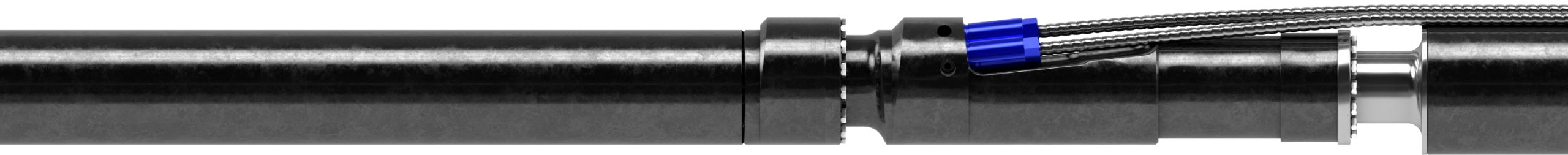


Novel Electrical Submersible Pump (ESP) technology boosted production by 56% from High-Enthalpy Geothermal Well



GEO THERM EXPO & CONGRESS. FEB 29TH & MARCH 1ST, 2024

Jorge Luis Villalobos Leon

ESP Product Champion . SLB

J.L. Villalobos, M. Radov, Y. Hamitoglu, T. Can Bilmez, F. Navarro. SLB; E. Şentürk, M. Tuzen, Zorlu Enerji;

Agenda

- Introduction
- General information about field of study
- Geothermal Energy
- ESP and Geothermal Energy
- Challenges
- Alternative ESP Solution
- Field deployment
- New opportunities
- Conclusions



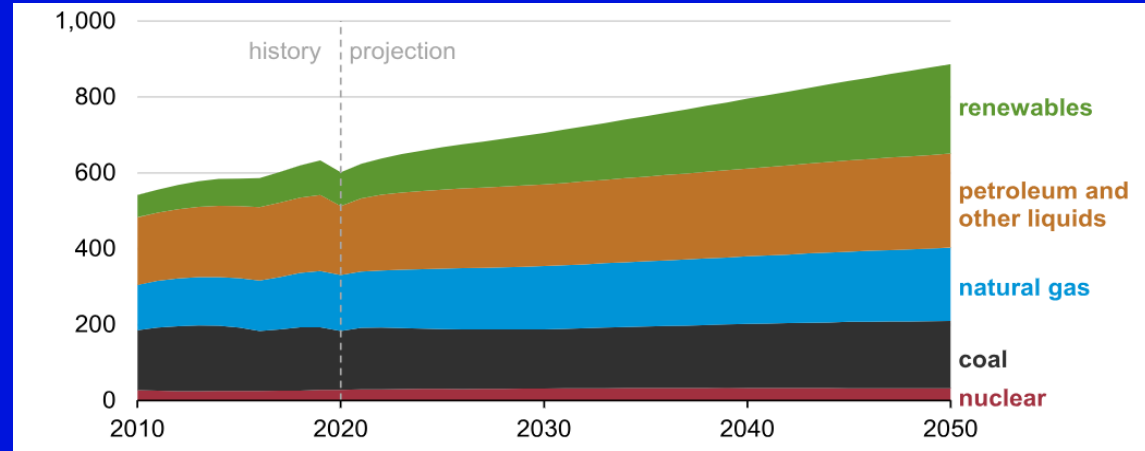
Introduction

- Nearly 50 % increase in world energy use by 2050, led by growth in renewables
- **Global warming!!! A clear concern**
- Petroleum and other liquid fuels will remain the world's largest energy source in 2050
- Renewable energy sources, which include **Geothermal**, solar and wind will grow to nearly the same level
- **More possibilities for renewable energy and alternative solutions!!!**

