



Volker Wittig

Applied, further development of ESP and LSP for better run time and economics of geothermal energy production (ANTLIA)

DGK 2025 Frankfurt

Reliable artificial lift and pumping systems are the backbone for an economic geothermal power and energy production

An ideal (geothermal) pump combines

efficiency

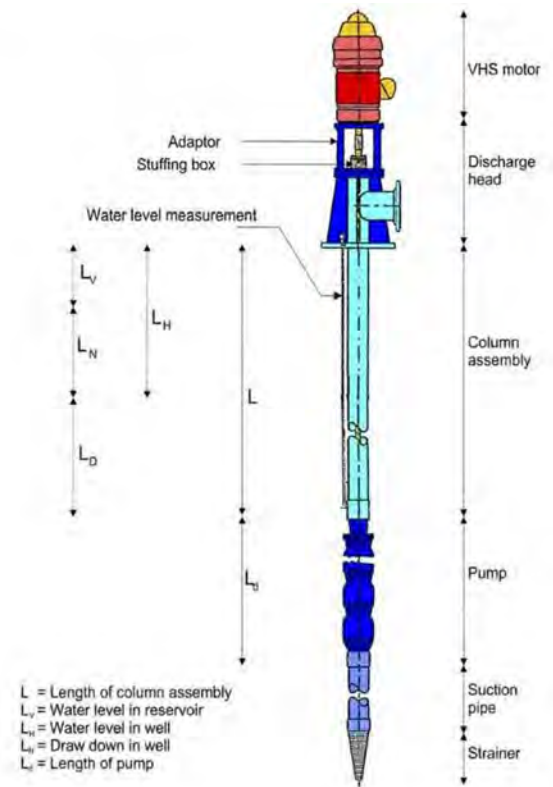
durability

environmental compatibility



LINE SHAFT PUMP (LSP)

- Multistage axial centrifugal pump
- **Motor on surface** (easy maintenance, no space limitation)
- **Limited depth** due to shaft system (appr. 750 m)
- No deviation of the well (down to mounting depth of pump)
- Complex installation
- **Shaft lubrication required** (open / closed)
- ⑦ Environmental impact



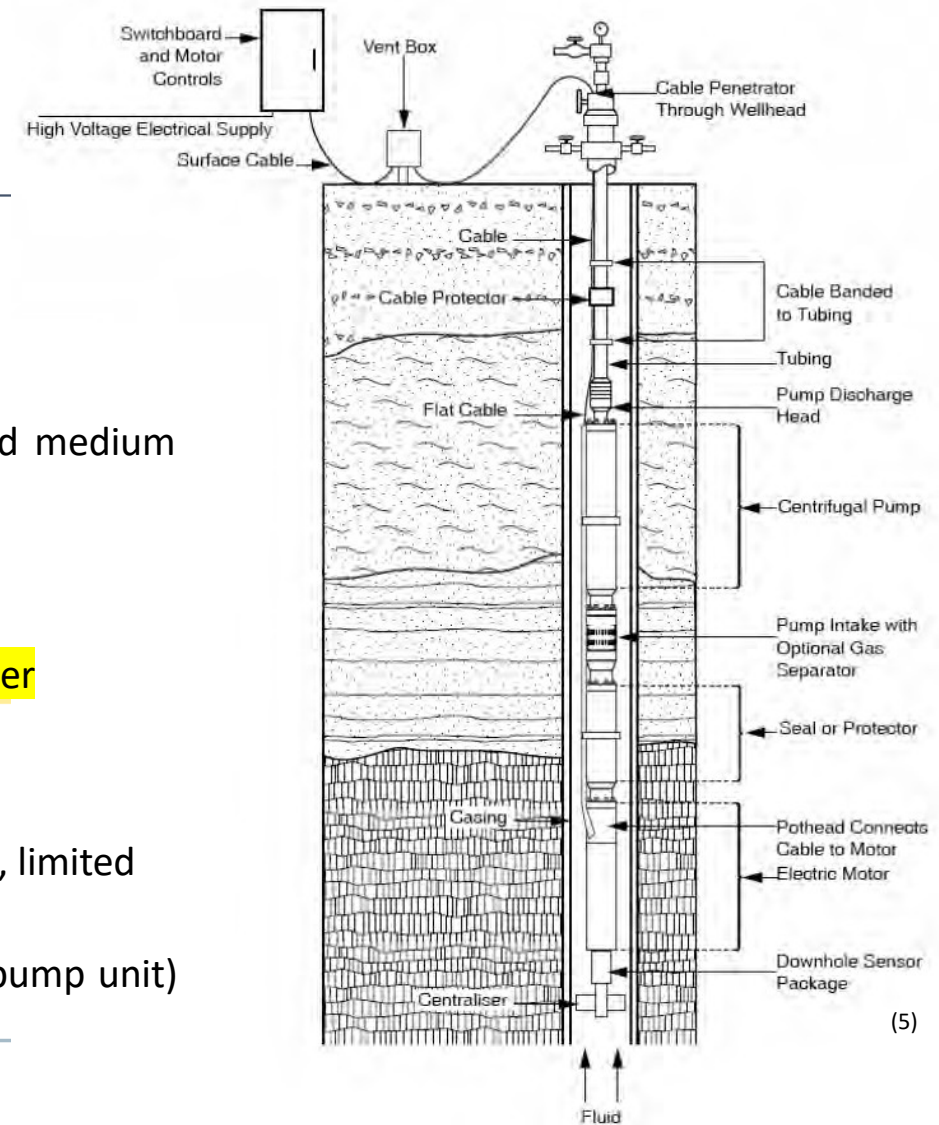
ELECTRIC SUBMERSIBLE PUMP (ESP)

