GEOTHERMAL DRILLING INTRODUCTION

25 October 2022

Ir. Yudi Hartono
Geodipa PMU Drilling Manager

AGENDA

- Geothermal Drilling Overview
- Typical Geothermal Well Design and Drilling Operation
- Drilling Process
- Drilling Organization Chart and Personnel

My Career

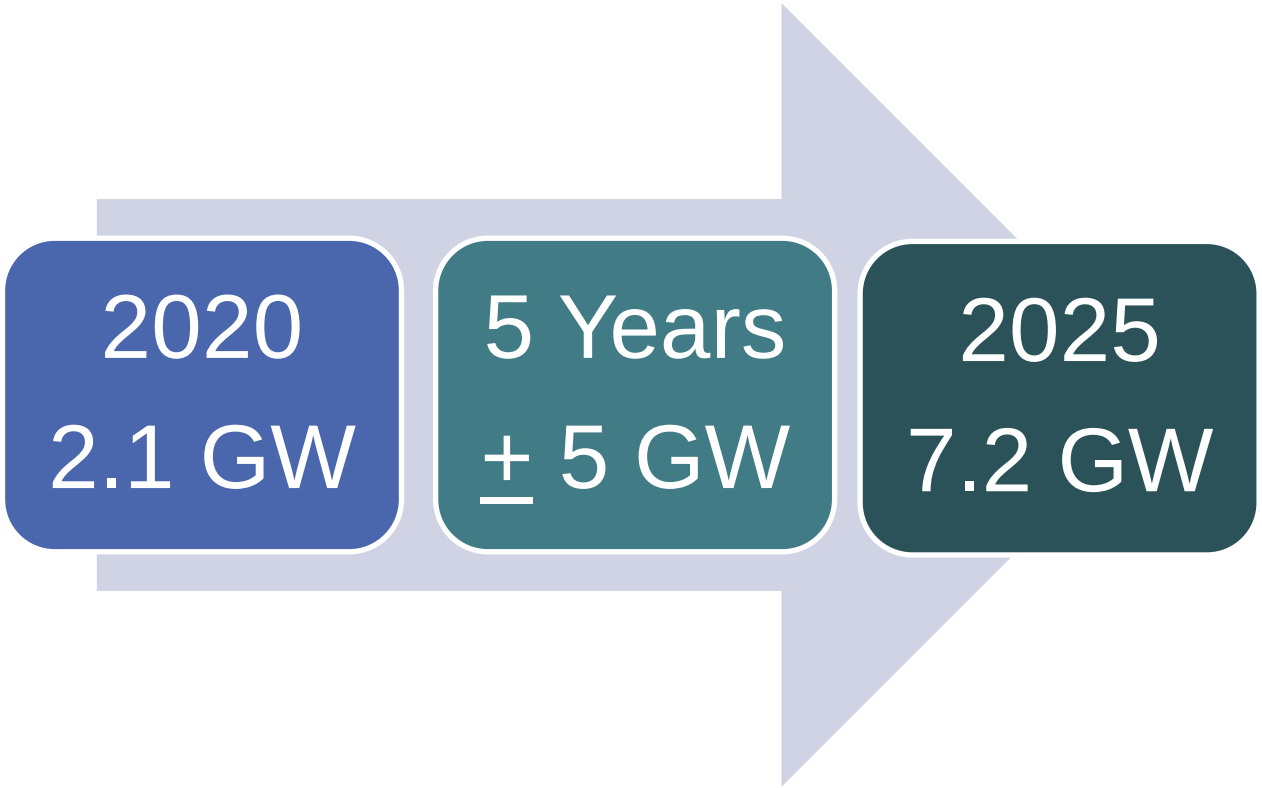
Yudi Hartono, Institut Technologi Sepuluh November (ITS), Mechanical Engineer, M-28.

1990: Mechanical Engineer , Vertical Pressure Vessel Engineer, PT IKPT: Train F Bontang LNG and Petrokimia Gresik.

Oil and Gas & Geothermal Energy:

- 1991 - 1996, Mobil Oil Indonesia, Drilling Engineer
- 1996 – 1998, PT Persada Madju, Drilling Engineer Consultant
- 1998 – 2003, Gulf Indonesia Resources, Drilling Engineer Consultant
- 2003 – 2005, Petronas Carigali, Kualu Lumpur, Drilling Engineer Consultant
- 2005 – 2006, BP Indonesia, Drilling Engineer Consultant
- 2006 – 2010, Pearl Oil, Drilling Engineer, Drilling Superintendent
- 2010 – 2012, Star Energy, Drilling Manager
- 2012-2013, Kris Energy, Drilling Engineer Consultant
- 2013-2015, Salamander Energy, Drilling Engineer Consultant
- 2015-2016, Talisman Energy, Drilling Engineer, Drilling Superintendent
- Agustus 2013 : ADB, Drilling Specialist.
- 2016 – 2018: PT SMGP & SGI, Drilling Engineer, Drilling Superintendent
- Oct – Dec 2018: Santos Sampang, Drilling Superintendent, 1 Offshore, well JU.
- Jan 2019 – March 2020: KS Orka, Geothermal, Drilling Superintendent.
- Jun 2020 – Now: PT Geo Dipa Energi, Drilling Manager
- 2019 – Now: JDS headmaster

Geothermal Drilling in Indonesia

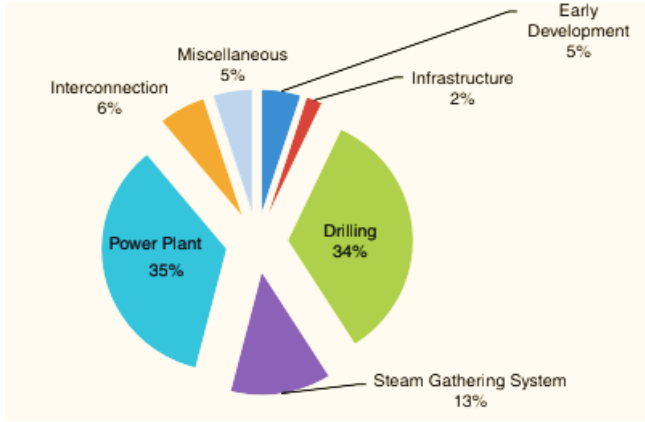


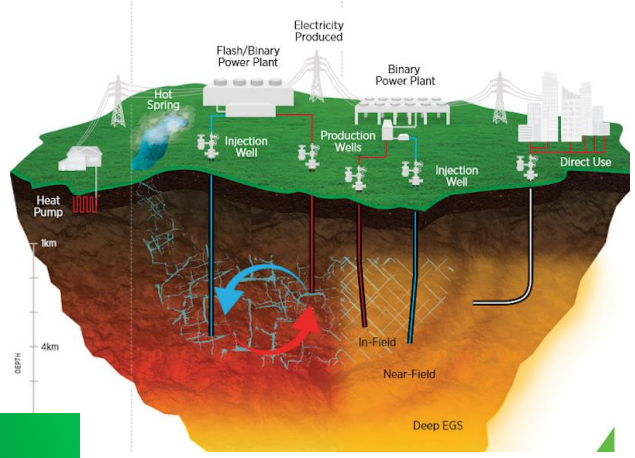
Then (Assumption):

- Every year = 1,000 MW
- 5-10 MW per well → 100 - 200 Geothermal Production Well per year.
- 60% Success ratio + need to drill injection well, → **160 - 320 Geothermal Well per year**
- USD 5 mill / well → **0.8 - 1.6 billion USD drilling business** per year.

Drilling Is Critical Part, Why…?

- Aims to prove the existence of considerable temperature as well as delineate the resource area for further development.
- Drilling Cost = **30-35%** of Geothermal Project Cost.
- Drilling will exist from beginning geothermal project until life of the field (Exploration, Exploitation, Wells Maintenance until abandonment of the well)