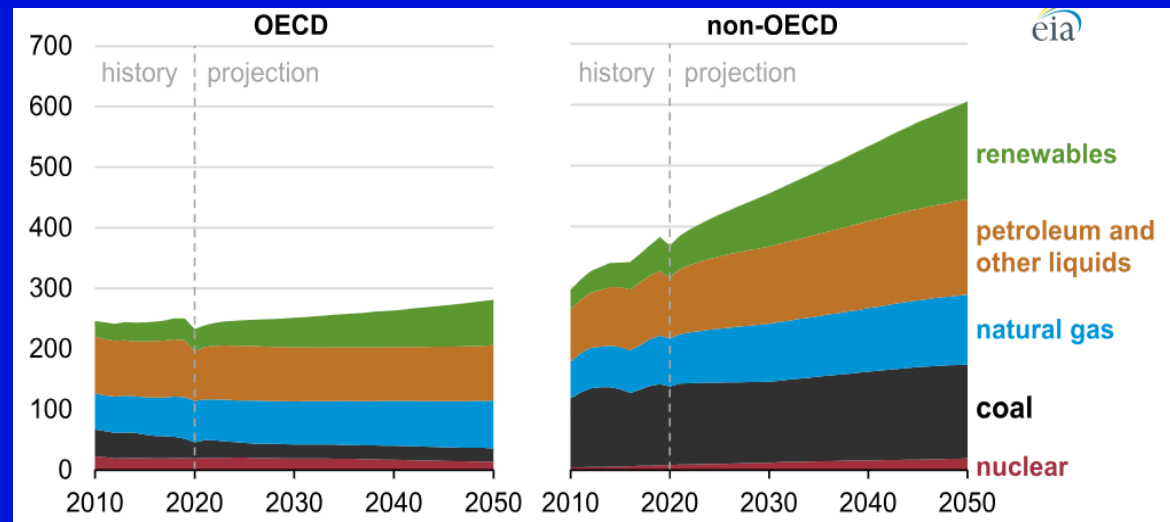


Source: EIA_US Energy Information Administration

Global primary energy consumption by energy source (2010-2050), quadrillions British thermal units




Primary energy consumption by source, OECD and Non-OECD countries (2010-2050), quadrillions British thermal units



General field information (Field of Study)

Zorlu Enerji ,
 Kizildere Geothermal Power Plant
 Installed capacity: 95 MW (aprox.)