Advantages

- Large mounting depths
- Operation in deviated wells possible
- Established technique for low flow rates / discharge head and medium temperatures

Disadvantages

- Pump unit (incl. motor and cable) is exposed to thermal water
 - ⑦ deposits, scaling, corrosion
- Motor unit downhole
 - Challenging conditions (high pressure, high temperature, limited diameter)
 - Expensive maintenance (complete removal of tubing & pump unit)



COMPARISON LSP - ESP

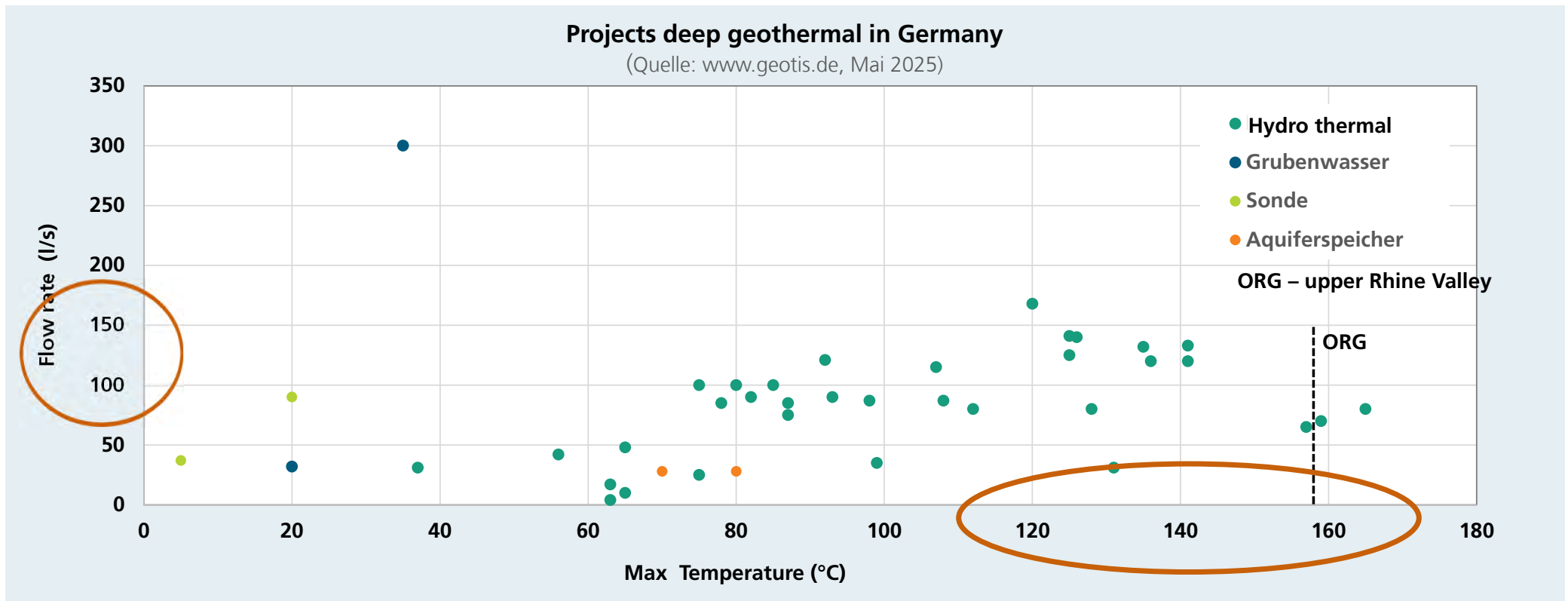
	Lineshaft Pump (LSP)	Electric Submersible Pump (ESP)
Temperature ^{1,2}	ca. 200 °C	ca. 150 °C
Assembly ¹	Motor, thrust bearing, seal accessible at surface	Motor, thrust bearings, seal, power cable downhole – less accessible
Wellbore deviation ^{1,2}	No deviation (unless the well is oversized to accomodate stiff pump and column)	ca. 5°/30 m (installation) 0 - 90° (operation)
System Efficiency ^{1,2}	up to 70 %	up to 70 %
Costs	<div style="border: 2px solid orange; border-radius: 50%; padding: 10px; display: inline-block;"> high high medium </div>	<div style="border: 2px solid orange; border-radius: 50%; padding: 10px; display: inline-block;"> medium medium high </div>
Invest Installation Maintenance		