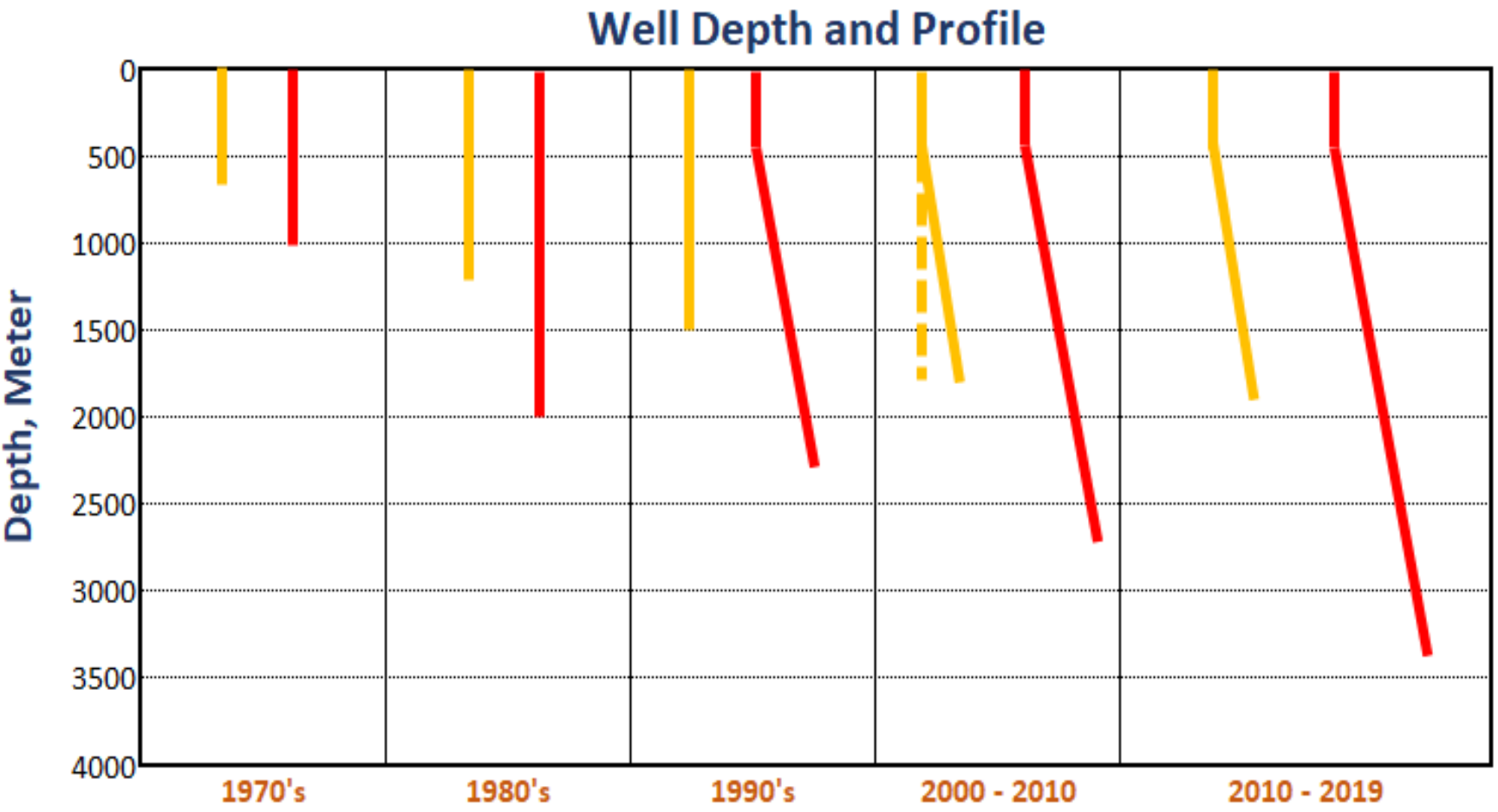


Drilling Success

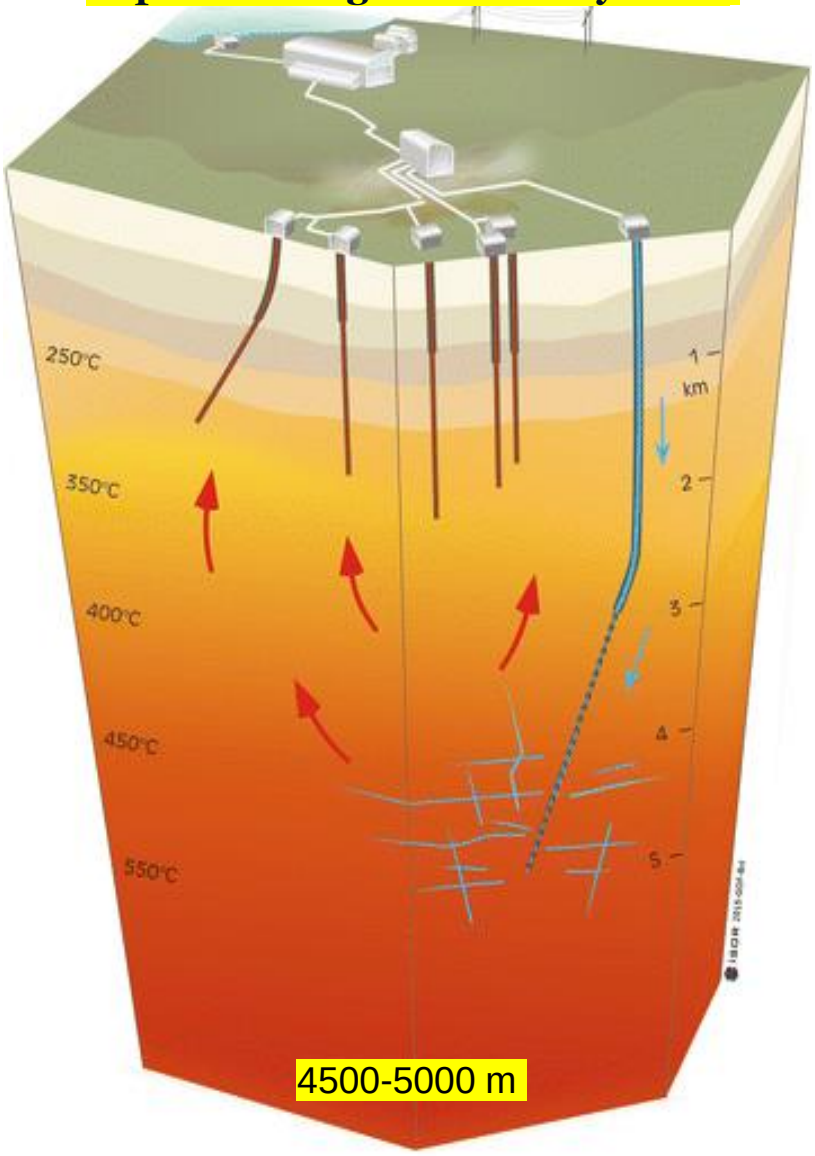
Geothermal Development

Total Depth of Geothermal Drilling Well

Conventional Geothermal Systems

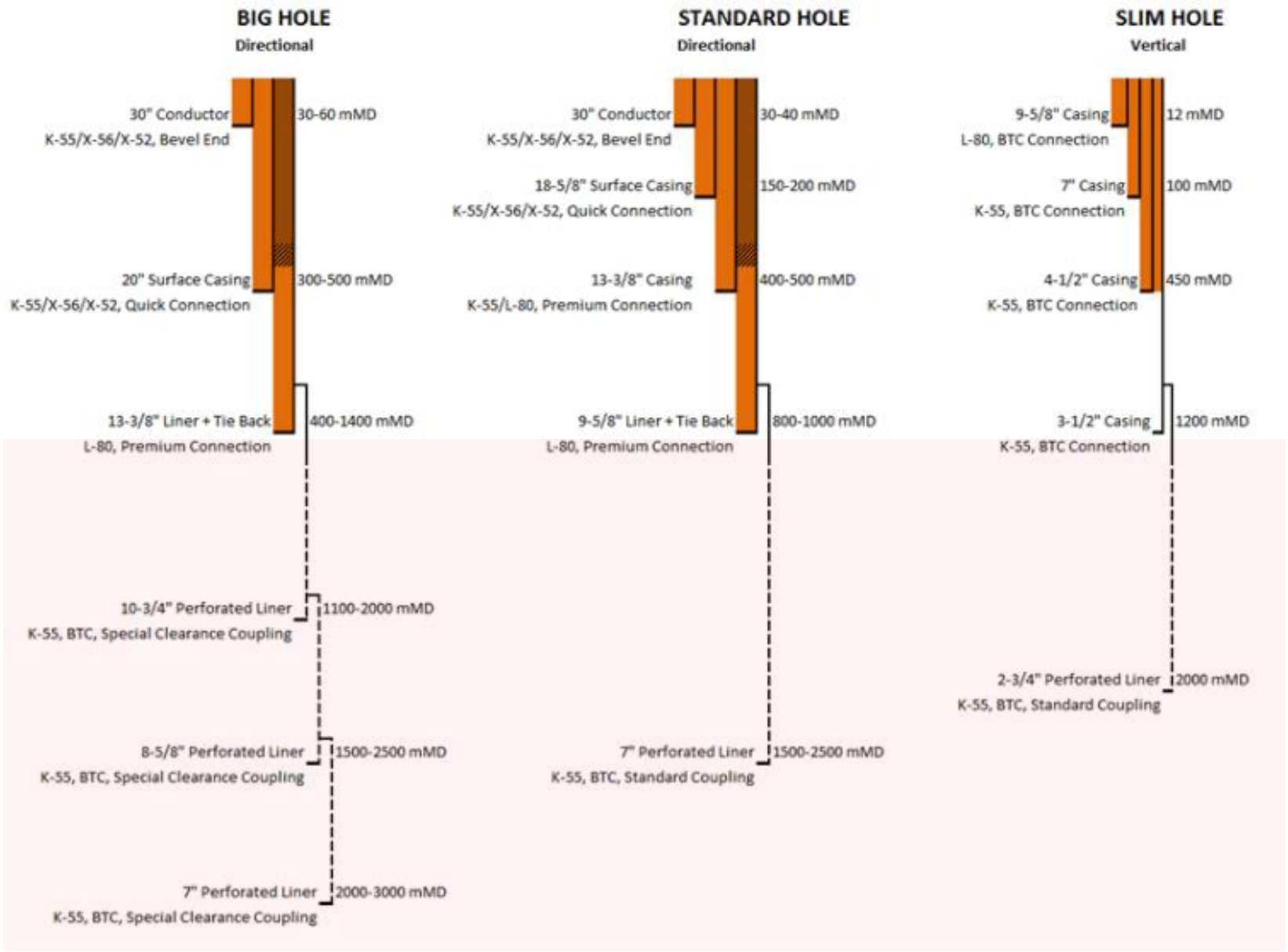


Supercritical geothermal systems



2017-2022

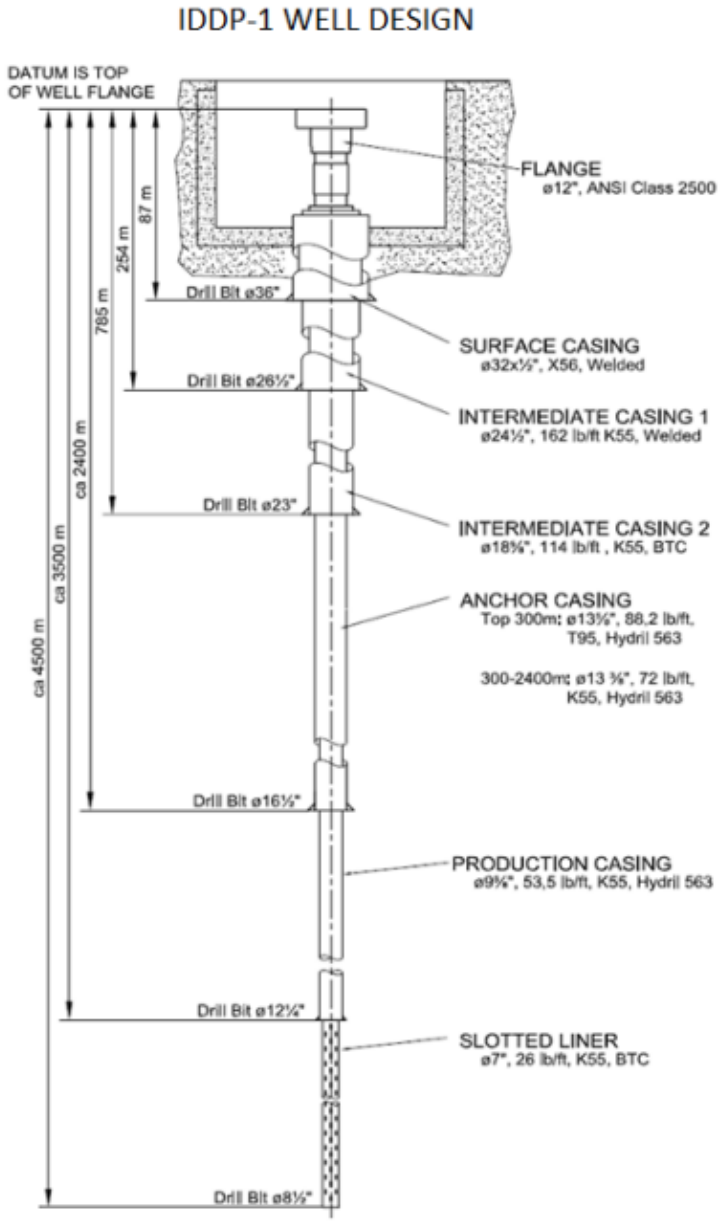
Typical Conventional Geothermal Well Design

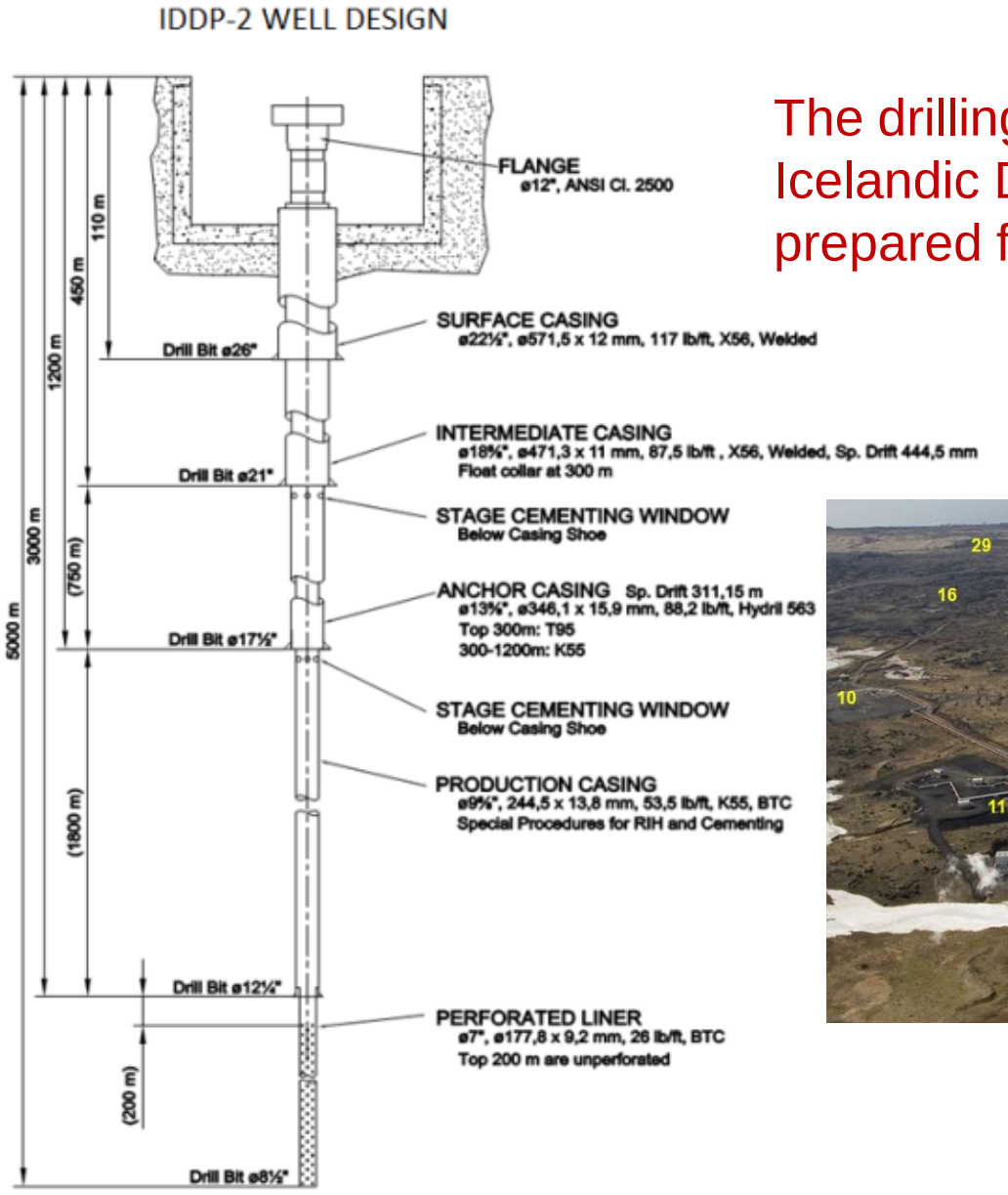


Big Bore is preferable:

- Less number of surface casing
- Could drill deeper
- More production hole section as contingency plan
- Similar well cost w/ Standard hole, even less cost
- Use bigger downhole tool → more temperature resistance

Super Critical Geothermal Well Design





The drilling of IDDP-2, well two of the Icelandic Deep Drilling Project, is being prepared for at Reykjanes, Iceland

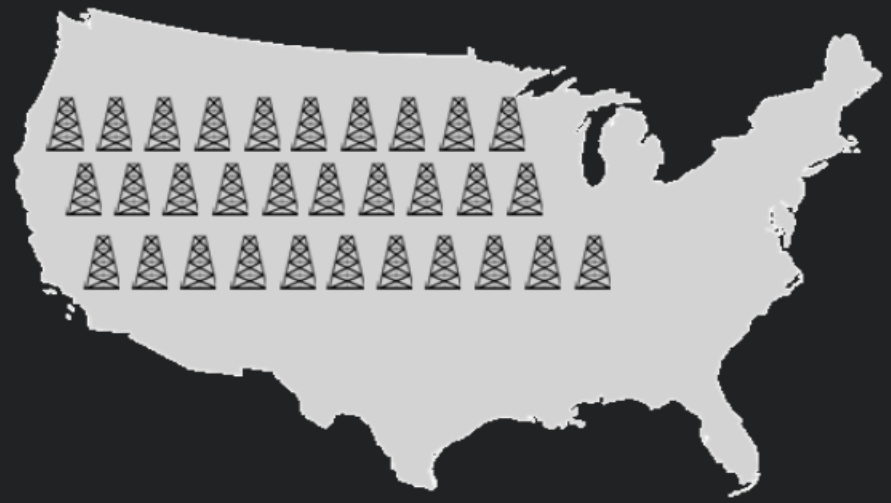
GeoX is the Lowest Scalable "Levelized Cost of Energy" $ per MWh

Levelized Cost of Energy (LCOE). Is total lifetime costs divided by energy production

https://www.iea.org/reports/projected-costs-of-generating-electricity-2020

GeoX Synthetic Supercritical generates 10X to 55X more Energy

Conventional 370ºF / 200ºC
31 Wells = 50 MWe



Only 15,000 MWn last 100 Years

Needs 4 attributes occur all in the same place :
1) Hot rocks
2) Permeable Wet Rock
3) Abundant water
4) Convected circulating water

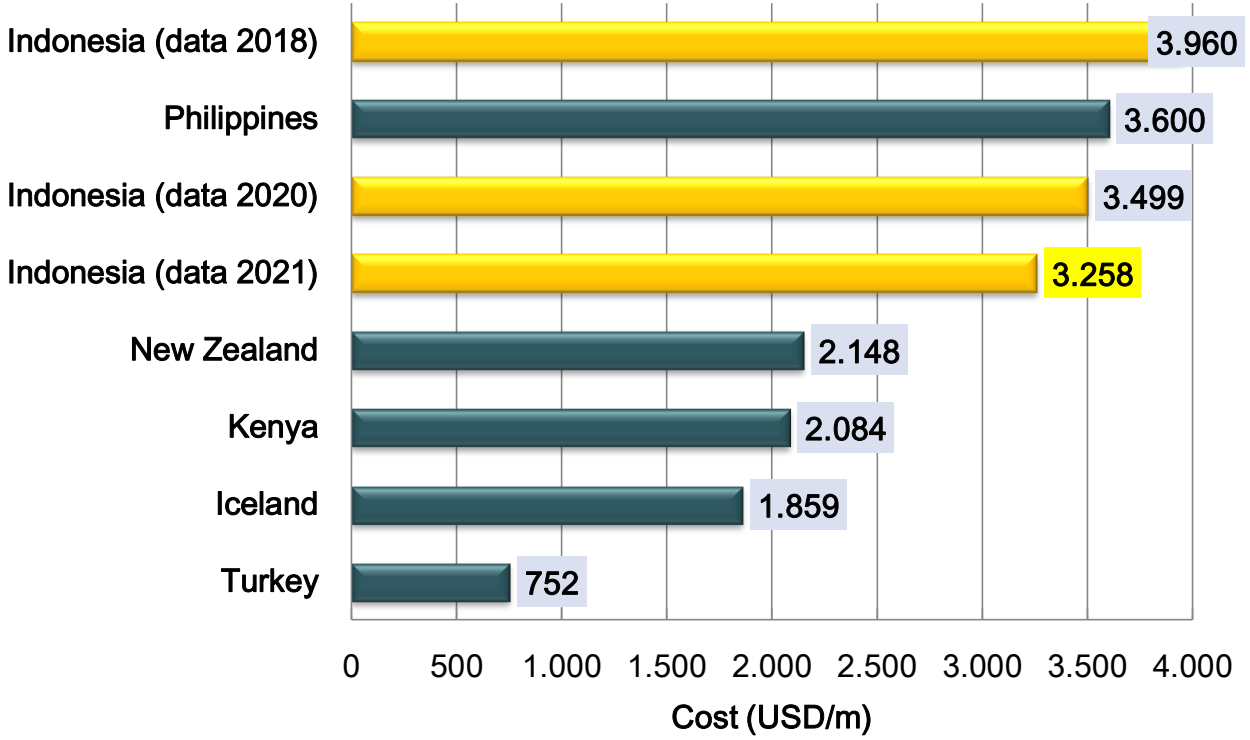
GeoX Supercritical 850ºF / 450ºC
3 Wells = 50 MWe

Supercritical Synthetic Geothermal

Only 1 attribute required "Dry Supercritical Rocks"

STATUS BIAYA PENGEBORAN PANAS BUMI (2018-2021)