 Denizli, Türkiye

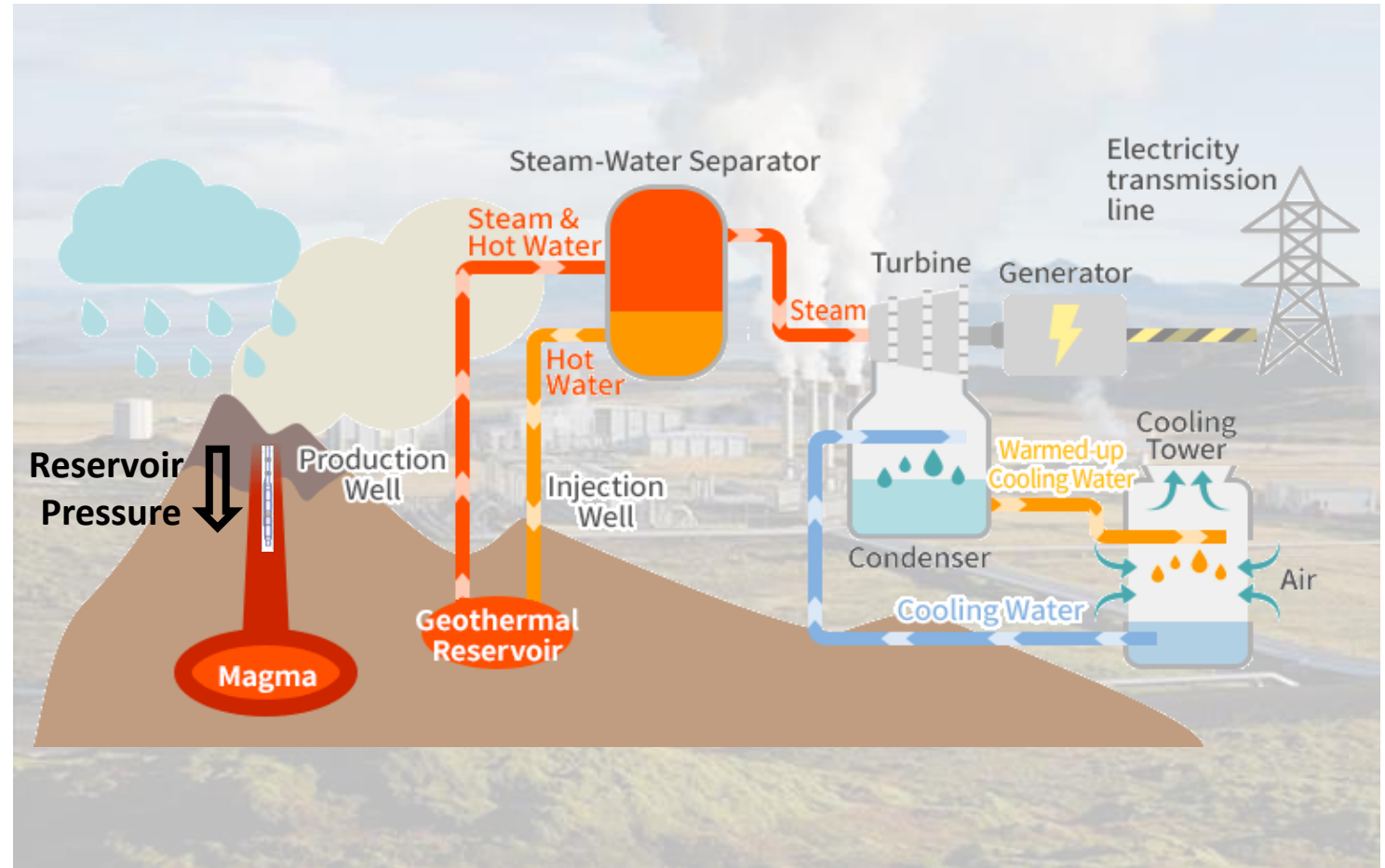


Variable	Unit	Value Range
Well Head Pressure (WHP)	barg	0-11
Well Head Temperature (WHT)	°C	170-190
Non-Condensable Gases (NCG)	%	1-2
Productivity Index (PI)	tph/bar	16-30
Flash pressure	bar	40-90
Feed Point	m	2000-3500
Reservoir Temperature	°C	200 to 240
Casing Size	In/lbs-ft	9 5/8
Inclination	degrees	1-10
Dogleg Severity (Pass Through)	°/30 m	0-3
Dogleg Severity (Operation)	°/30 m	0-1