¹ Culver G., Rafferty K. (1998): „Geothermal Direct Use Engineering and Design Guidebook“, Third Edition, Geo-Heat Center, Oregon Institute of Technology, Klamath Falls, OR

² Palka K. (2015): “PCP - ESP - SRP Choosing the best artificial lift; the first step to profitability”, presentation 2015

Pump Applications within deep Geothermal systems

from 20 °C to 200 °C – both ESP and LSP systems



R&D Project to improve ESP + LSP systems (ANtLiA)

Better reliability, economics and sustainability of artificial lifting systems for geothermal applications

Project

„Anwendungsbezogene Weiterentwicklung von Tauchkreiselpumpen und Line Shaft Pumpen in geothermischen Anlagen“

schedule: 01.2025 – 12.2027

Grant #: 03EE4067A

Grant through :



Bundesministerium
für Wirtschaft
und Klimaschutz

© Bundesministerium für Wirtschaft und Klimaschutz

Partners



Goals

1

Service time ↑

2

cost ↓

3

environmental ↑

Scientific and technical goals of ANtLiA project

From data collection to system optimization of LSP and ESP Technologies

1. Understanding the Causes

Data collection and analysis of failures (LSP & ESP)

Classification of failure causes

Development of predictive maintenance concepts

2. Improving the Systems

Line Shaft Pumps (LSP)

Development of a closed oil recirculation system

Test bench for testing and optimization

Investigation of alternative, aromatic-free lubricants

Deployment in the Bavarian Molasse

Electric Submersible Pumps (ESP)

Recommendations for design improvements

Design, prototyping, and testing of optimized components

Development of an (AE based) intelligent monitoring system

3. Economics & Communication:

Economic evaluation of the approaches

Visualization and knowledge transfer for operators & manufacturers & general public (open source)



▪ We still welcome you to share your experience and data

Data from Upper Rhine Valley; DE : LSP systems state of the art

Dimensions and typical use of LSP

questionare ESP:



Line Shaft Pumps Upper Rhine Valley

	Soultz	Landau	Insheim	Rittershoffen
Salinität (g/l)	96-101	106	107	100
GBO (bar)	18 - 18,5	18,2	19,2	19
Gas:Wasser	0,8:1	1,1:1	1,1:1	1:1
Fließrate (l/s)	31	50-60	70	87,5
Temperatur (°C)	150	159	163,8	168,5
Bohrung	9 5/8"	13 3/8"	13 3/8"	13 3/8"
Pumpenmaterial	Edelstahl	Gusseisen	Edelstahl	Edelstahl
Effizienz	42%	70%	68%	70%
Laufzeit	4+ Jahre		4 Jahre	4 Jahre

questionare LSP:



