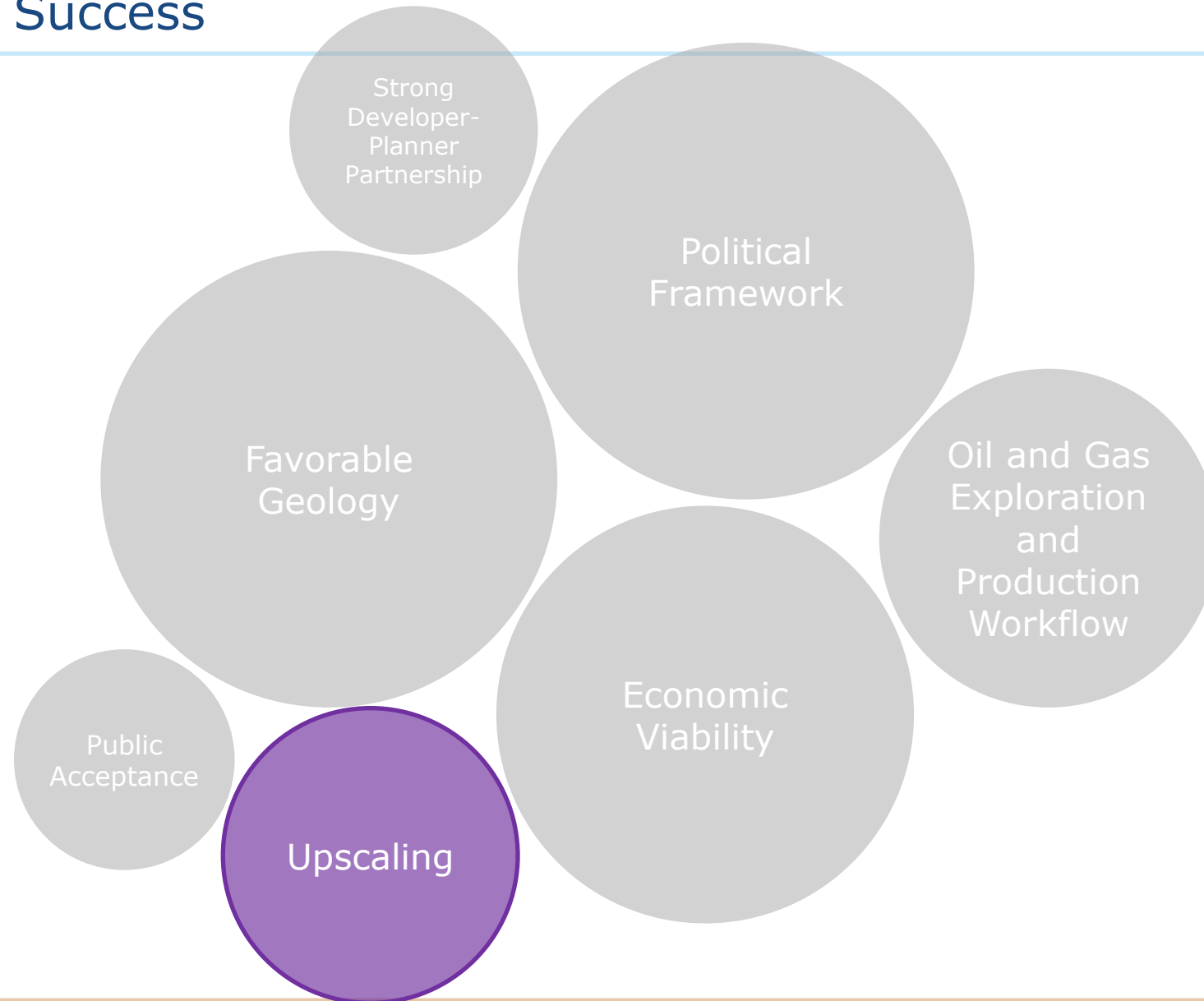


Figure 1: Junction Classification. Source: New Aspects of Multilateral Well Construction, Fraija et al (2002)