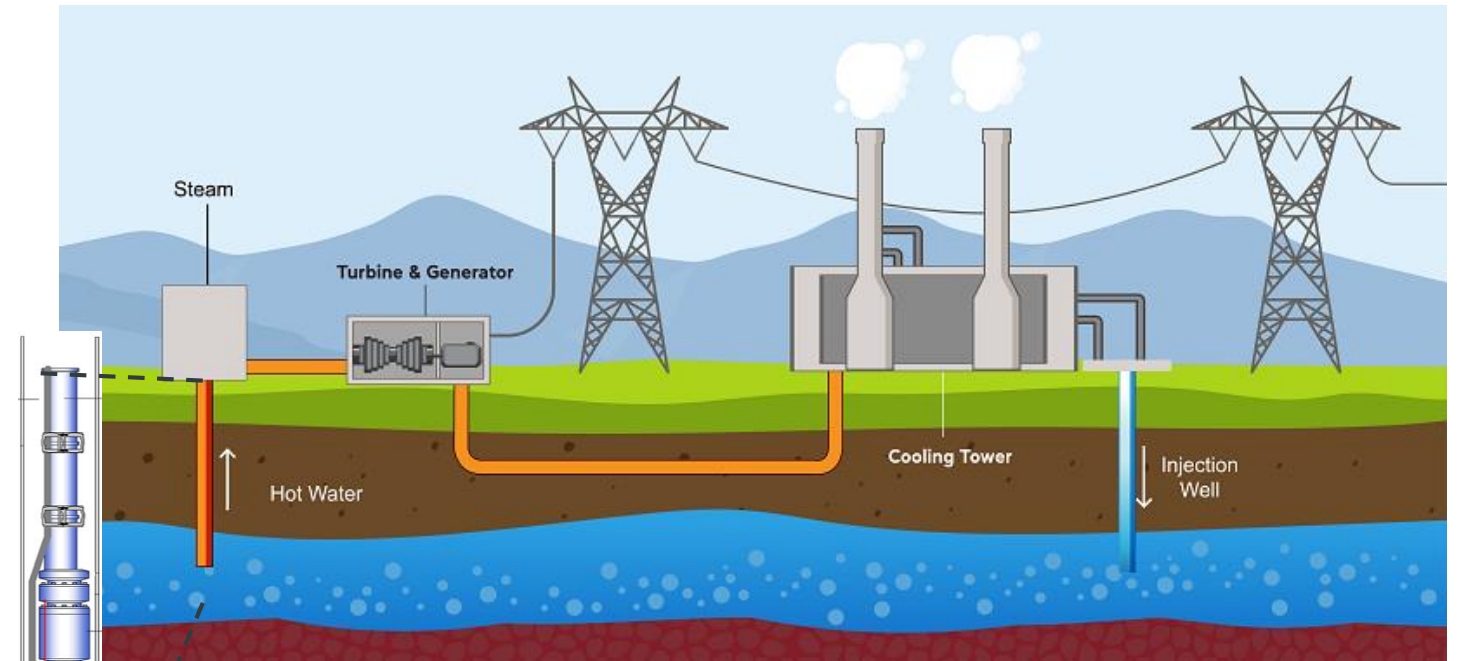
Geothermal Energy

- **Renewable:** Available for billions of years
- **Baseload:** 24/7, regardless of weather conditions.
- **Small footprint**
- **Clean:** Less greenhouse gasses, emissions, less water consumption



ESP and Geothermal Energy

- Improve flow rate
- Could be installed in deviated wells
- Reduced installation time (compare with other ALS)
- Flexible operating range
- No loss of lube-oil to formation due to self-contained lubrication