Country comparison



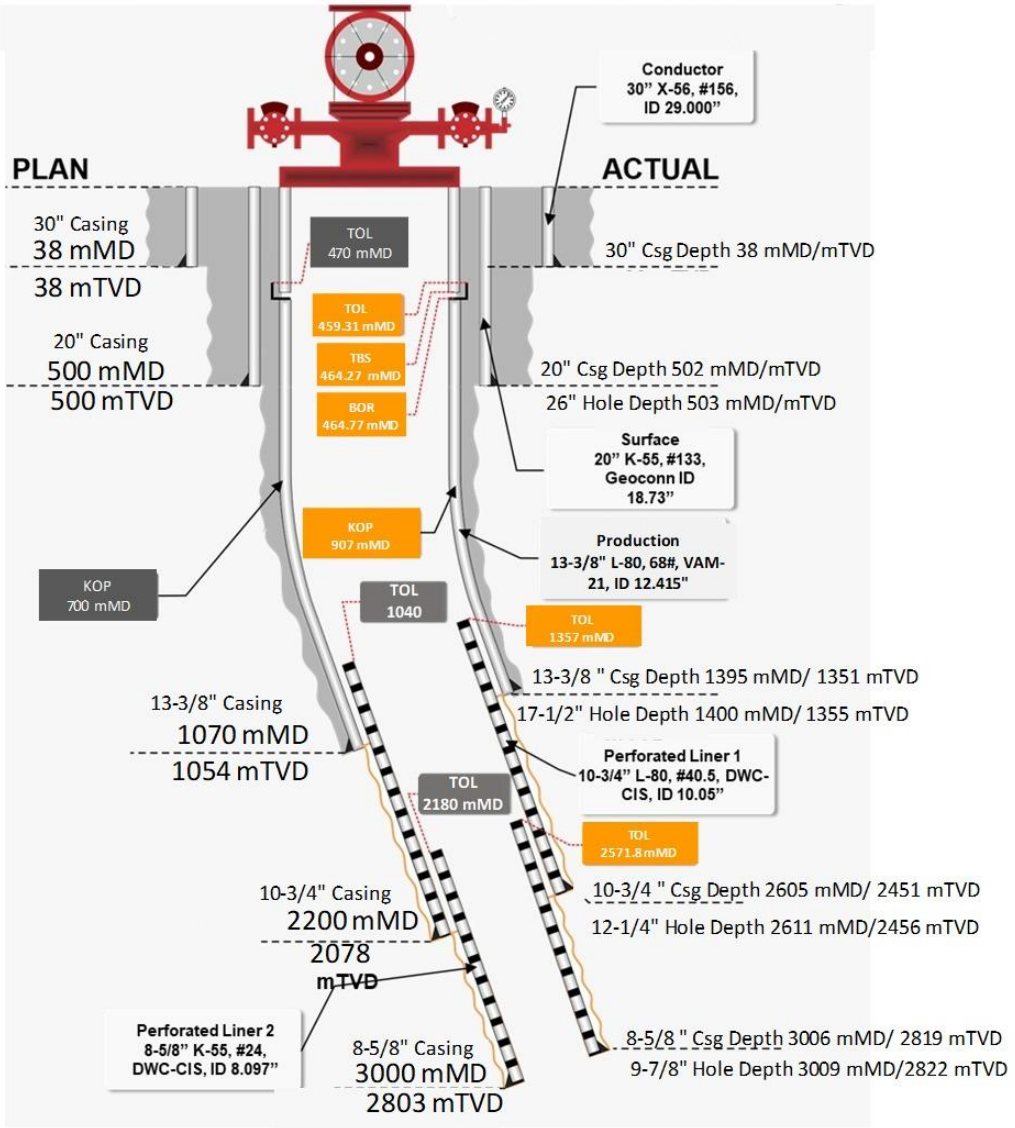
Highlight pengeboran di Indonesia

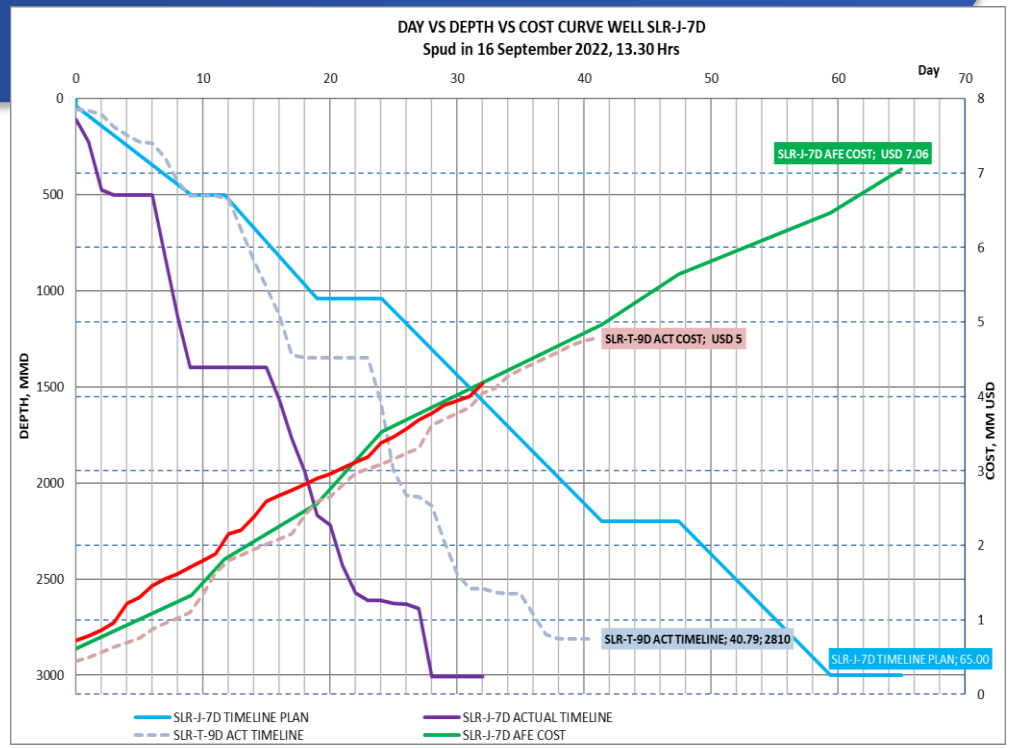
- Biaya mobilisasi dari yard rig hingga ke lokasi yang *remote* (jarak, pengadaan alat angkat tambahan).
- *Geological setting* pegunungan.
- Pada umumnya menggunakan perjanjian kontraktual konvensional *(daily rate*).

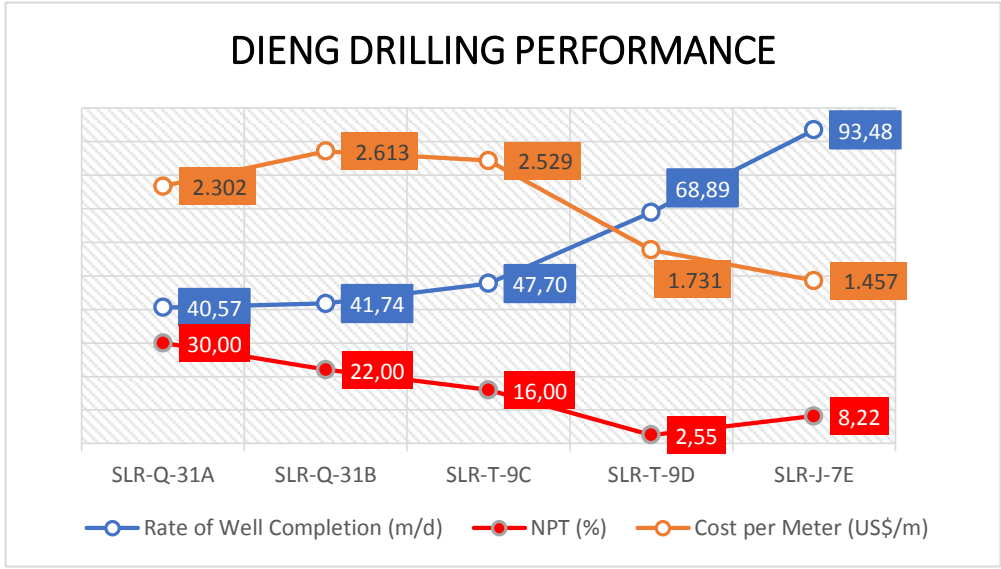
Perbandingan antar negara

- Pengeboran panas bumi di Filipina paling mahal, mengingat sistem panas bumi yang dalam dengan topografi pegunungan.
- Pengeboran di Kenya dan Islandia relatif lebih murah. Biaya pengeboran di Kenya yang dilakukan pengembang yang memiliki rig sekitar 3,5 juta USD/sumur dan dengan sewa rig sekitar 6,5 juta USD/ sumur (Ngugi, 2013) .
- Biaya pengeboran di Islandia berkisar antara 2,5-4,8 juta USD/sumur. Hal ini dikarenakan pengembang panas bumi mempergunakan *hybrid drilling contract*, yaitu gabungan *daily rate, meterage* & *lump sum* dengan biaya 1000-2000 USD/m (Palsson, 2017).
- Pengeboran di Turki lebih murah karena pada umumnya memiliki sistem panas bumi pada *geological setting* yang relatif datar yang didominasi oleh batuan carbonat sehingga lebih mudah dibor.

Dieng-2 Drilling Performance: SLR-J-7E

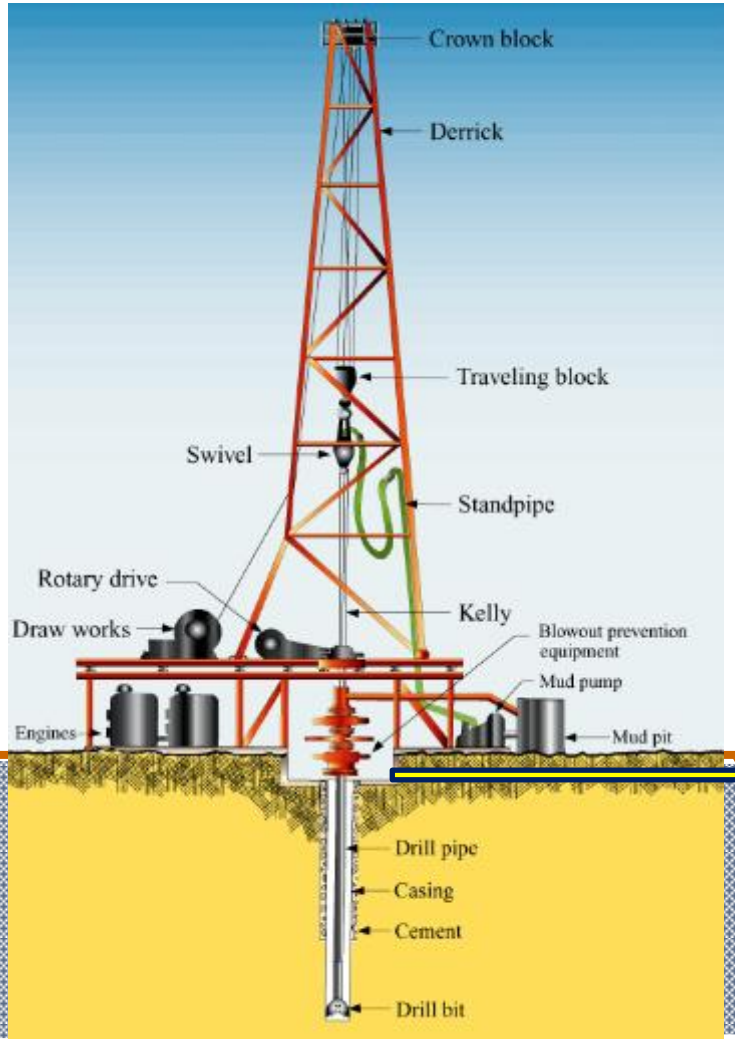






Ideal Well Pad Design

Ideal: Elevated Well-Pad Design



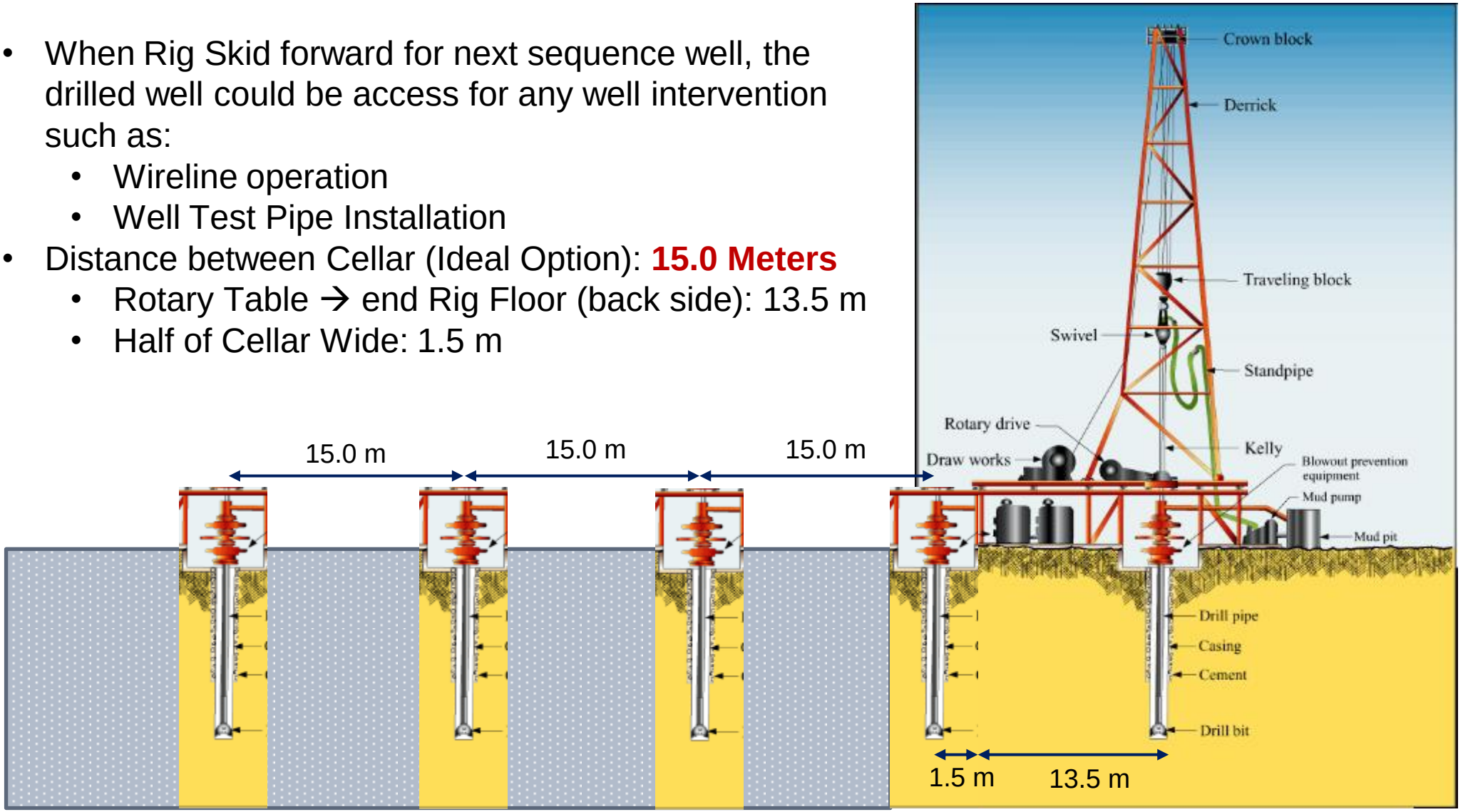
Underground Drainage Line from Cellar to Mud Pond

Settling Pond

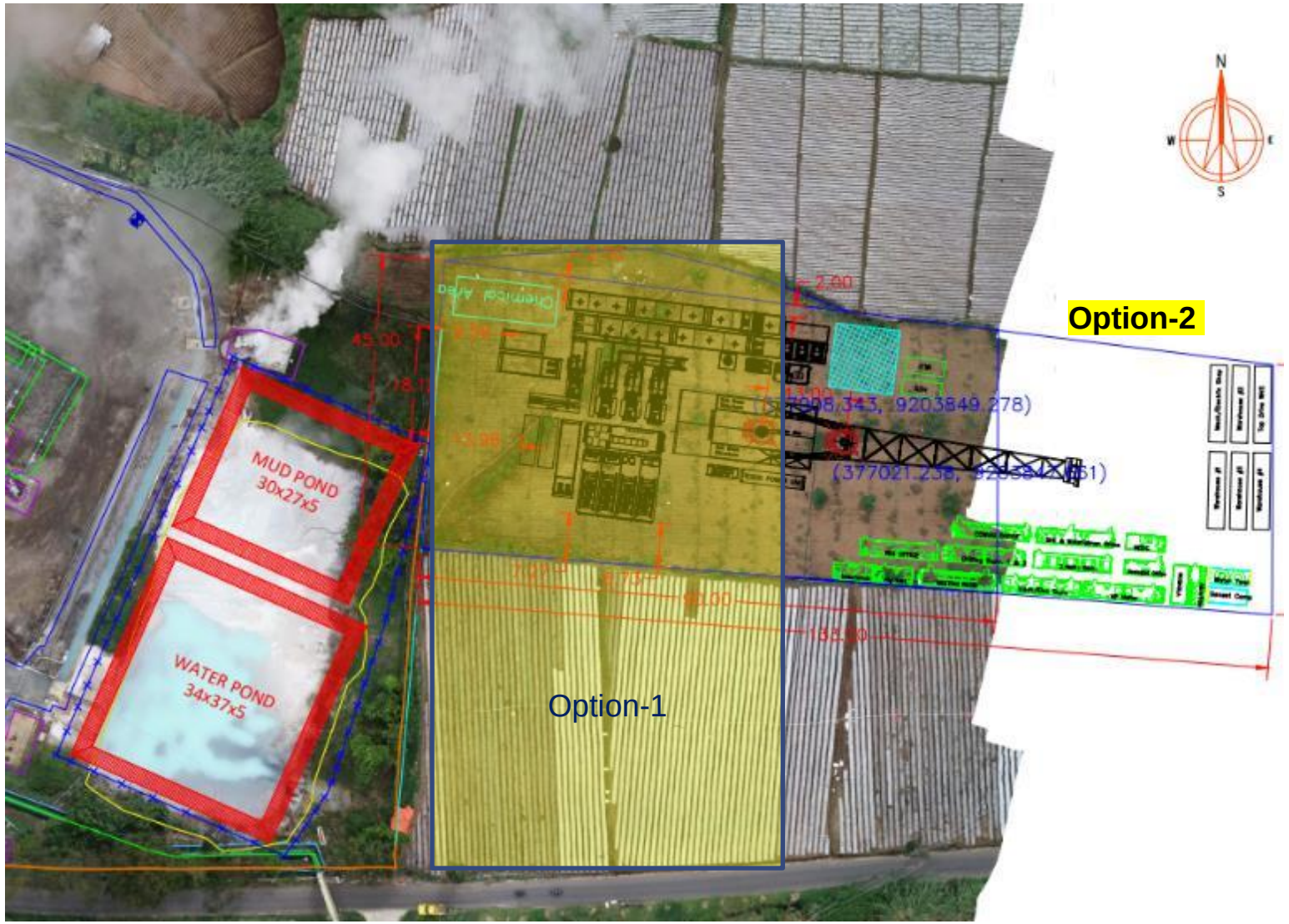
Water and Mud Pond

Rig Picture: Side View for Determining Distance between Cellars

- When Rig Skid forward for next sequence well, the drilled well could be access for any well intervention such as:
  - Wireline operation
  - Well Test Pipe Installation
- Distance between Cellar (Ideal Option): **15.0 Meters**
  - Rotary Table → end Rig Floor (back side): 13.5 m
  - Half of Cellar Wide: 1.5 m



Detail Rig Lay out Design



Case-1:

Best Case?