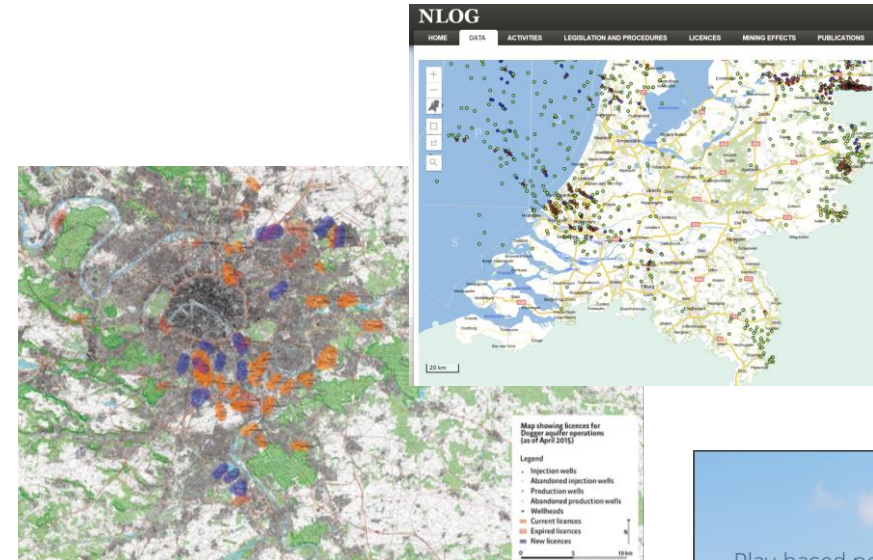
Reasons for Success



Reasons for (*future*) Success: Upscaling

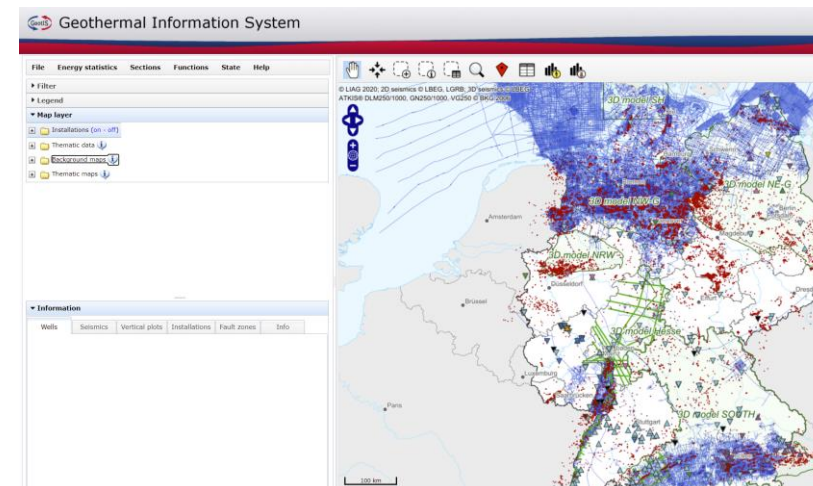
Exploration without Exploration

- Experienced planner with extensive inhouse project performance data.
- Opensource centrally held information
- NLOG, Paris Dogger Database, GeotIS

