SLURRY MICROTUNNELLING METHODS AND HDD: ALTERNATIVES AND COMPLEMENTS

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HERRENKNECHT IN GERMANY

- Strongly rooted in the location of Schwanau and the surrounding region
- Around 2,400 employees work in Schwanau and Kehl, Germany
- Our long-term and sustainable thinking is reflected in our support of education, environment and society

MARKET SEGMENTS HERRENKNECHT GROUP

WATER

- Sewage infrastructure
- Water supply
- Desalination
- Flooding infrastructure
- Storage and reservoirs

TRANSPORT AND MOBILITY

- Road
- Railway
- Metro
- Passenger transport
- Cargo

SUPER-SAFE UNDERGROUND STRUCTURES

- Safe storage facilities, e.g. castor storage
- Safe underground facilities, e.g. for research purposes

ENERGY

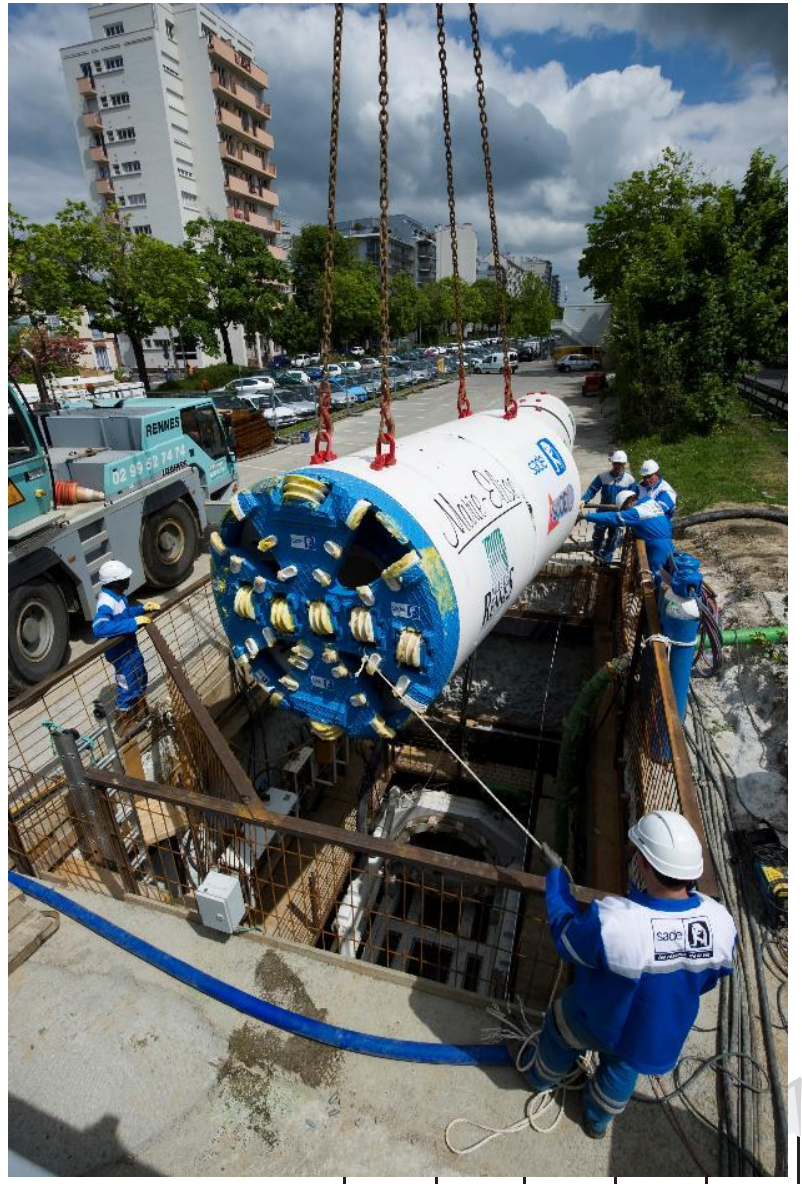
- Transportation of oil, gas and hydrogen
- Development drilling
- Hydroelectric power
- Geothermal energy
- District heating/geothermal energy
- Energy storage
- Power lines