Pad-7 Dieng-2

Geothermal Drilling Work Location

Muara Laboh – Supreme Energy

Karaha Bodas

Wayang Windu, Pengalengan, West Java

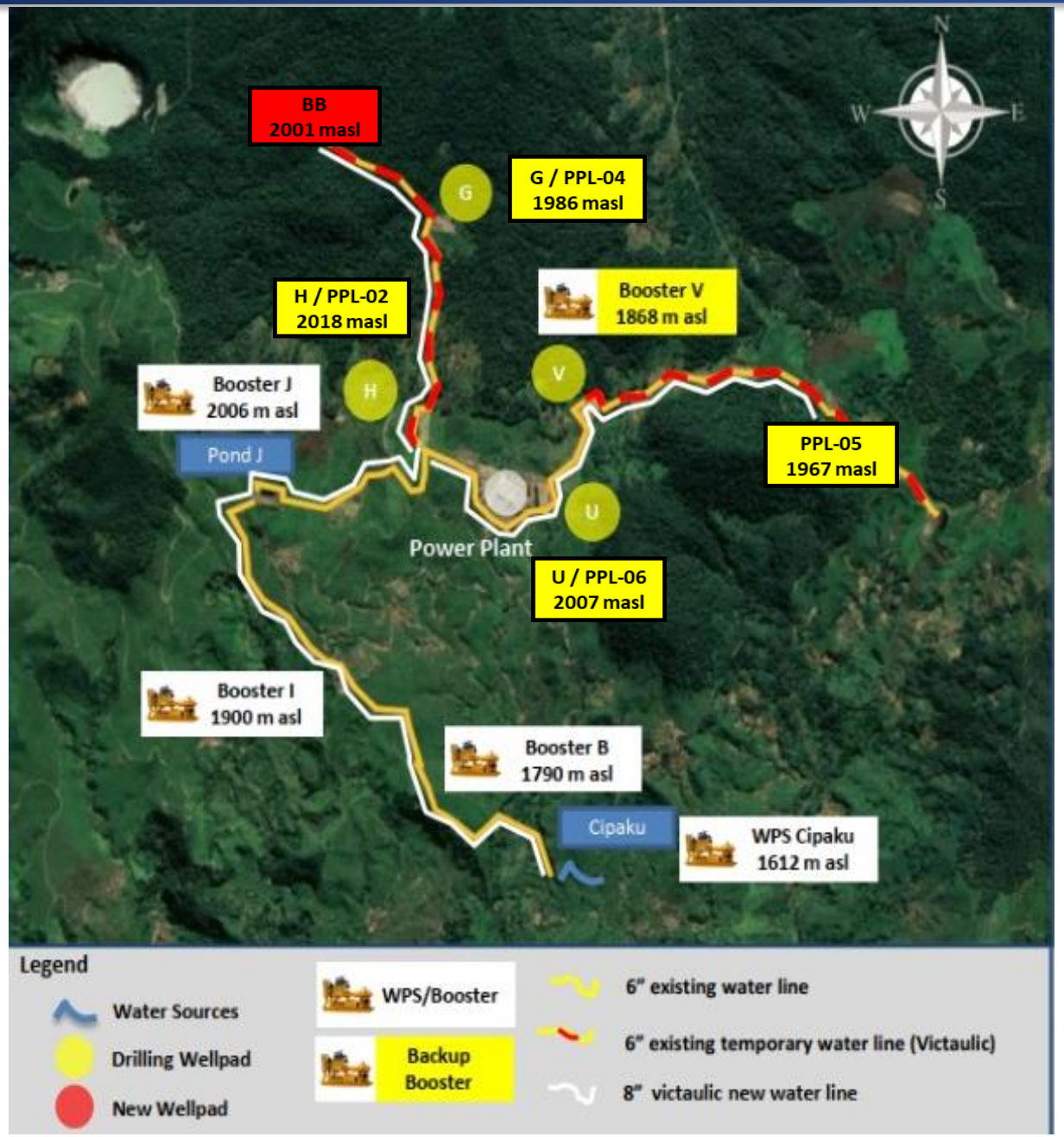
KS Orka – Sorik Marapi

KS-Orka - Sokoria

PT Geo Dipa Energi, Dieng, Central Java

PT Geo Dipa Energi, Patuha, Bandung West Java

Critical Water Supply



WATER MANAGEMENT PATUHA

Water Source :

- WPS Cipaku (pH ±7)
- Belum dilakukan pengukuran debit air di WPS Cipaku

Proper Rig Type Selection


Drawwork

Mud Pumps


Hawk Jaw

Top Drive System


Rotary Table


Drill Pipe


Rig Skid System

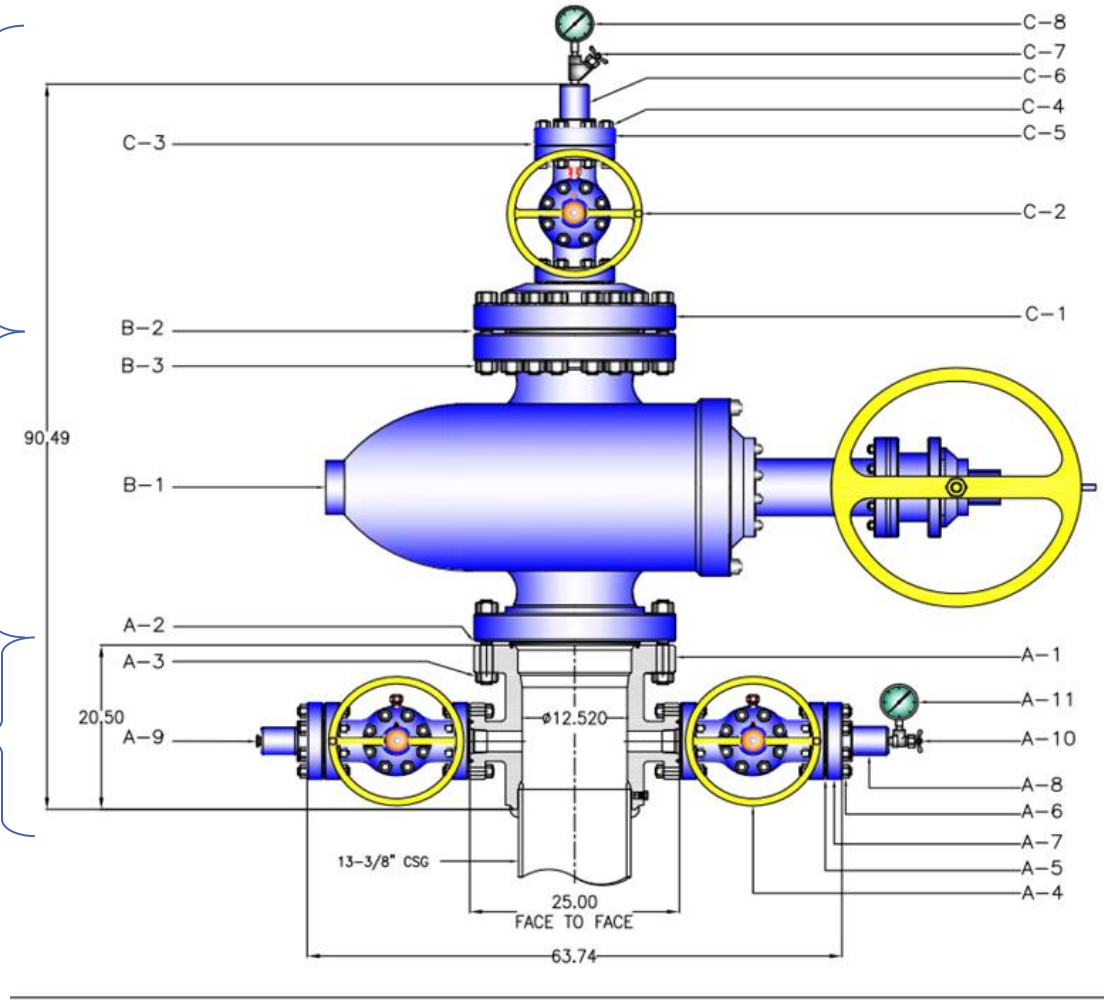

Rig Walking System

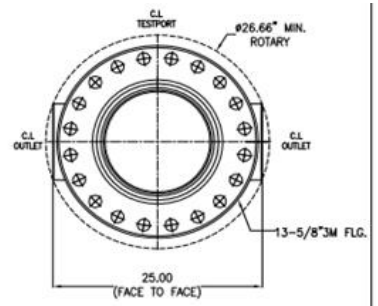
Wellhead Design

Companion Flange

Master Valve

Wellhead Housing





CASING HEAD
VIEW TOP

NO	DESCRIPTION	QTY
C-8	PRESS. GAUGE, 0-3000 PSI, W/1/2"NPT CONN.	1
C-7	NEEDLE VALVE, STRAIGHT, MxF, 1/2"NPT CONN.	1
C-6	BULL PLUG, 3"LP x 6"LG., W/1/2"NPT	1
C-5	COMP. FLANGE,3-1/8" 3M, W/3"LP	1
C-4	STUDBOLTS, W/TWO NUTS ZINC COATED ø7/8"-9NC DIA X 6-1/4" LG.	8
C-3	API RING GASKET, RX-31 SS	2
C-2	GATE VLV.,3-1/8" 3M PSI,W/3-1/8" 3M , FE.	1
C-1	ADP. FLANGE,12" CLASS 900 X 3-1/8"3M STD'D.TOP.	1
B-3	STUDBOLTS, W/TWO NUTS ZINC COATED ø1-3/8"-8NC DIA X 10-3/4" LG.	20
B-2	API RING GASKET, RX-57 SS	1
B-1	MASTER VALVE, 12" CLASS 900,W/12" CLASS 900, FOR GEOTHERMAL ,FE,RTJ. BEVEL GEAR.	1
A-11	PRESS. GAUGE, 0-3000 PSI, W/1/2"NPT CONN.	1
A-10	NEEDLE VALVE, ANGLE, MxF, 1/2"NPT CONN.	1
A-9	PLUG , 1/2" NPT.	1
A-8	BULL PLUG, 3"LP x 6"LG., W/1/2"NPT	2
A-7	COMP. FLANGE,3-1/8" 3M, W/3"LP	2
A-6	STUDBOLTS, W/TWO NUTS ZINC COATED ø7/8"-9NC DIA X 6-1/4" LG.	32
A-5	API RING GASKET, RX-31 SS	4
A-4	GATE VLV.,3-1/8" 3M PSI,W/3-1/8" 3M , FE.	2
A-3	STUDBOLTS, W/ TWO NUTS ZINC COATED ø1-3/8"-8NC DIA X 10-3/4" LG.	20
A-2	API RING GASKET, RX-57 SS	1
A-1	CASING HEAD,13-5/8" 3M TOP X 13-3/8"SOW. W/TWO 3-1/8" 3M EXTENDED FLANGE SIDE OUTLETS	1

PT. Sarana Adikarya Utama

TITLE : WELLHEAD ASSEMBLY FOR GEOTHERMAL 13-5/8" X 13-3/8" CSG. – 3000 PSI 550 DEG. F

APPV. BY CUSTOMER:

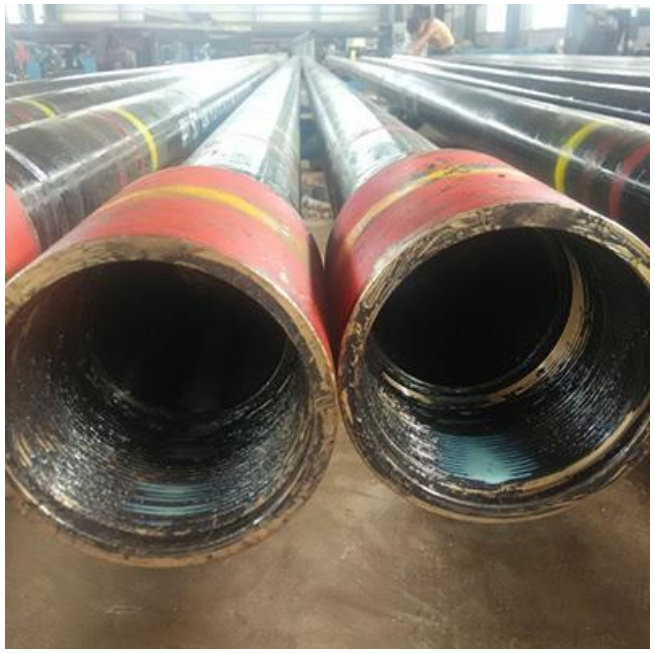
CUSTOMER : KSO ORKA SORIK MERAPI

DWG. NO. : CCSAU -10421A | REV. 00

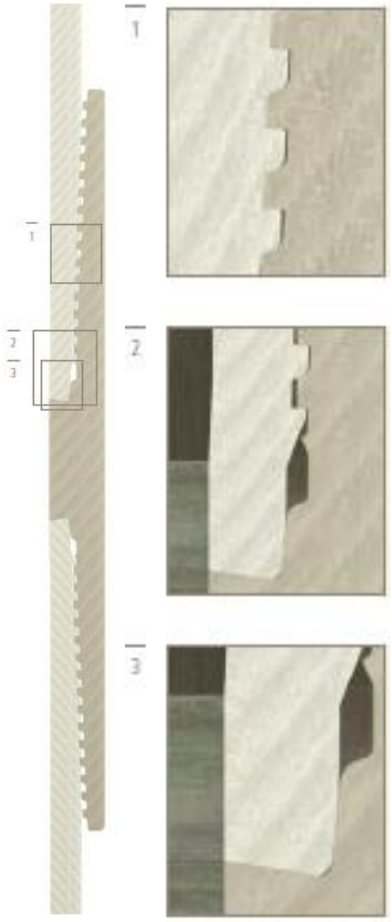
SPEC. API : –

MATERIAL CLASS : 'DD-NL'		PREP.	SAMSUL	25/01/18
TEMPERATURE : 'Y' (0-650°F)		CHECKED	ASSEGAF	25/01/18
RATING LEVEL : PSL-1	PR-1	APPROVAL	DAMON	25/01/18