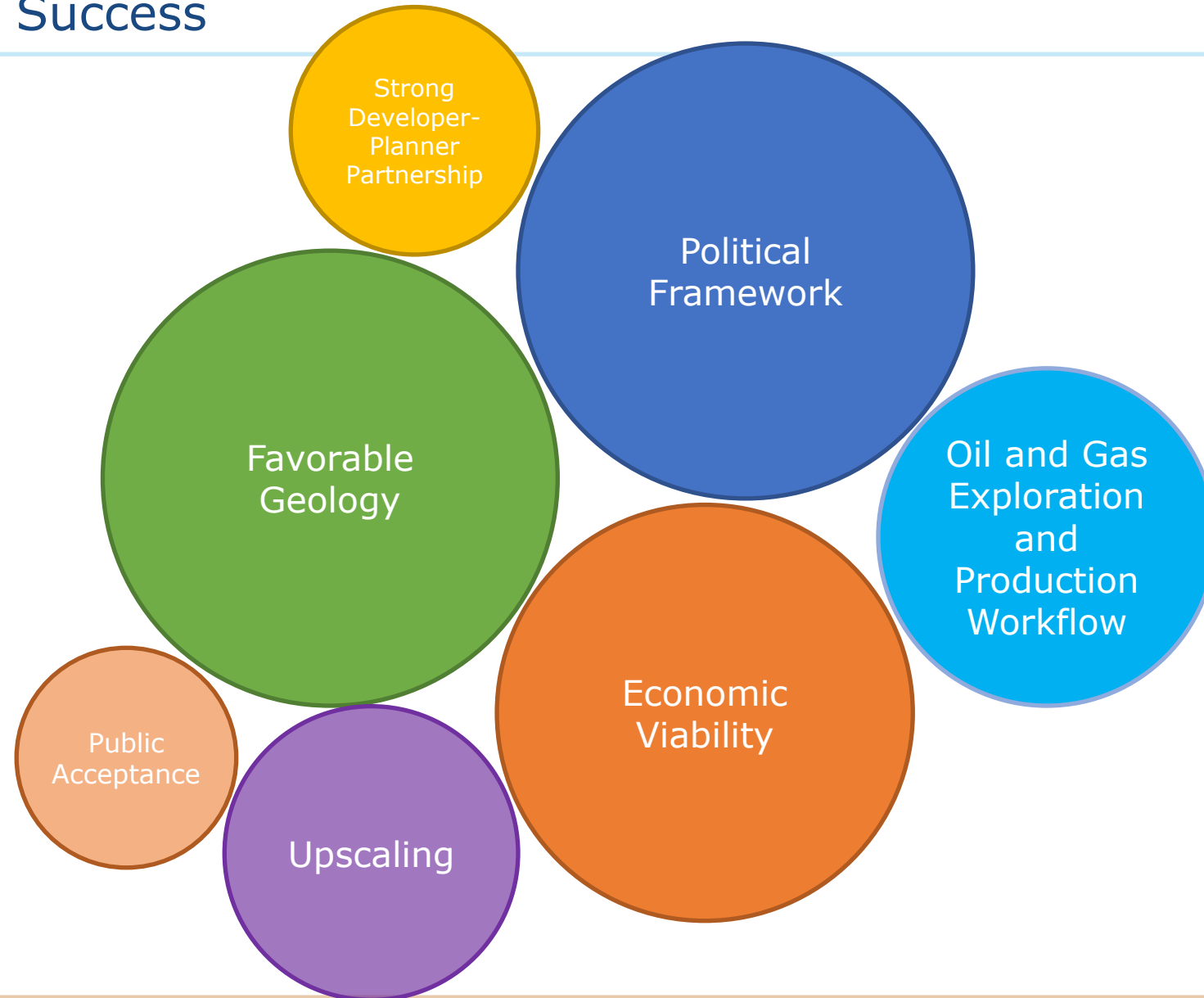


Play based Exploration

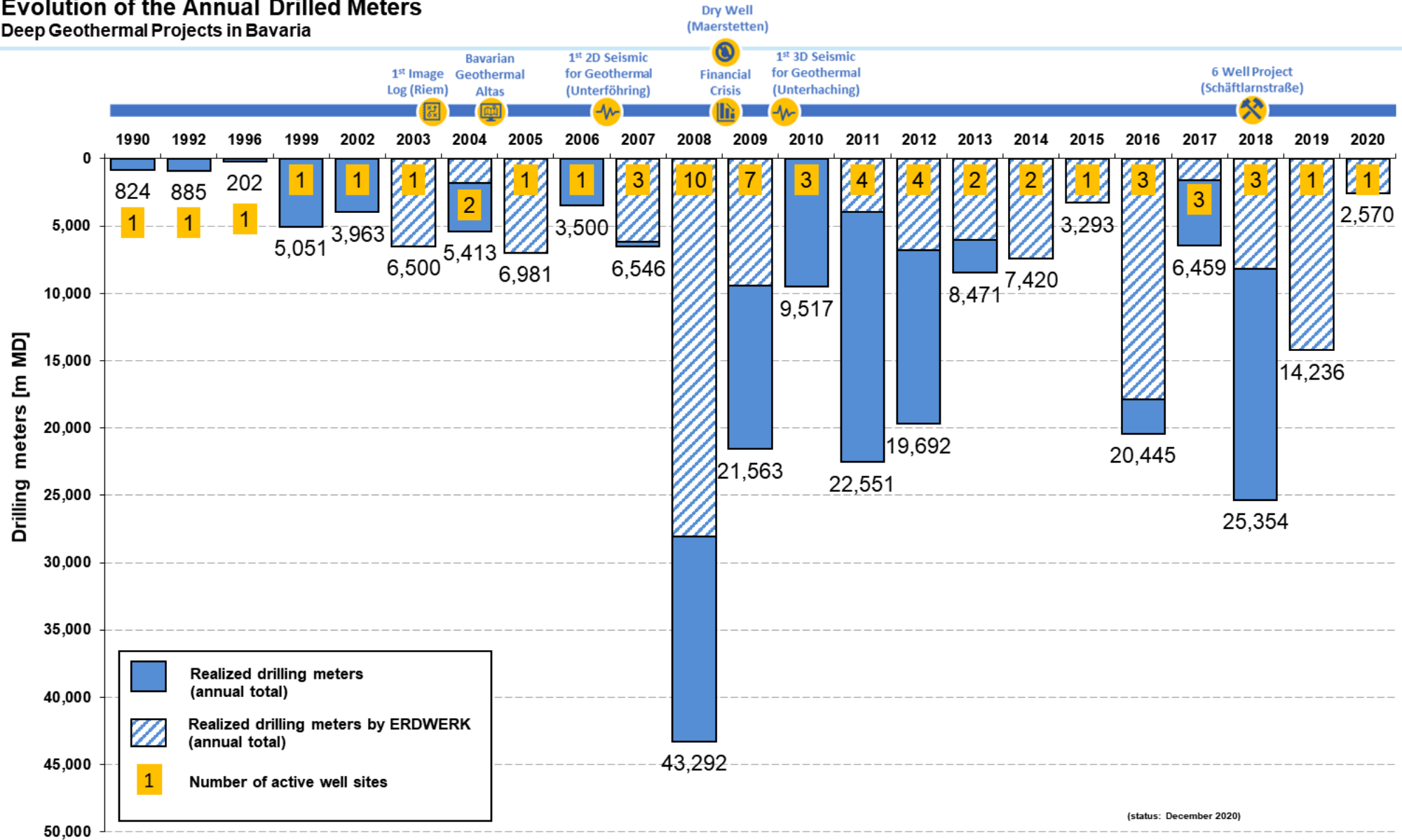