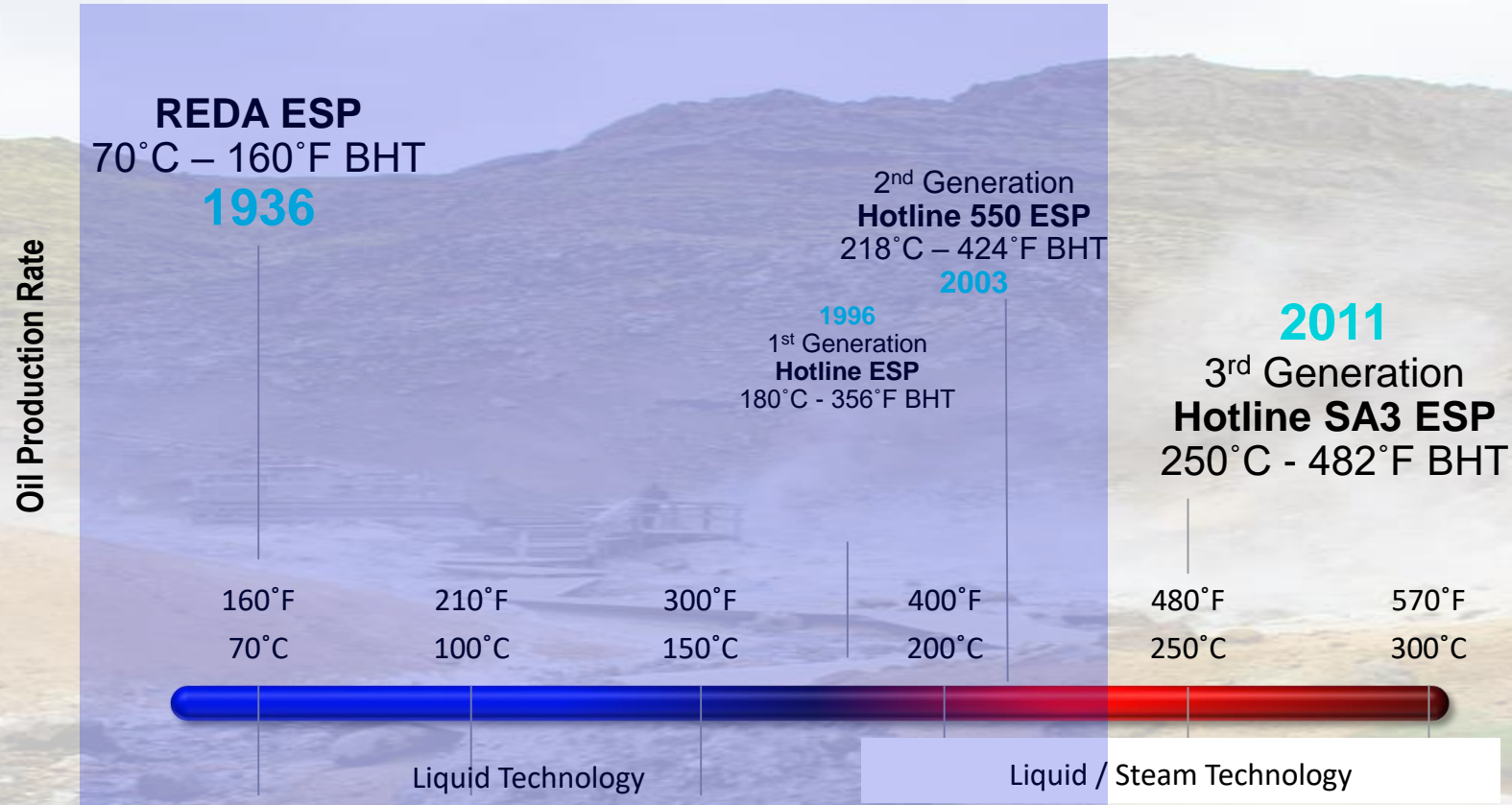


A Geothermal Power Plant

ESP (Centrifugal Pump, Intake, Protector-Seal, Downhole Motor)



ESPs in Geothermal wells



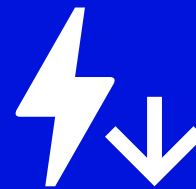
Oil Wells, Low-Enthalpy Geothermal
Line Shaft Pumps, Traditional ESP

SAGD, High-Enthalpy Geothermal Wells, EGS
Line Shaft Pumps, Geothermal ESP

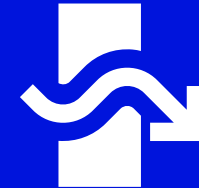
The geothermal ESP challenge



>400 °F
[>200 °C]



Parasitic load
reduction



High flow rate
and high
horsepower



Reliability



Alternative ESP Solution. A Novel approach

PMM Motor 1000 HP

High Horsepower
High Efficiency [94%]
Single unit
Encapsulation
High temperature materials

Protector

Metal bellows Shaft Seal
Dual sealing
High temperature materials

Pump

High efficiency
High thermal conductivity
material

MLE/Cable

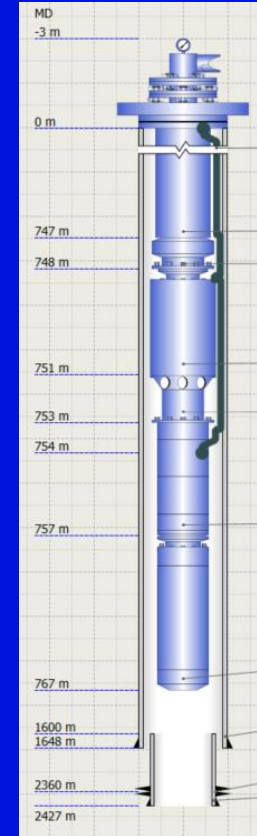
Advanced sealing
Individual phase connection into
motor
High temperature materials