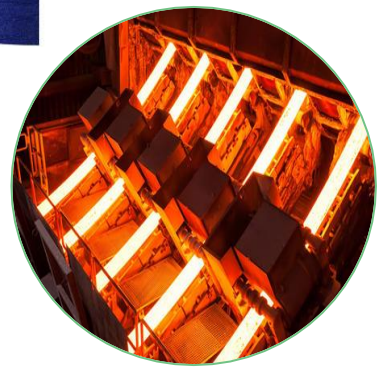
Casing Design



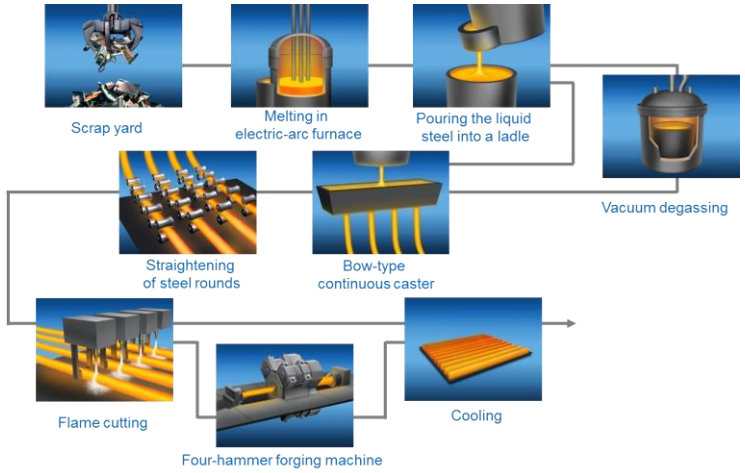
Casing Box and Pin



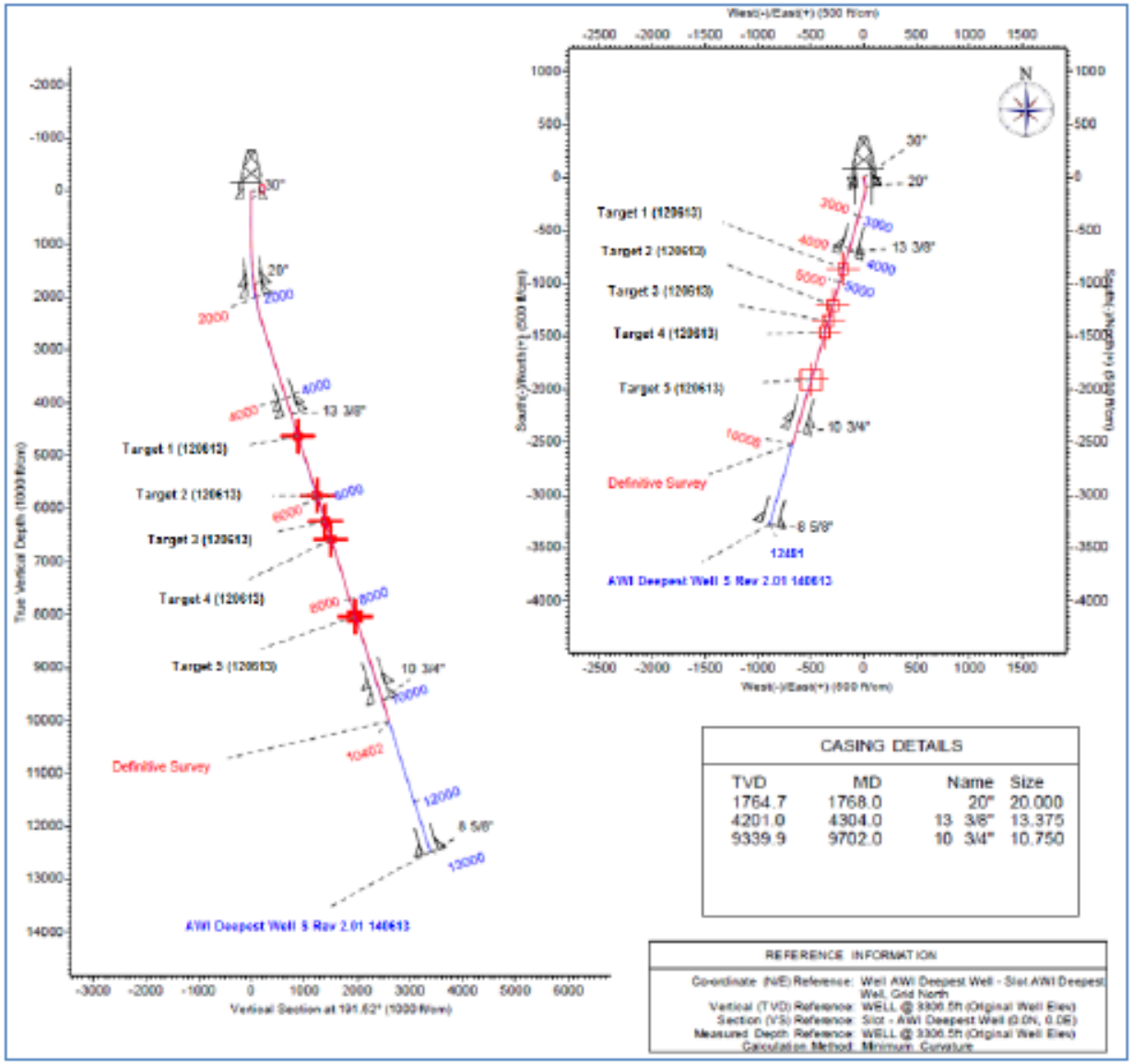
Premium Thread

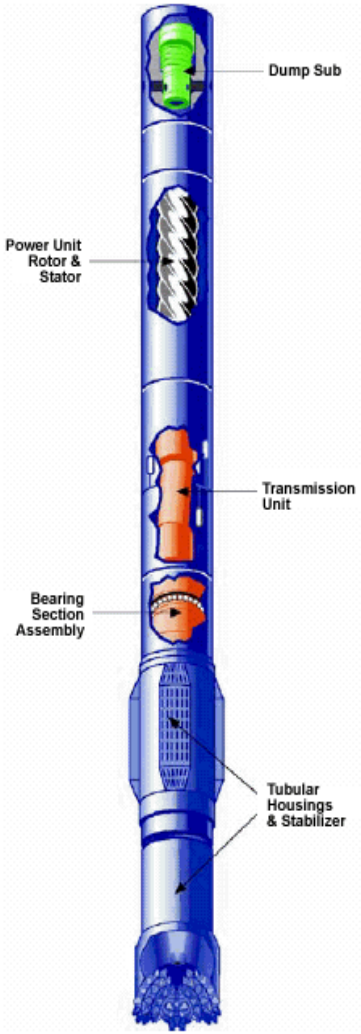


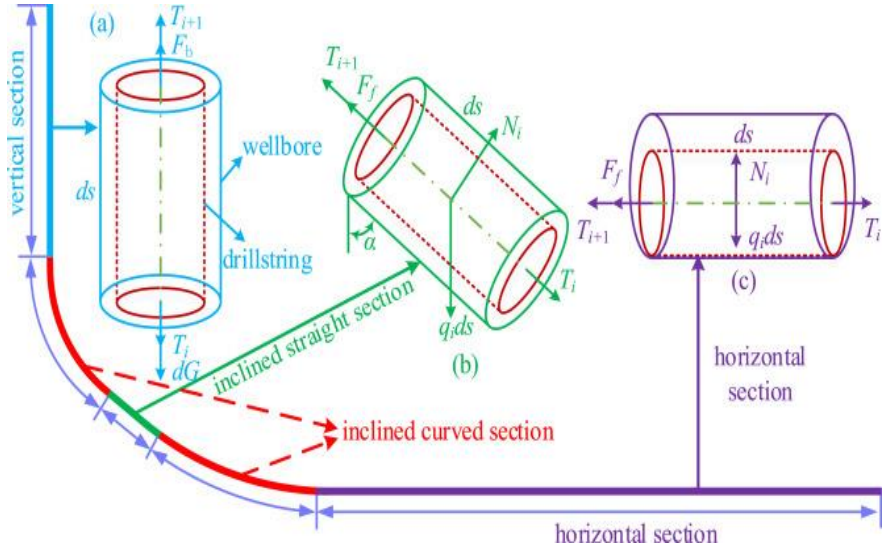
Quick Connector

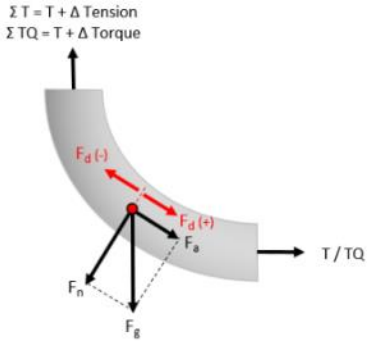


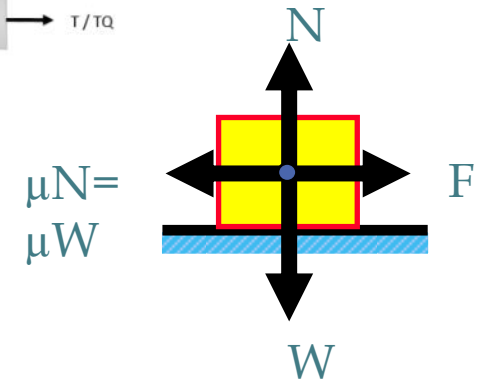
Well Trajectory, BHA, Torque and Drag











Drilling Bits

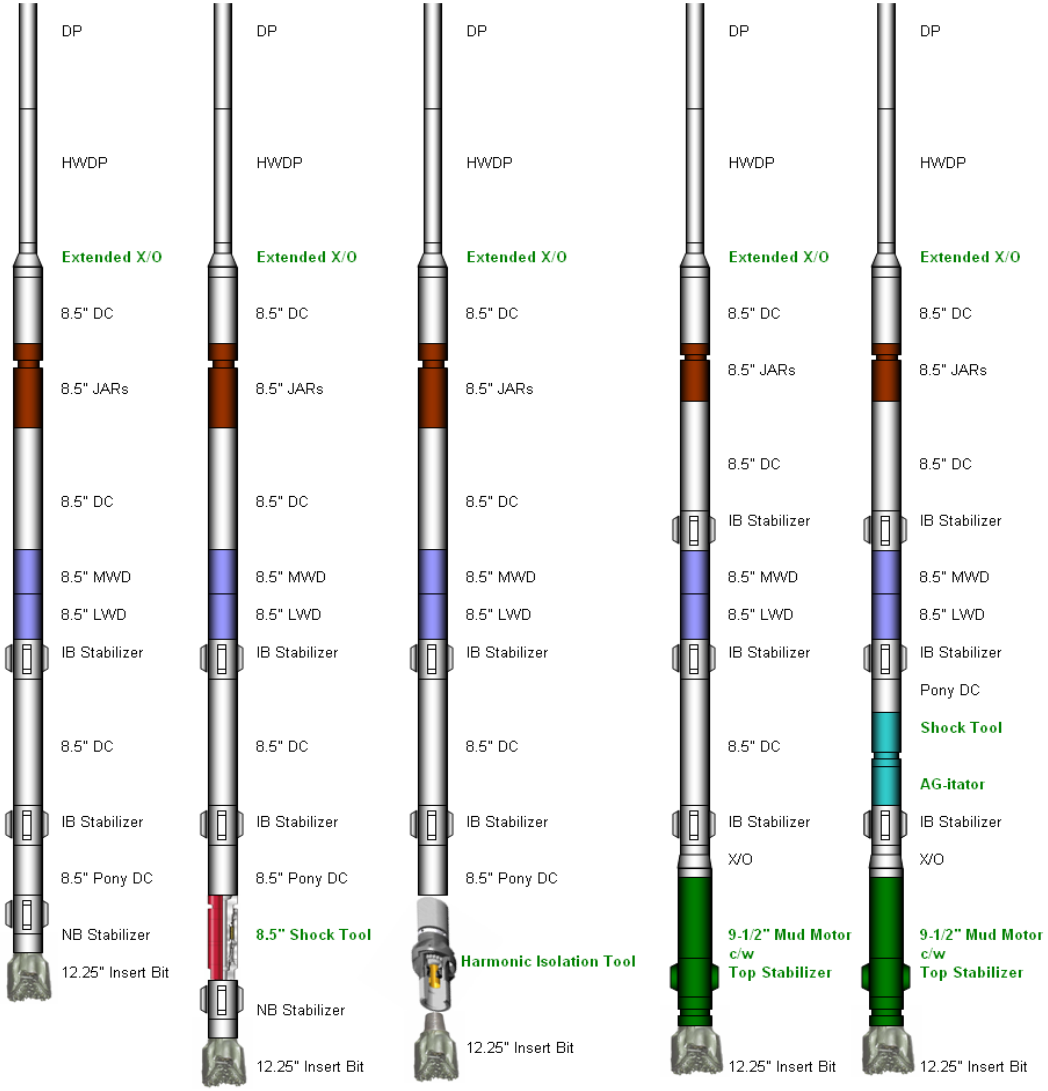
- Drilling Bit
  - Tri Cone
    - Mill Tooth
    - Insert
  - Hybrid
    - Keymera
  - PDC

New Drilling Bit Technology: Faster and Longer Run

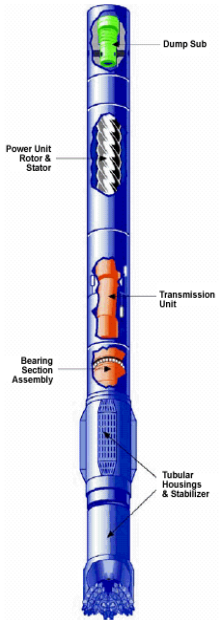
Sting Blade
PDC Bit

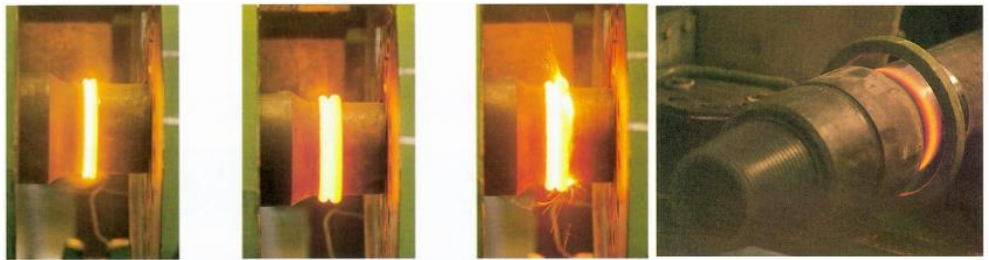
Kymera
Hybrid Bit

Develop Less Vibration Bottom Hole Assembly



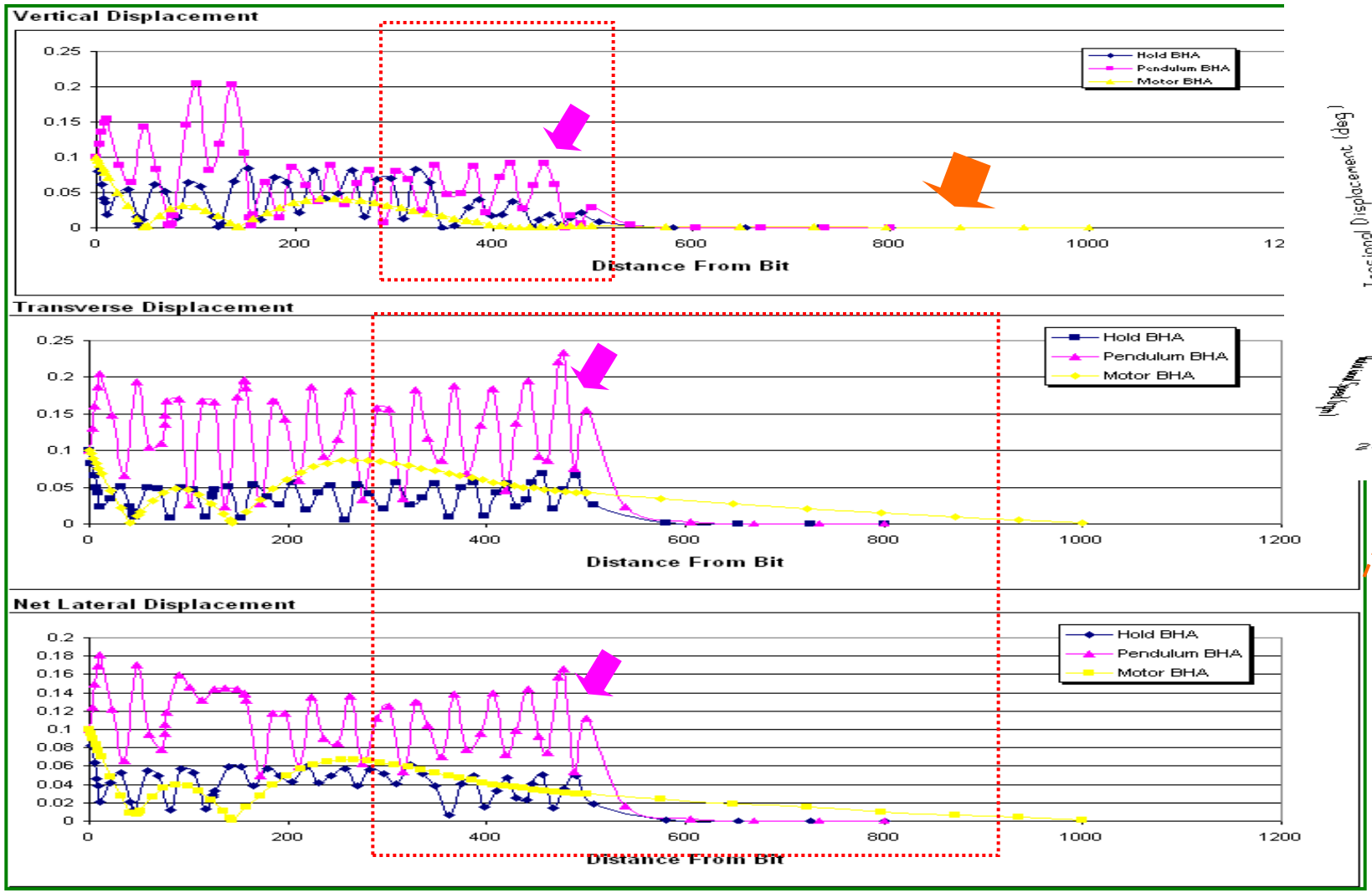
- BHA Configuration
- Directional BHA
- Survey and Navigation
- BHA failure and stress check
- Hard Banding
- Hard Facing
- Friction Welding
- BHA Vibration Analysis