Quelle: Hettkamp et al. (WGC 2020)

Challenges for downhole, geothermal type pumps

Rough environment and high power requirements

Thermal and chemical

- High **temperatures** lead to increased **material fatigue** (especially in seals, insulation, and electronics).
- Temperature fluctuations → **thermal stresses** and expansion effects on shafts, housings, and bearings
- Aggressive **fluid chemistry** can cause **corrosion**, deposits, and scaling
- Gas content in the fluid leads to **cavitation** or gas bubble formation in the pump system

Mechanical and operational influences

High **ambient pressure and fluctuations** put strain on seals and pressure compensation / accumulator systems

incorrect **installations** of pumps

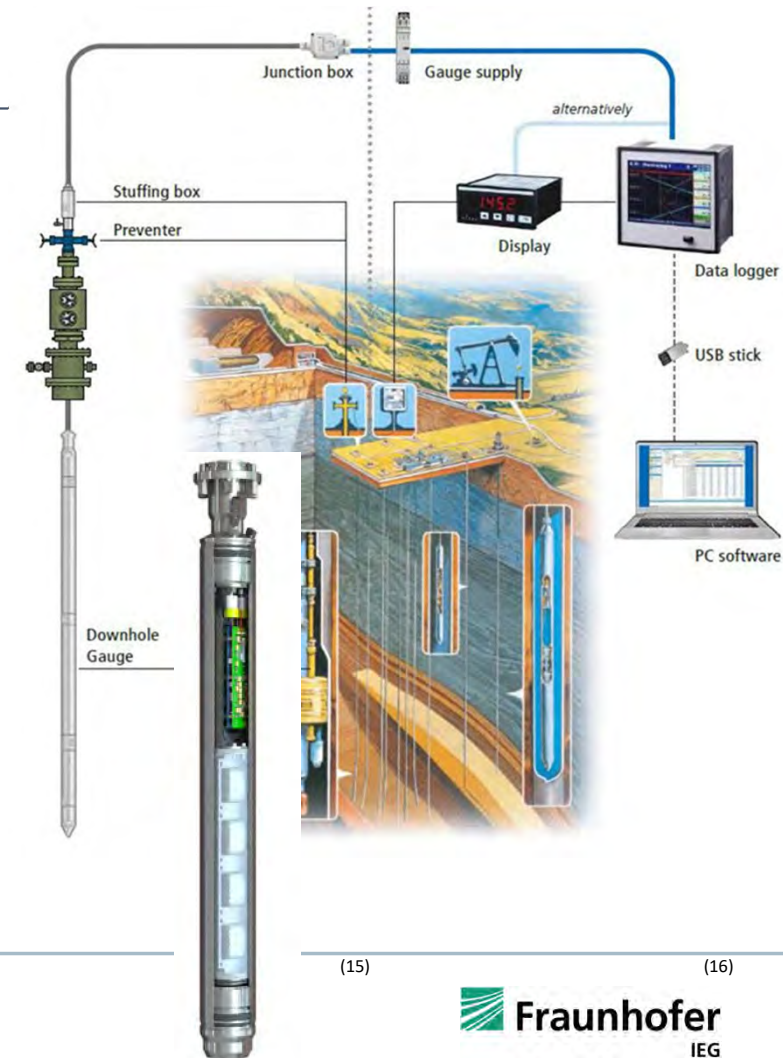
Changing speeds / loads due to fluctuating demand (daily / seasonal)