Experience in Oil & Gas to
enable Geothermal Solutions
and reliable alternatives



Field Deployment. Proving a concept

Well ID	KD-A
T_{PSD}	213 °C (415 °F)
Q (Natural Flow)	126 tph
T_{WH}	166 °C (330 °F)
P_{WH}	7.9 bar
Power Generation (Natural Flow)	2.80 MWe in gross
Casing	9 5/8" (47 ppf)
Inclination	1.76 deg
PSD	750 meter



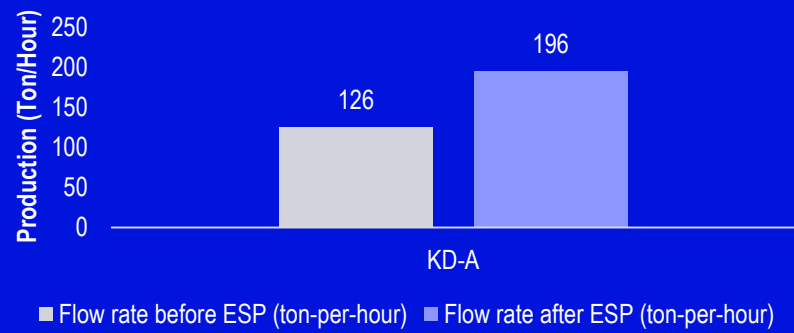
Pump
 OD: 7.25"
 Flow Rate @ BEP: 43000 (7500 m3/d)

Protector
 OD: 5.4"
 Modular, GT, High temperature

Protector
 OD: 5.4"
 Modular, GT, High temperature

PMM GT
 OD: 5.62"
 High Power Series, GT, High Temperature

Production comparison before and after geothermal ESP installation.



- Reservoir temperature: 213 degC.
- Incremental fluid production: 56%.
- Incremental AL Run life: > 2X. (>400 days).
- ESP power: < 0.4 MW.
- Power Generated by KD-A: 4.1 MW (Aprox.).
- Increase of 1.7 MW in power supplied to the grid