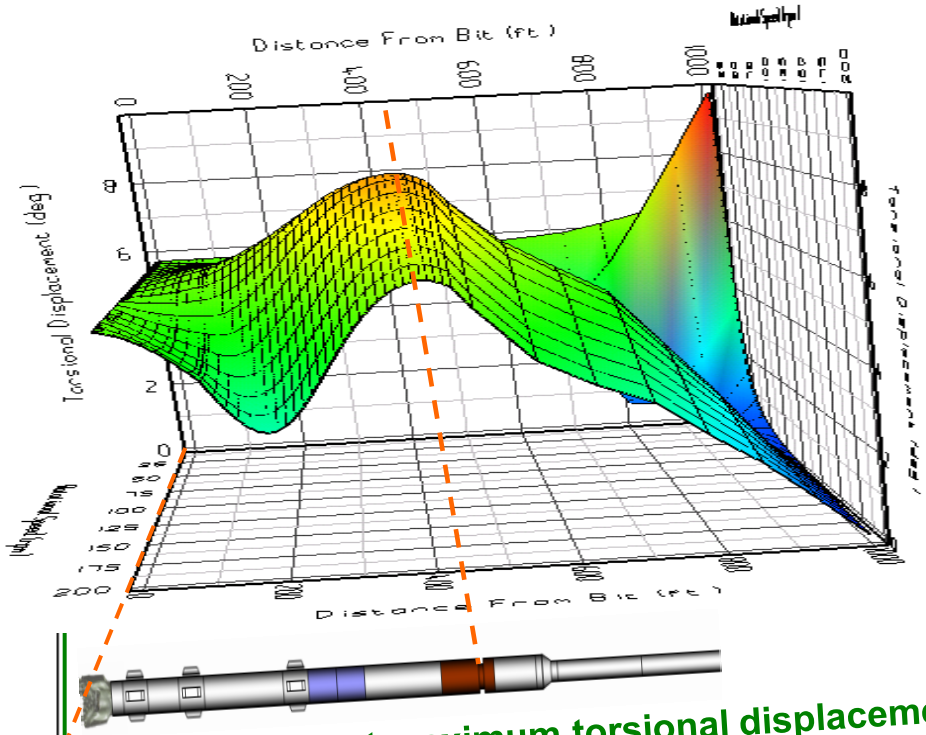




12-1/4” BHA – Lateral Displacement and BHA type

Why Drilling Jars fail..?

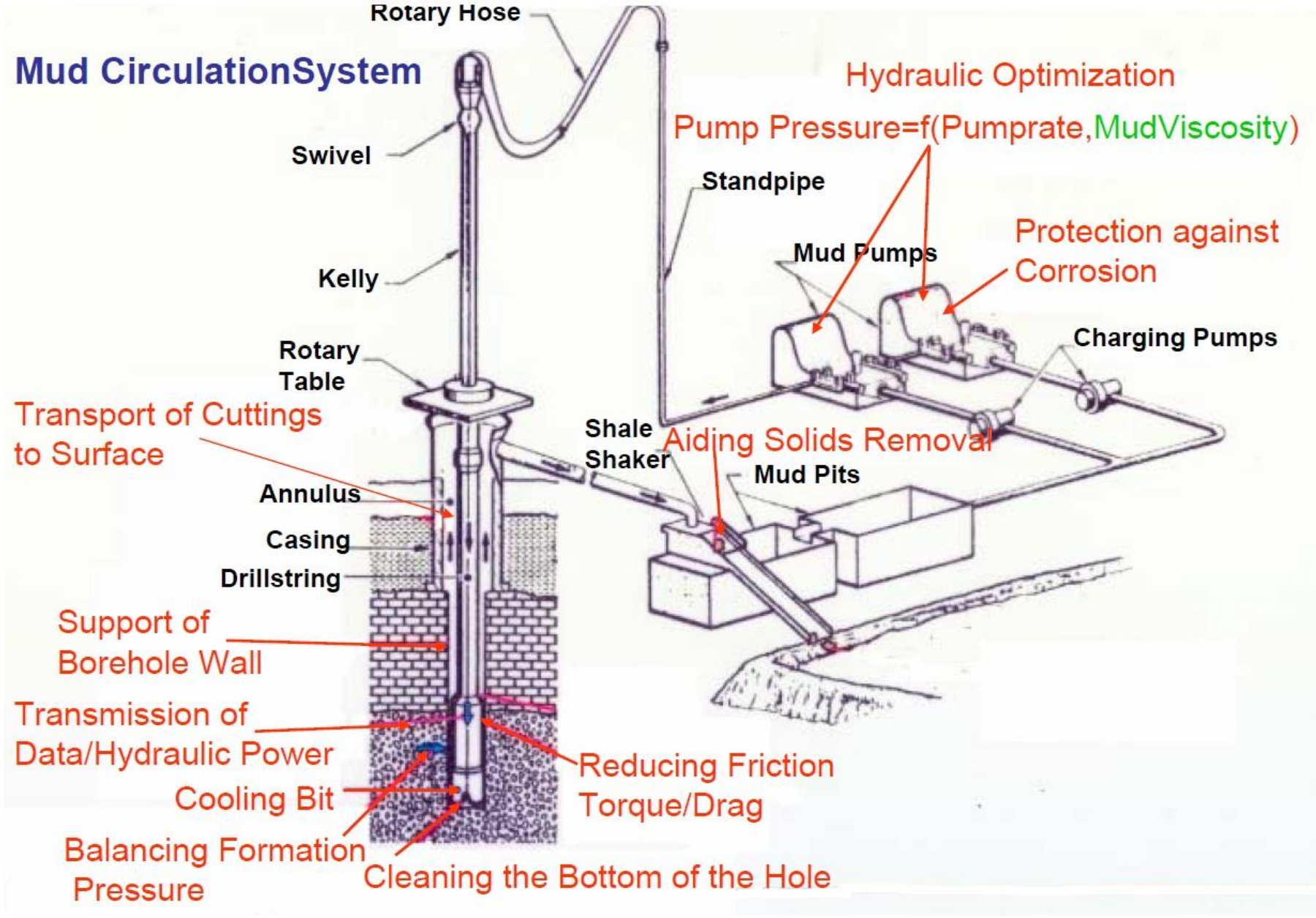


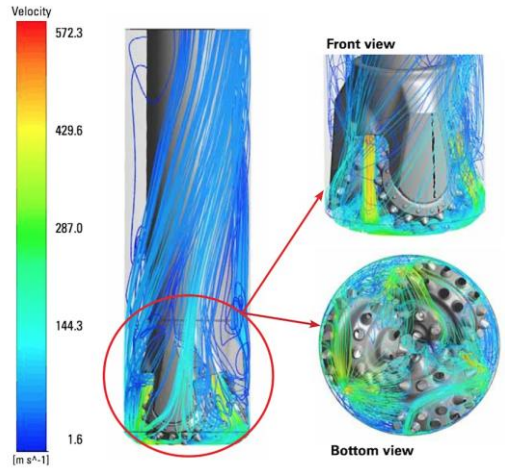


Jars position at maximum torsional displacement

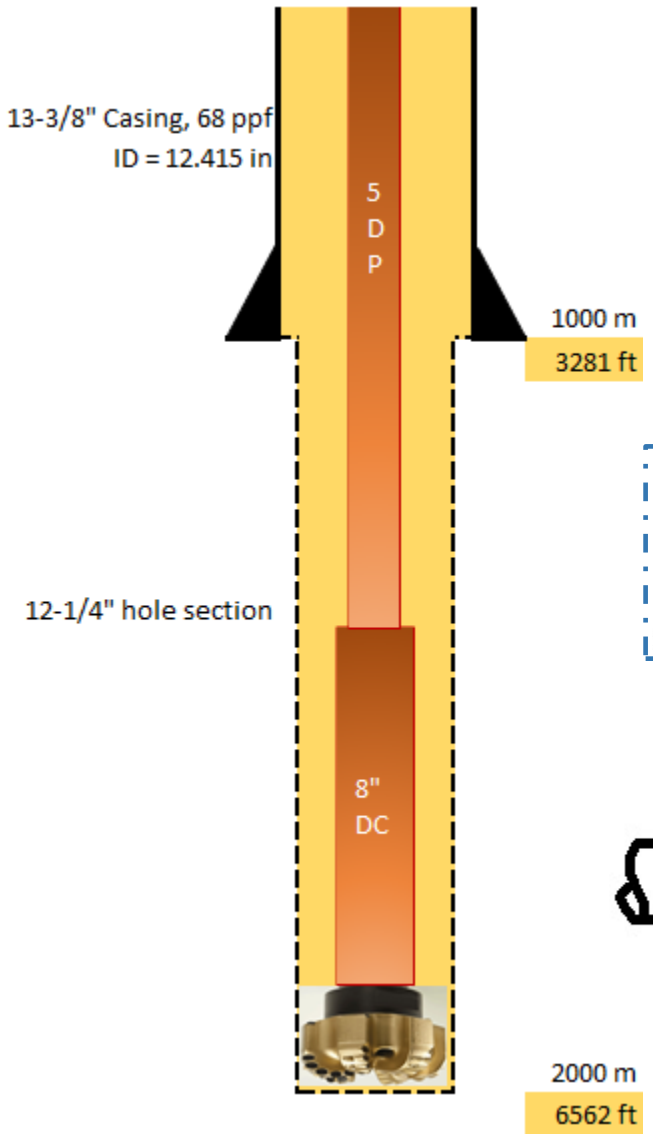
Wellplan 2000, Critical Speed Module

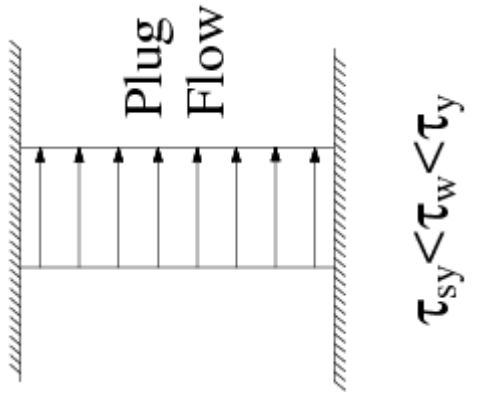
Technical Key Functions of Drilling Fluids