Inadequate **electrical insulation** leads to shorting

Downhole sensors + ESP MONITORING → predictive maintenance

Possible ESP sensors

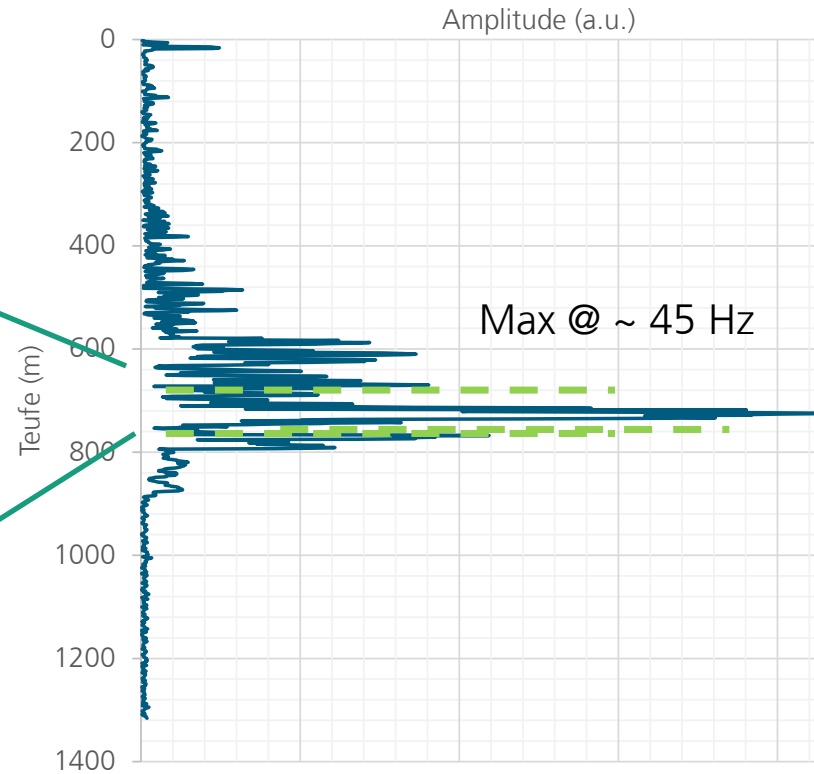
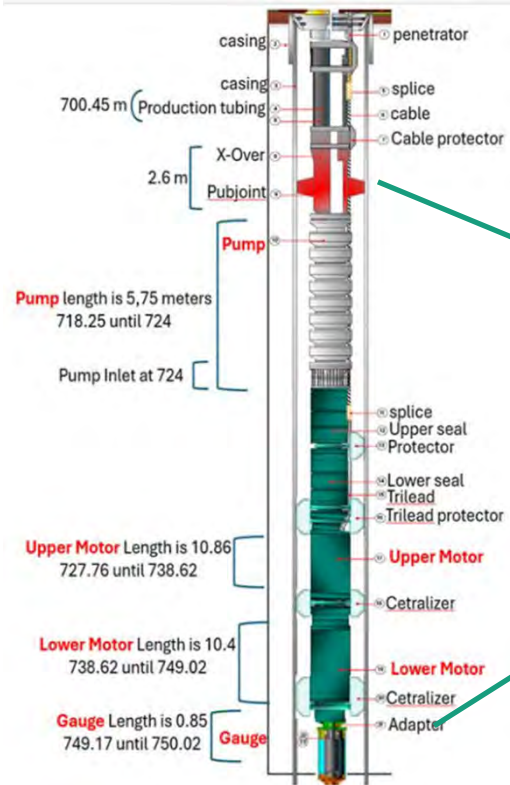
- fluid temperature (downhole)
- inlet pressure, discharge pressure
- Electric Current leakage
- engine temperature
- vibration / acoustics AE sensors
- Initially use of monitoring sub
- Later integration directly into pump
- Challenge : data analysis (with AI)
- Even more potential : fiber optic cable (GFK) → DTS + DAS



R&D project GFK Monitor as „vibration“ sensor / Accoustic / Temp. Monitoring

distributed acoustic sensing
 distributed dynamic strain sensing
 distributed temperature sensing

DAS
 DDSS
 DTS



Faseroptische Messungen in Tiefenbohrungen

GFK Monitor

- Entsendung eines Laserpuls entlang einer Glasfaser
- Partielle Rückstreuung des Lichts durch Wechselwirkungen mit der Faser
- Analyse des rückgestreuten Lichts auf I und λ
- Positionsbestimmung der Messpunkte über Laufzeit des Lichts

als Temperatursensor
 Distributed Temperature Sensing (DTS)
 Auswertung der temperaturabhängigen Streuung des Lichts

als Vibrationsensor
 Distributed Acoustic Sensing (DAS)
 Distributed Dynamic Strain Sensing (DDSS)
 Auswertung der dehnungsabhängigen Streuung des Lichts