- Economies of Scale
- SWM-Munich



Reasons for Success



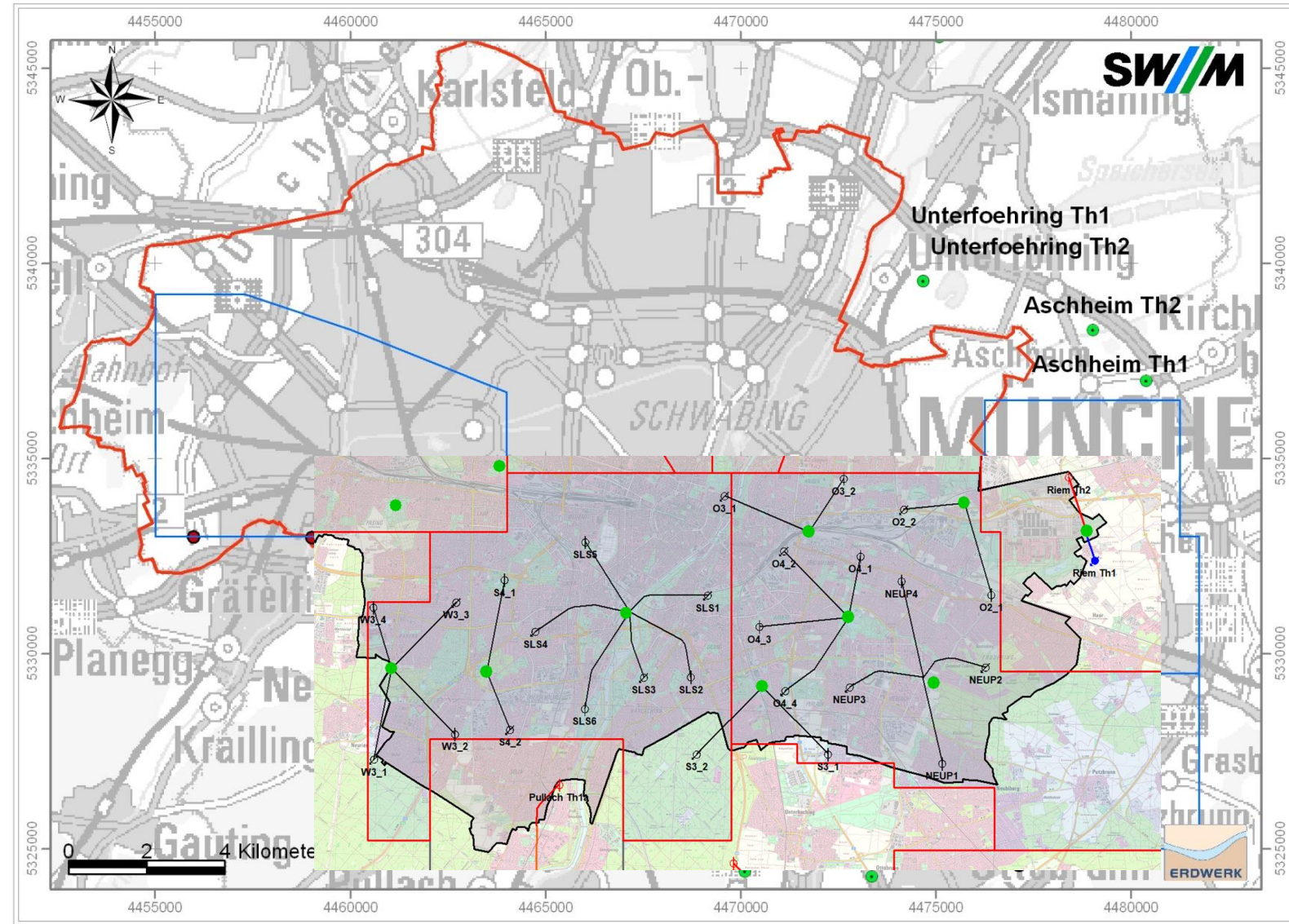
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The Present and the Future