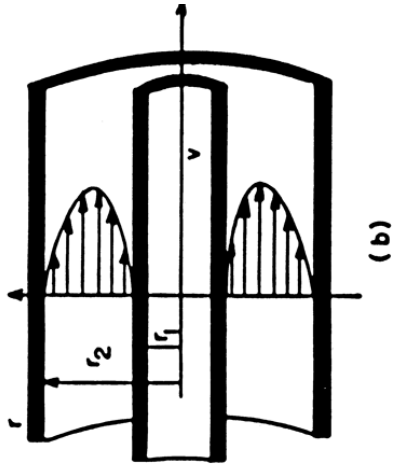


Drilling Hydraulic



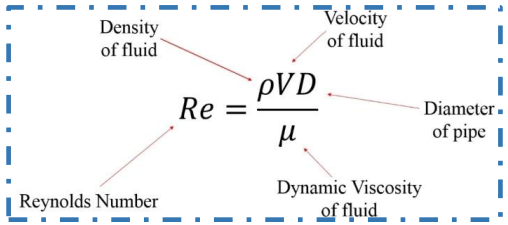


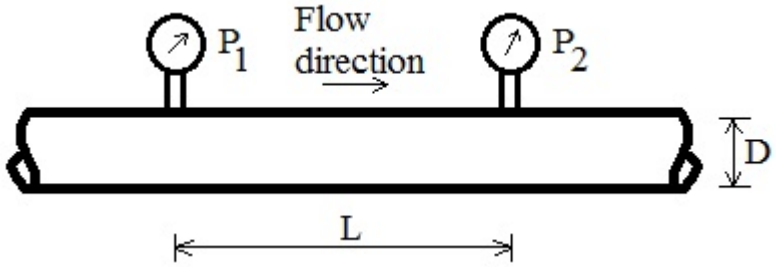
$$\tau_{sy} < \tau_w < \tau_y$$



Turbulent Flow

Laminar Flow





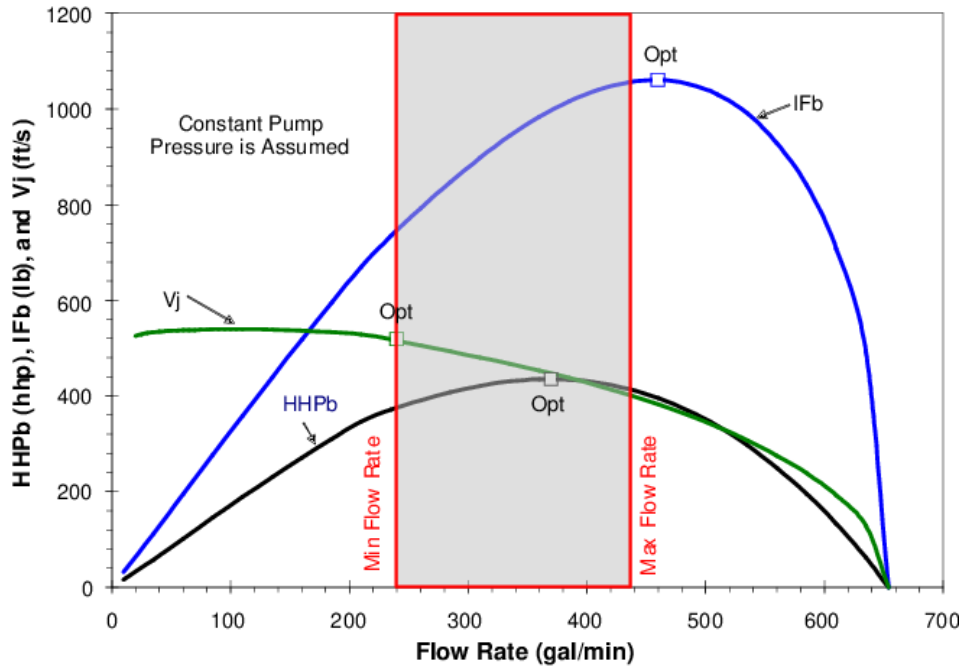
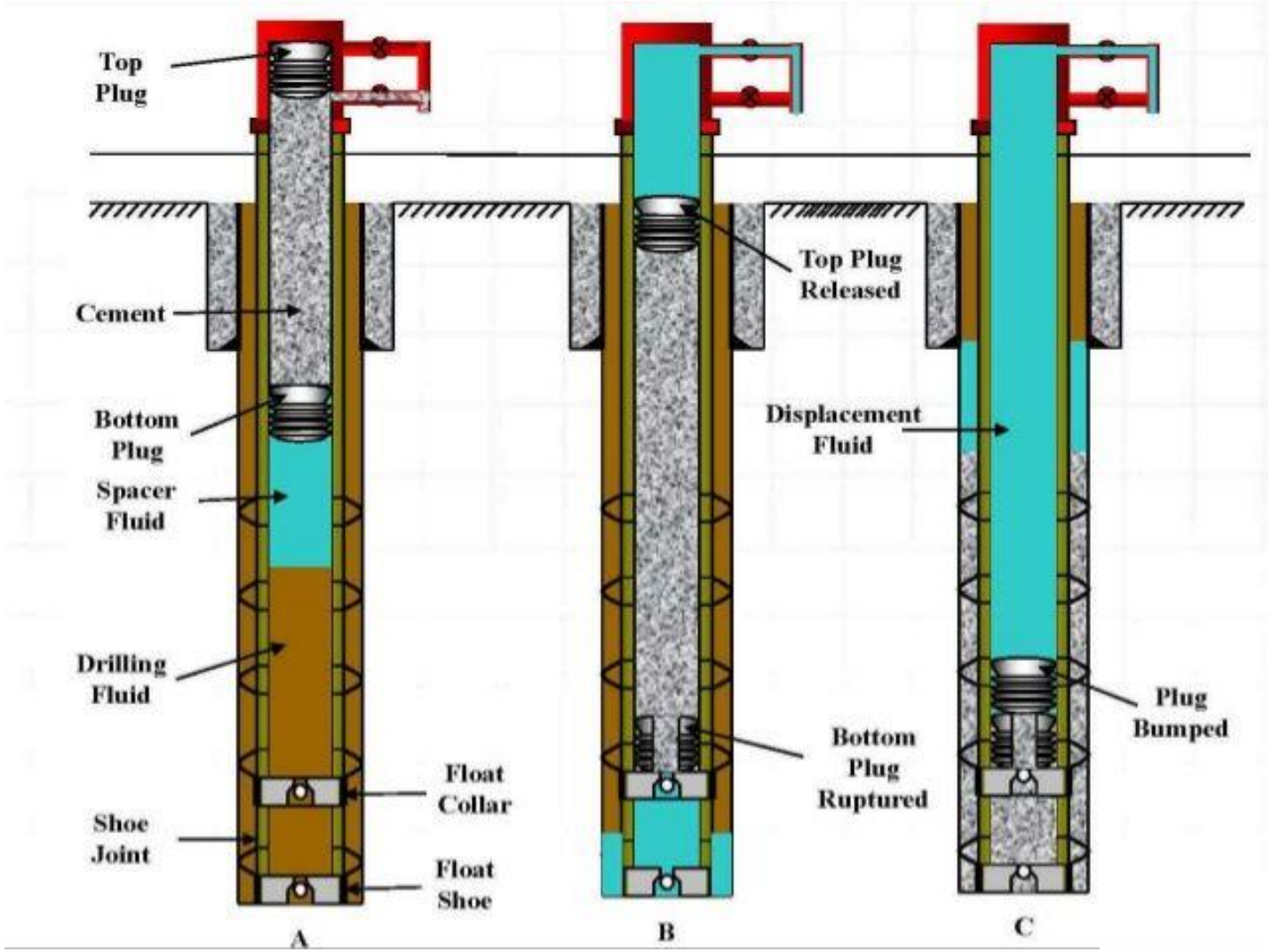
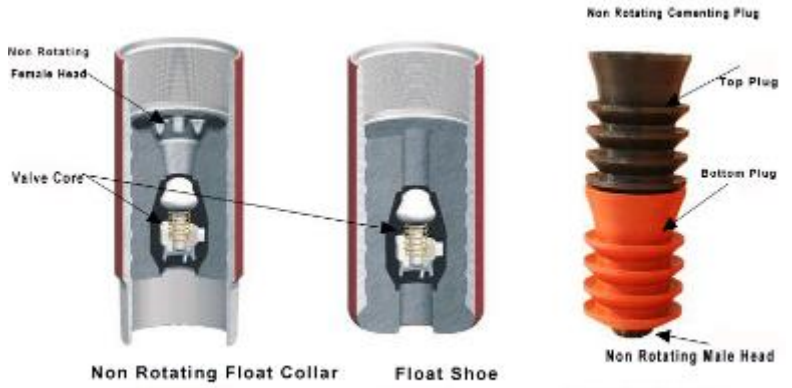


Fig. 2 – HHPb, IFb, and Vj at constant pump pressure as

Cementing Technology





$$2(CaO)_3(SiO_2) + 7H_2O \rightarrow (CaO)_3(SiO_2)_2.4(H_2O) + 3Ca(OH)_2 \quad (1)$$

$$2(CaO)_2(SiO_2) + 5H_2O \rightarrow (CaO)_3(SiO_2)_2.4(H_2O) + Ca(OH)_2 \quad (2)$$

Drilling Risk and Problems

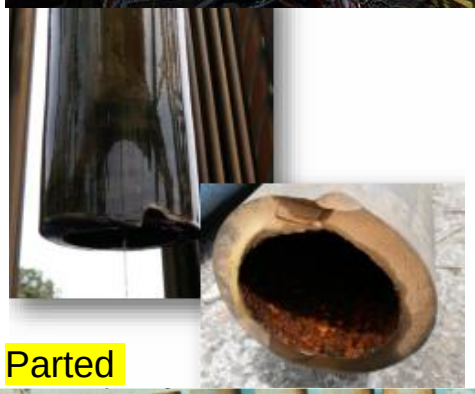

In Proper Heavy Equipment


Drop Object


Stuck Pipe


Ball up

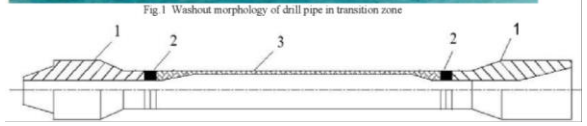

Longsor


Parted


Steam Kick

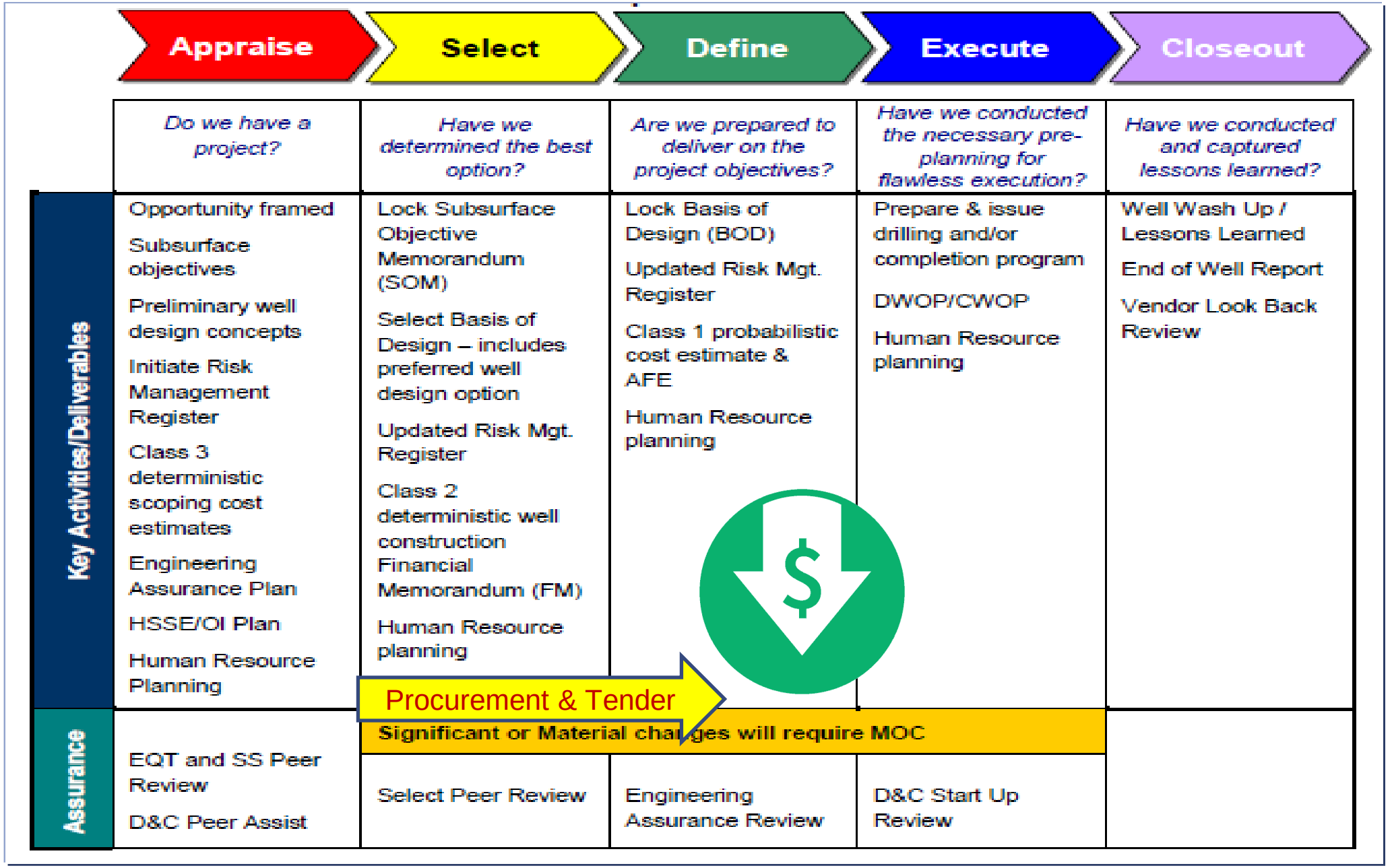
Penolakan Masyarakat


Pipe Washout




Kebocoran

Drilling Process

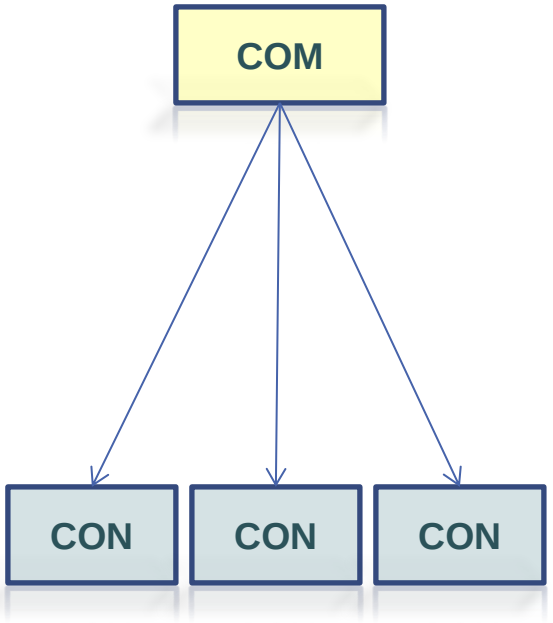


Drilling Material and Services

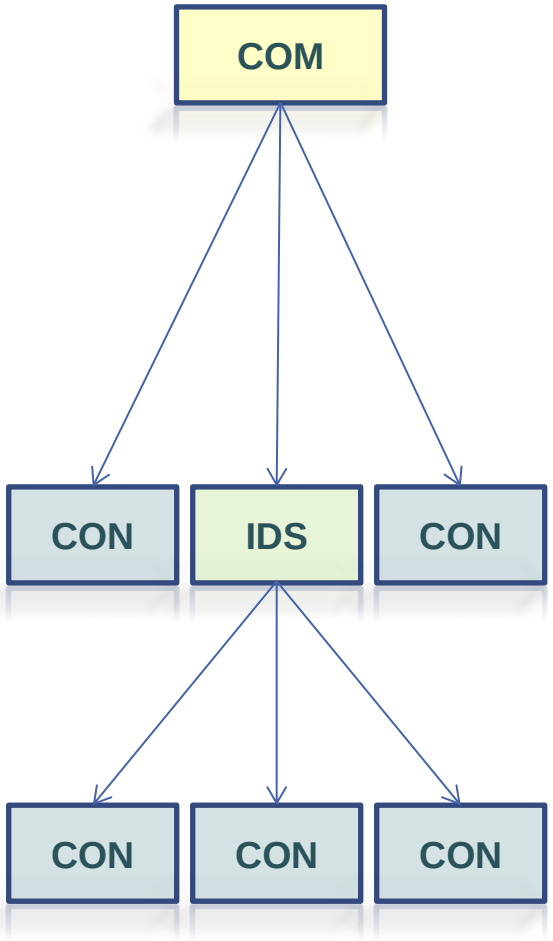
Purchase	Services	Support
1. Casing 2. Wellhead 3. Liner Adapter 4. Drilling Bits 5. Casing Accessories 6. DSA and X/O	1. Drilling Rig 2. Cement and Mud 3. Directional Drilling 4. Air Drilling 5. Mud Coller 6. Wellhead Installation 7. Drilling Personnel 8. Heavy Equipment 9. Drilling Waste Handling 10. VSAT 11. Drilling Report 12. Casing Handling 13. H2S Service 14. Mud Logging 15. Drill String Inspection 16. Hard Bending 17. Solid Control Services 18. Fishing Tool Services 19. Coring Services 20. E-Line & Explosive	1. Drilling Site Construction 2. Diesel Fuel 3. Water Pump Services 4. UKL / UPL 5. Security Services 6. Road Survey 7. Tubular Inspection 8. Explosive Handling 9. Permits 10. Perforated Liner 11. Logistic Services 12. General Services