Installation der Kabel
 (a) Dringende Notwendigkeit, ein Kabel mit 11 Kanälen im Bohrer abzulassen

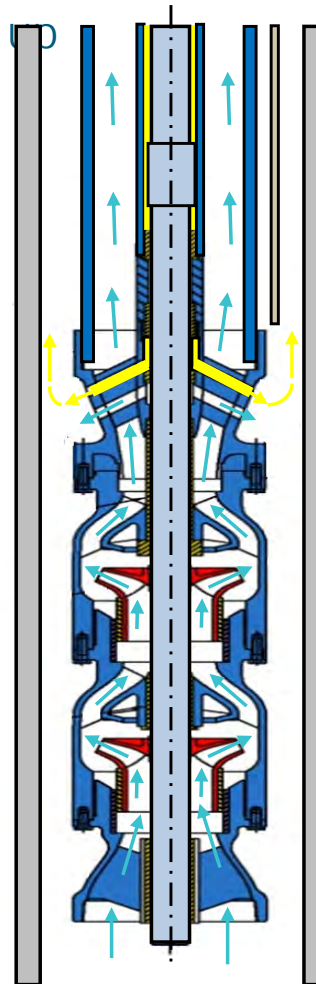
als Fabry-Pérot Punktsensor
 Druck und Temperatur Messung (PT)
 Messung des Interferenzmusters von reflektiertem Licht zwischen zwei Spiegeln

LSP systems : Development of Closed loop oil lubrication system

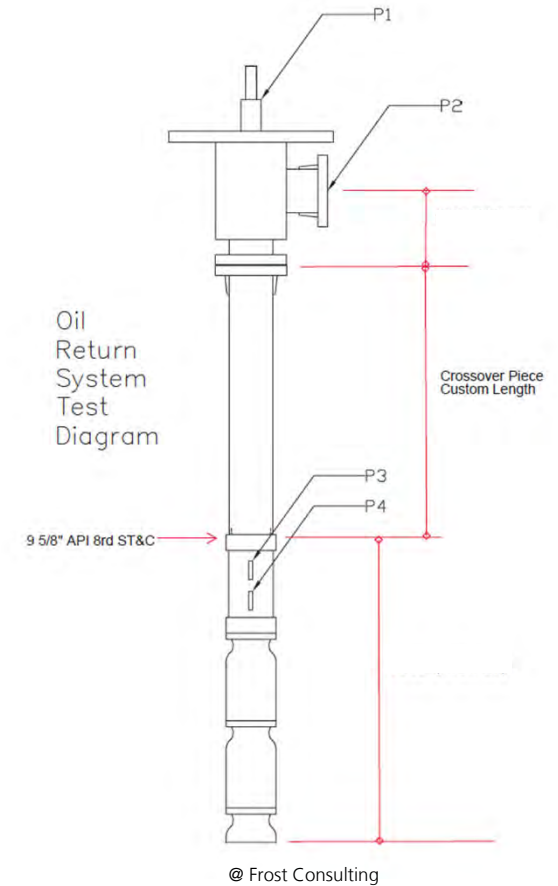
Mitigation of environmental concerns + hold up

Innovation LSP system

Development, design and field test of Closed loop oil lubrication system „full oil return system“



@ Frost Consulting



WP 6 – Design, Prototyping, Test of new drive system for ESP

Outlook:

ESP drive system based on **multiphase permanent magnet synchrone motor** (HM)



How To:

Dynamic **modeling and simulation of entire electric drive system** (including converter, sine filter, cables)
Numerical analysis and evaluation with regards to specified performance indicators for selected designs
Validation in lab tests



Challenges:

Geometric requirements and **environmental** conditions (temperature)
Conflicting objectives between **power density, machine temperature, and torque** ripple
Multi-criteria optimization and simulation of machine design





Project details ANTLIA

ANTLRIA

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This **work** has received funding from federal government GER Via PTJ

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Thank you much

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