The Present and the Future



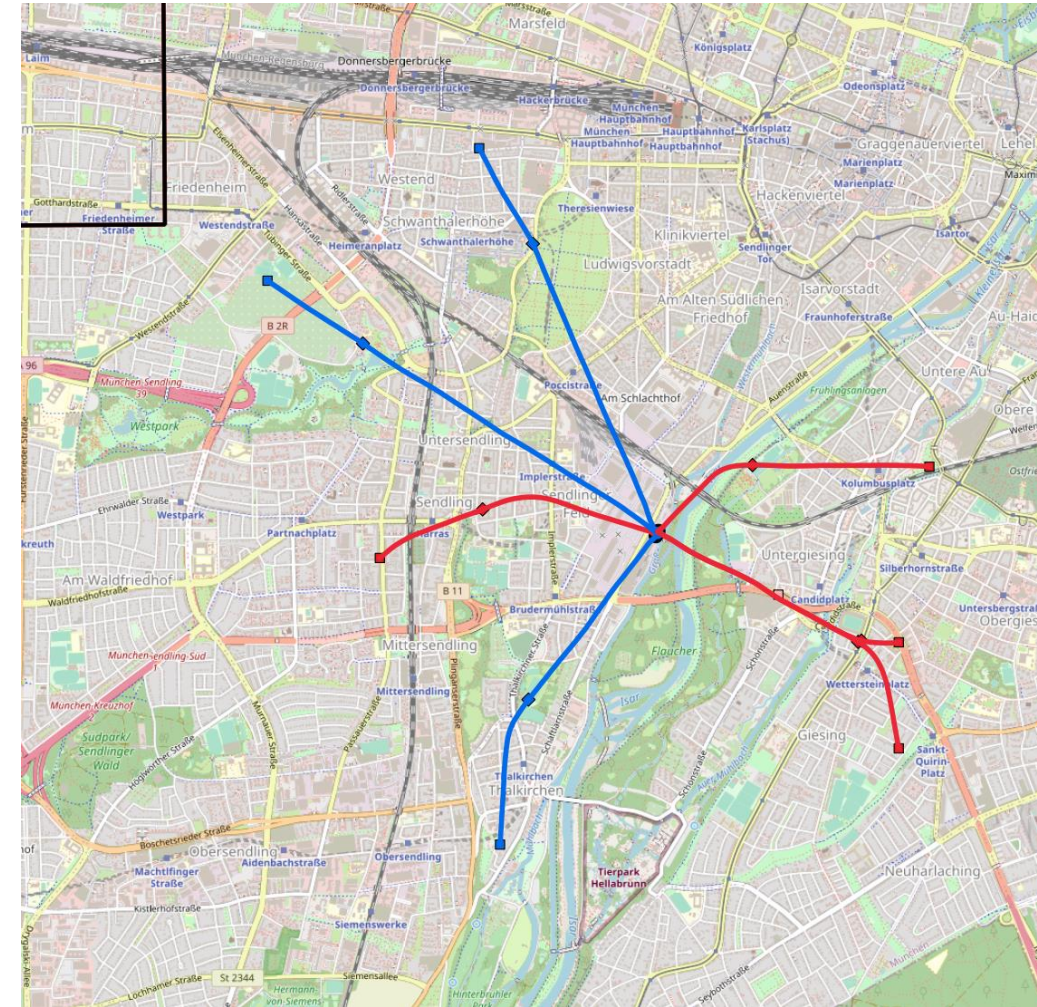


The Present and the Future



Project Schäftlarnstraße – State of the Art

Th1:	2,809 m TVD
Th2a:	3,044 m TVD
Th2aM1:	2,650 m TVD
Th3:	2,723 m TVD
Th4:	2,947 m TVD
Th5:	2,668 m TVD
Th6:	3,141 m TVD
total length of wells:	25km
Thermal Output:	50MWth
Avg. Temperature:	>100° C
Avg. Production rate:	>100 l/s



The Present and the Future



Template for Further Regions and Cities?



Problems	Drivers	Solutions
High project risk. High CAPEX. High cost of single project. No knowledge transfer/sharing. Catch up with E&P professionalism. Slow Investment returns.	Passionate and motivated people. Political Change and Climate Targets (Horizon 2020) Social Political demand for change. Market for Geothermal. Subsidies.	Opensource. Research and innovation. Centralized risk minimization. Seismic Monitoring funding. Regional initiatives. Portfolio Approach.

Thank You