TYPE OF CONTRACT for Procuring Drilling Services

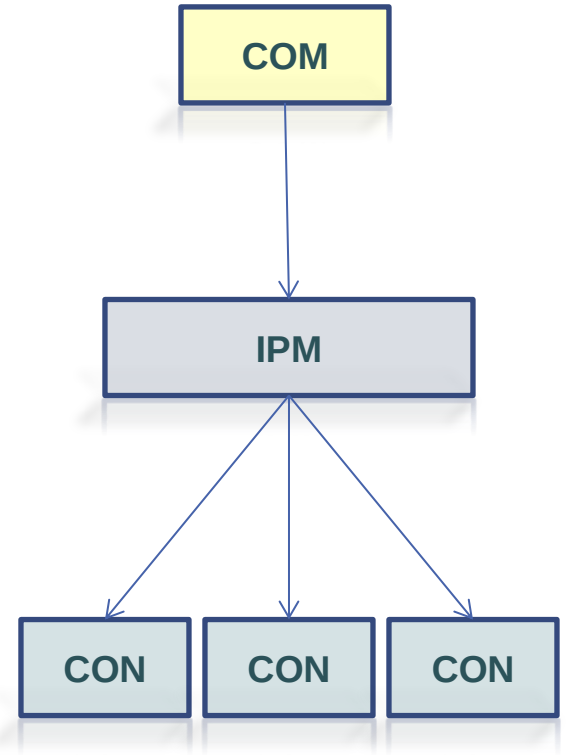
Discrete



Bundled

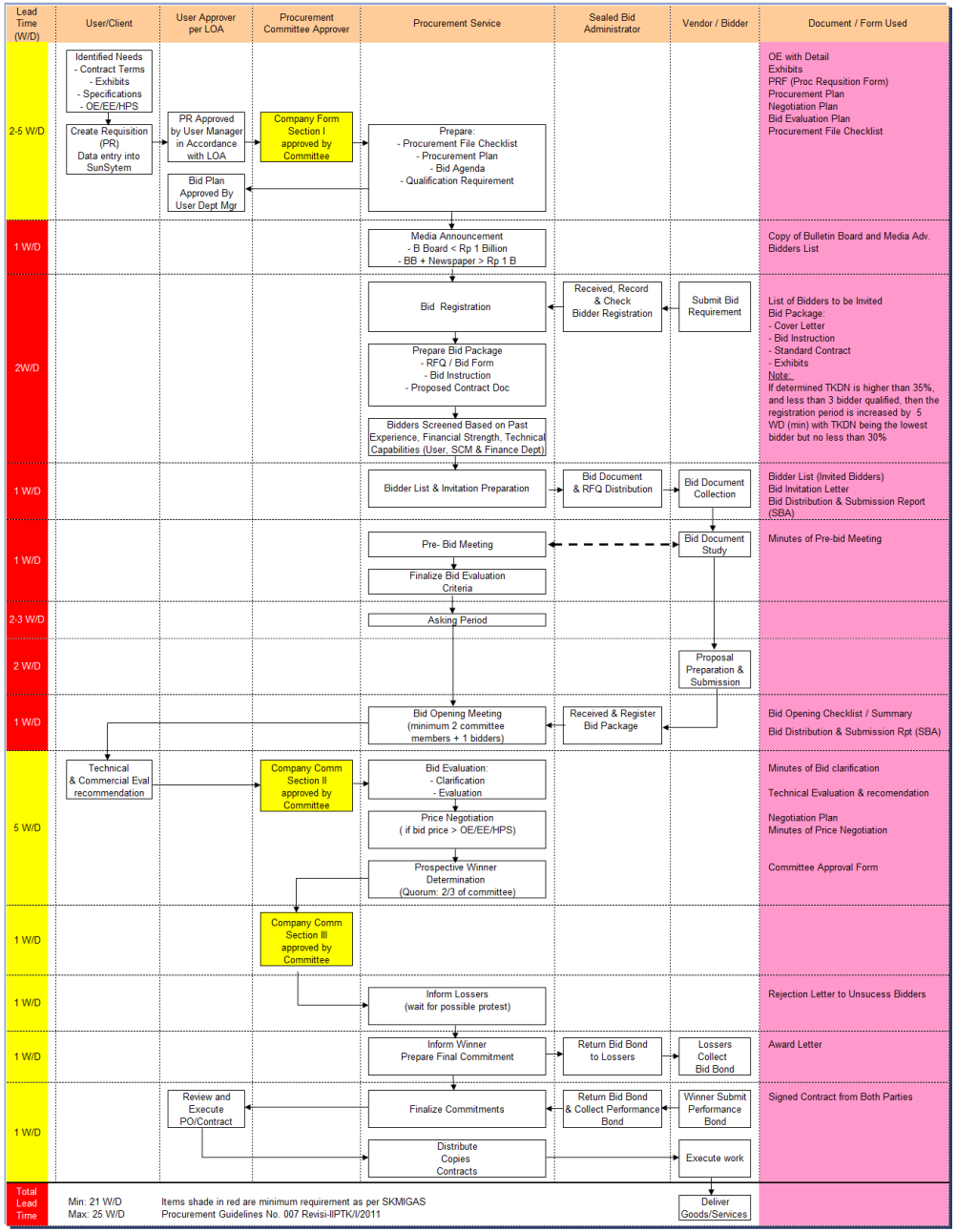


IPM / Turnkey



- **COM: Company**
- **CON: Contractor**
- **IDS: Integrated Drilling Services**

COMPETITIVE BIDDING PROCESS

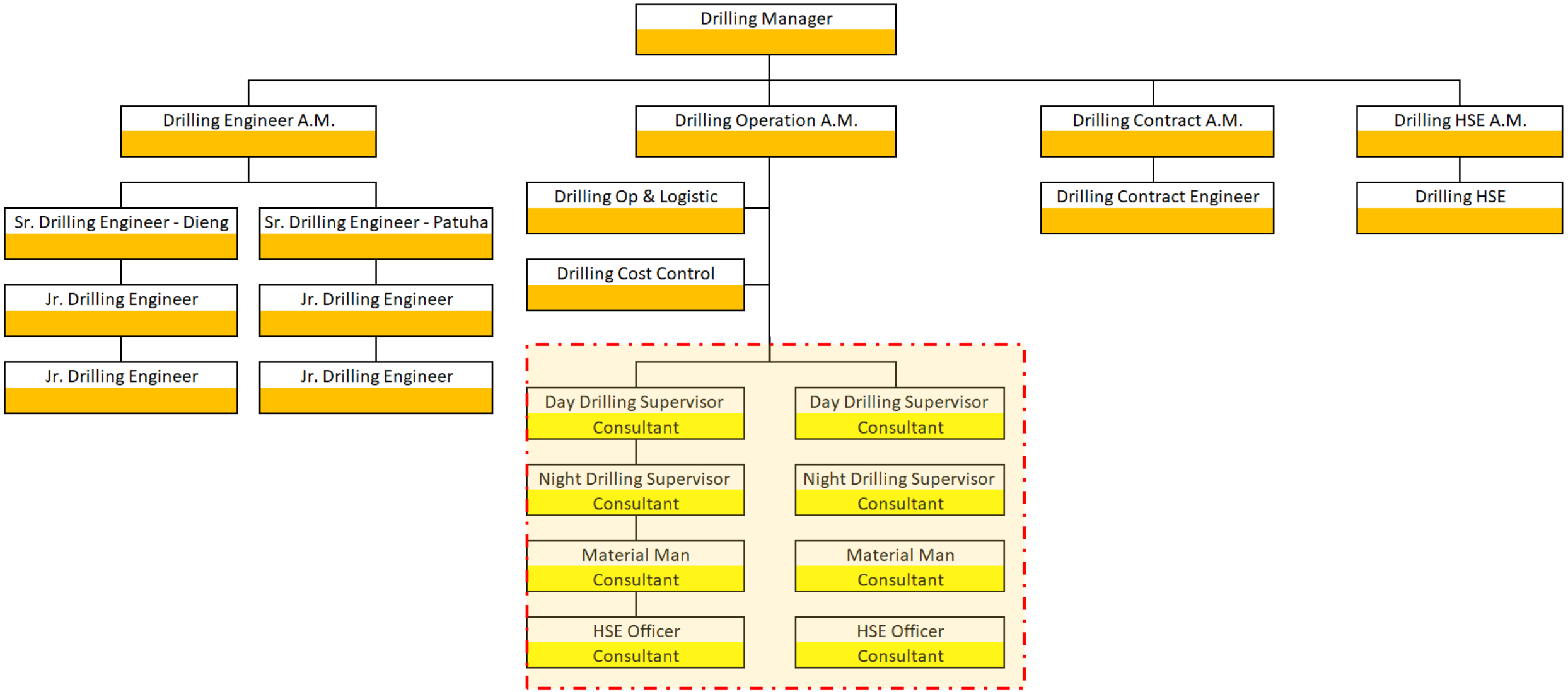


12 – 25 weeks:

- Pra Qualification
- CSMS Qualification
- Legal (Terms and Condition) Clarification
- Protest Clarification
- Technical Evaluation
- Commercial Evaluation
- Contract Award
- Delivery time
- Rig Up or Installation time
- Internal Approval
- Avoid any Conflict of interest

Drilling Personnel

Ideal Geothermal Drilling Organization Chart



Drilling Personnel – Office and Site

Company Personnel (Office + Site):

1. Drilling Manager
2. Drilling Admin
3. Drilling Specialist
4. Drilling Fluid Specialist
5. Drilling Superintendent
6. Sr. Drilling Engineer
7. Drilling Engineer
8. Completion Engineer
9. Drilling Accountant
10. Logistic Coordinator
11. Procurement
12. Civil Engineer
13. Day Drilling Supervisor
14. Night Drilling Supervisor
15. HSE Site Officer
16. Material Man

Rig Company (Office):

1. Manager
2. HSE Manager
3. Warehouseman

Rig Personnel (Rig Site):

1. Toolpushers (Sr)
2. Toolpushers
3. Rig Superintendent
4. HSE Supervisor
5. Drillers
6. Assistant Drillers
7. Derrickman
8. Floorman
9. Roustabouts
10. Rig Mechanics/Electricians
11. Welders
12. Storekeepers
13. Crane /Forklift Operators
14. Drivers/Helpers (truck/cars)
15. Catering
16. Security

Service Company Personnel

Directional Drilling, MWD, LWD	Drilling Fluid	Cementing	Casing Handling	Mud Logging	H2S
Sr. DD Engineer DD Engineer MWD Engineer LWD Engineer	Sr. Mud Engineer Mud Engineer Solid Control Mud Boy Helper	Cementing Engineer Operator Mechanic Helper	Casing Crew Torque Turn Eng.	Pressure Engineer Mud Logger Sample Catcher Technician	H2S Engineer Sweeper

Heavy Equipment	Air Drilling	Electric Logging	Drilling Equipment	Geothermal Well Test
Forklift Operator Crane Operator Hi-Boy / Low Boy Trailer Driver Foco Truck Driver Vacuum Truck Driver + Operator Tronton Truck Driver Truck Pusher Flag Man Light Vehicle Driver	Aerated Engineer Operator Helper	E-Log Engineer Operator Helper	Liner Hanger Engineer Down Hole Packer Engineer Completion Engineer Fishing Engineer Wellhead Engineer Tool Engineer Coring Engineer VSAT Engineer Drilling Bit Engineer QA/QC Engineer	Well Test Superintendent Well Test Engineer Reservoir Engineer Team Lead/Coordinator Well Test Leader HSE Engineer Welder Operator / Helper


Thank You!

We plan to Change the World Forever

With a Paradigm Shift to a New Scalable Baseload Energy

Supercritical Synthetic Geothermal

Founder & CEO - Andrew Fleming

Co-Founder & CTO - Greg Szuitiak

Problem - There is no Scalable Baseload Renewable Energy to power the World

- Conventional Geothermal and Hydro, can't scale to power the world
- We need to cut 18 Billion tonnes of Coal CO_2 year by 2050

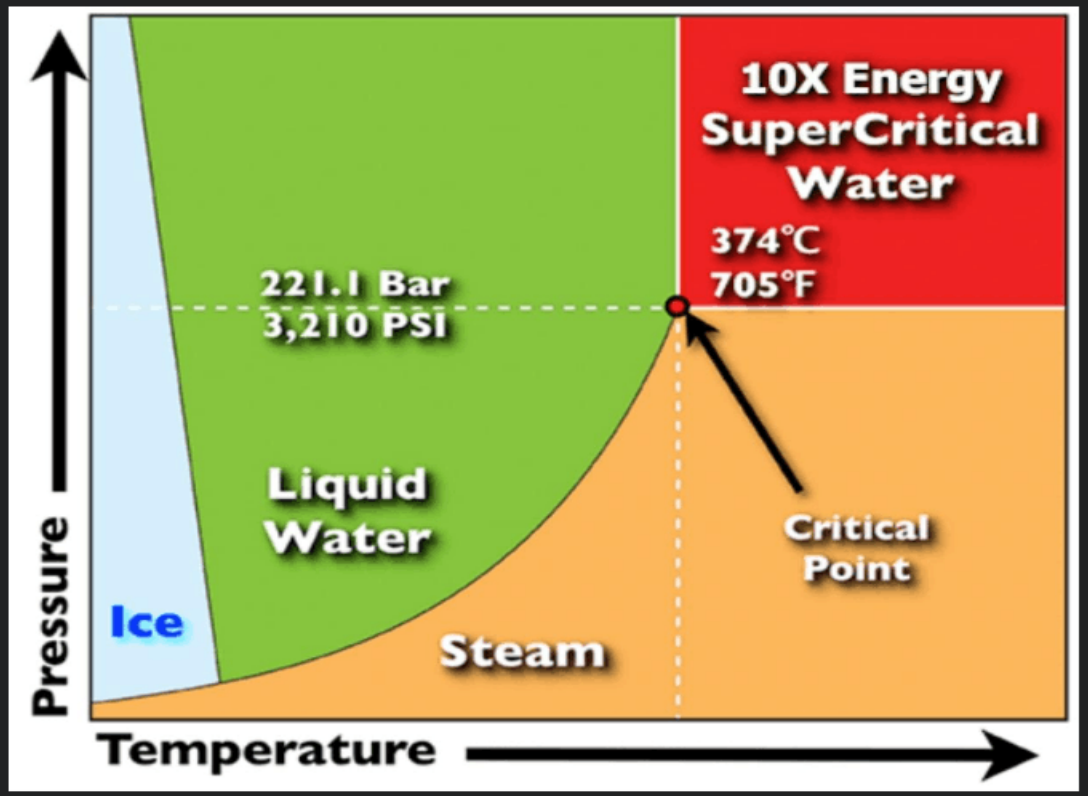
Solution - A Paradigm shift to a New Baseload Power
GeoX's Synthetic Geothermal Energy

GeoX supercritical 850°F (450°C) sites in Orange

At depths of 9,000 ft to 33,000 ft (3 to 10 Km)

GeoX's Scalable Synthetic Geothermal Baseload can Power a 70 TW World

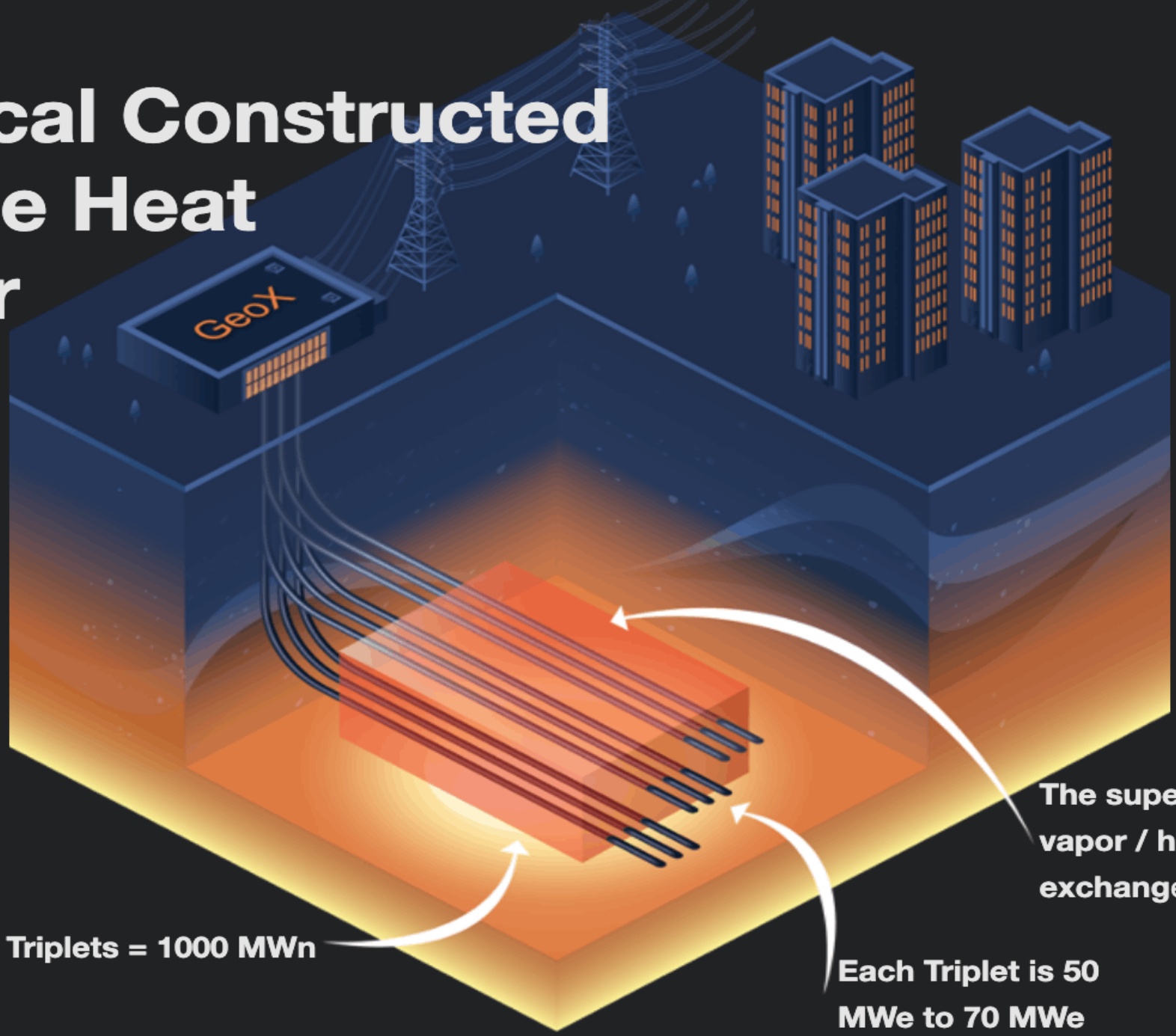
Why Supercritical?



"Supercritical" can be thought of as the "fourth state" of a material

It is not a solid, a liquid or a gas - appears like a vapor

Supercritical Constructed Subsurface Heat Exchanger



Superheated Vapor in the formation up to 850°F up to 55X more energy

1000 MWn plant has a constructed 320 billion cu/ft subsurface heat exchanger

20 Triplets = 1000 MWn

The supercritical vapor / heat exchanger

Each Triplet is 50 MWe to 70 MWe

Milestones

2018 - 2019

Geothermal Research Started 2018

GeoX incorporated 2019

2019-2021

Successfully Modeled GeoX Breakthrough Heat-Exchanger Design

File IP for EGS up to 850°F / 450°C Drilling, & Completion Equip, Well Control, Cement, MWD, Drilling and Power Plant Technology

2021 & 2022

The world's largest drilling contractor, Nabors, invested $11M in GeoX - Closing $25m round mid-Nov 2022

Secured and securing supercritical 20 X 1000 MWn or larger sites in the US and overseas

2022 - Q1 2023

All 850°F (450°C) Drilling, & Completion Equip, Well Control, Cement, MWD, Drilling and Power Plant Technology well casing FEA (Finite Element Analysis), from 500°F to 850°F / (200°C - 450°C) ready for service

2023 -2050

Build 50 MWn GeoX power plant by 2024 and grow to 450 MWn within 5 years - Value 2027 = $4B with 4.2X ROI. Scale to 1 x 1000MWn per year thereafter.

Global Scaling via 40 Fortune 500 Firms building one 2000MWn plant per year until 2050m will eliminate 18B tons/year CO_2 from coal power