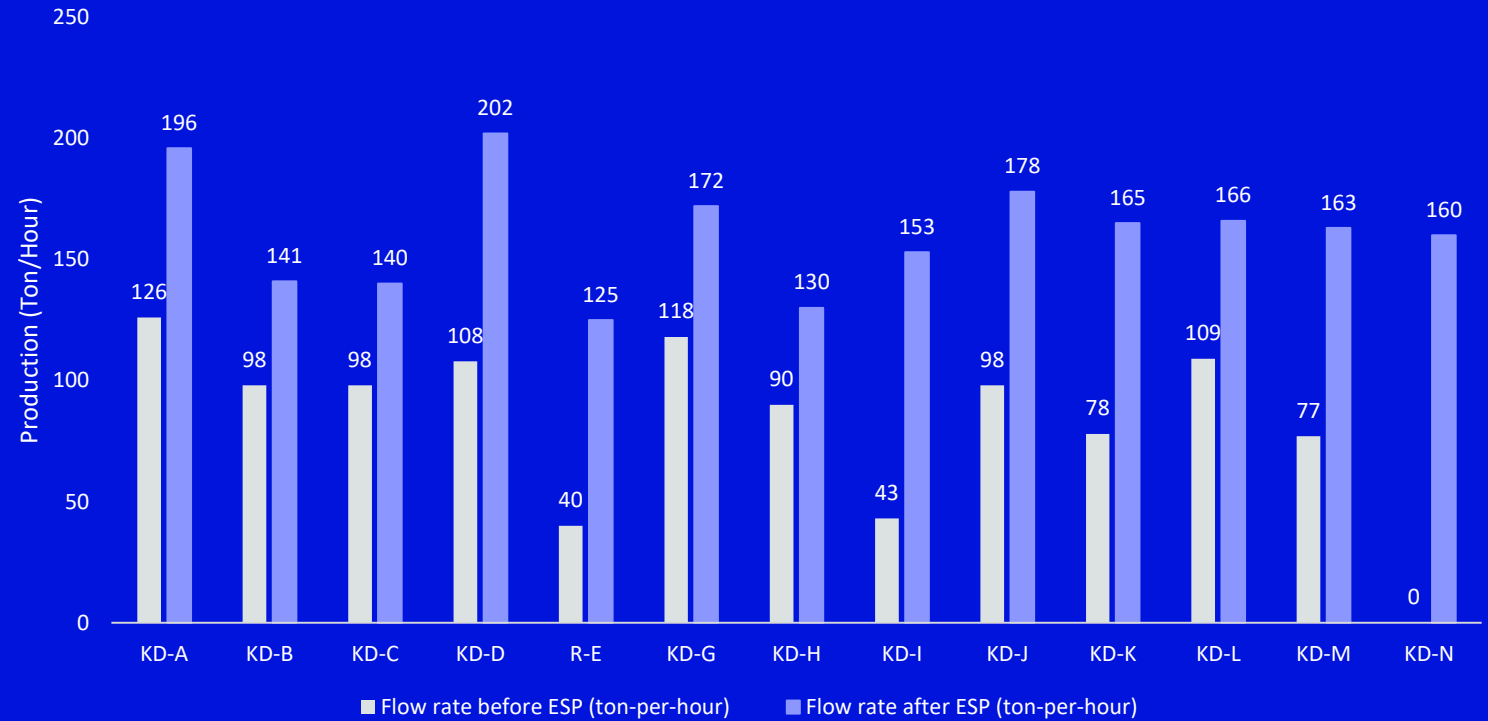


Field Deployments

- **13** Wells Already completed. (GT ESP Vs Natural Flow)
- Challenging well conditions including:
 - PSD of Up to 1700 mts.
 - BHT: Up to 230 degC.
- Average Workover operation (Days): 5
- Average Runlife of the units: 300 days
- **Max Runlife > 400 days @ Feb 2023**



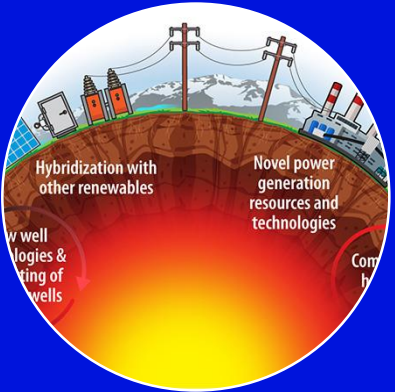
Production comparison before and after geothermal ESP installation.



Conclusions



Fluid production increased by nearly 90%. After thermal Novel ESP

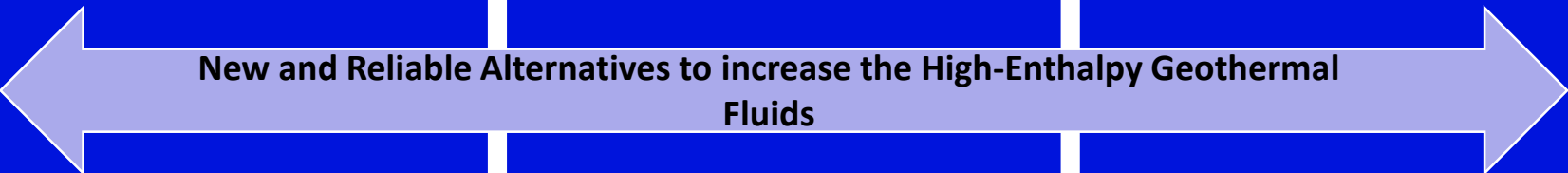


Additional advantages of the ESP system includes installation time, surface motor service and operational flexibility



Sustainable & Renewable Energy

95% less carbon emission than fossil fuel power plants of similar size



New and Reliable Alternatives to increase the High-Enthalpy Geothermal Fluids



Acknowledgements



Special thanks to Zorlu Enerji, SLB and GEOTHERM EXPO & CONGRESS
GeoTHERM expo & congress

J.L. Villalobos, M. Radov, Y. Hamitoglu, T. Can Bilmez, F. Navarro. SLB; E. Şentürk, M. Tuzen, Zorlu Enerji;

SLB, Houston, United States

SLB, Singapore Product Center, Singapore

SLB, Ankara, Türkiye

ZORLU Enerji, Denizli, Türkiye

Questions?