MINING AND RAW MATERIAL

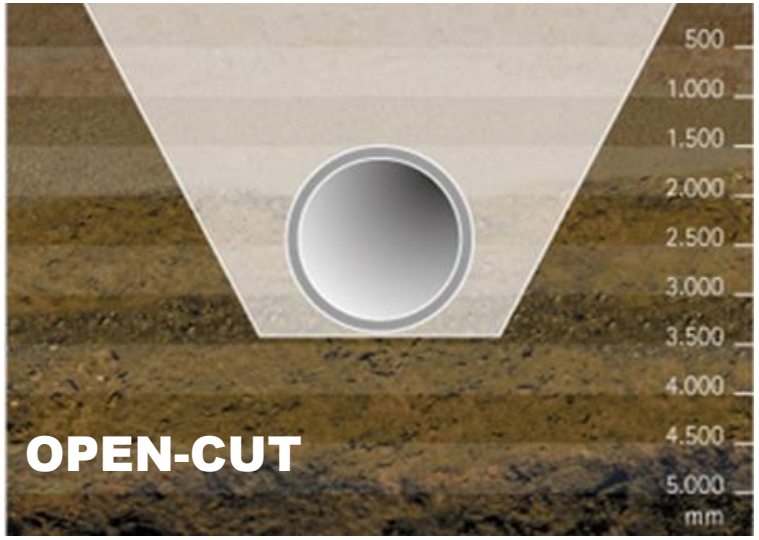
- Vertical access or production shafts
- Ventilation shafts
- Access ramps and transport infrastructure
- Tunnel infrastructure

WHY GOING TRENCHLESS?

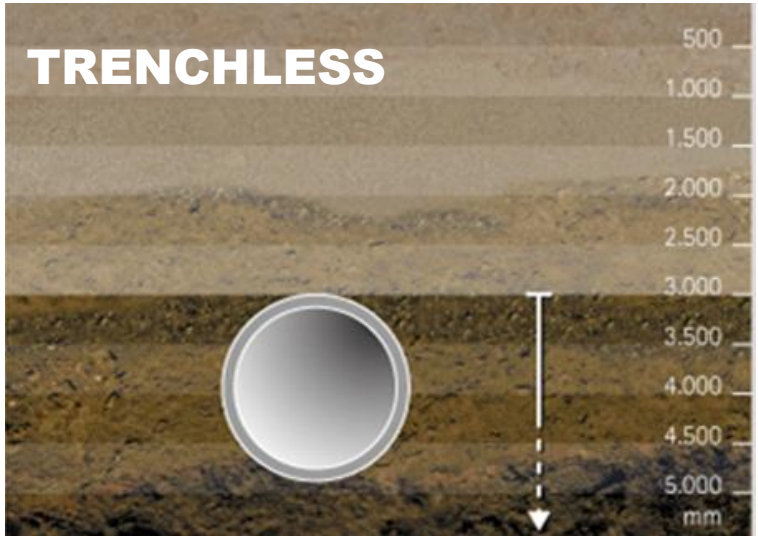
- Less emissions and impact on life on surface
- No groundwater lowering needed
- Lower settlement risk for roads and buildings
- Better tunnel quality
- Only way to cross rivers, traffic ways and buildings



OPEN-CUT VS TRENCHLESS CONSTRUCTION



- Surface intervention / Earth movement
- Recultivation necessary
- Operation of machinery
- Construction time & costs



- Installation length vs. diameter
- No surface intervention
- Min. earth movement
- Min. recultivaton

Criteria

- Protected areas
- Crossing infrastructures
- Compliance with distances
- Construction time
- Construction costs
- Capacities on the market

SLURRY MICROTUNNELLING METHODS OVERVIEW

	PIPE JACKING	DIRECT PIPE®	E-POWER PIPE®
MTBM	**AVN or AVNS** with jet pump		
BOREHOLE SUPPORT	**Mechanical borehole support** over the entire installation process		
PIPE MATERIAL	**Pressure resistant** reinforced concrete pipes	**Pressure resistant** steel pipeline	**All** Pulling of product pipe in 2nd step
PIPE DIAMETER	**250 – 4,000 mm** **10” – 13 ft** Ø Tunnel (ID)	**600 – 1,500 mm** **24” – 60”**	**250 – 700 mm** **10” – 27”**
MAX. INSTALLATION LENGTH	**~ 2,000 m (6,500 ft)** *Depending on project-specific conditions*		

SLURRY MICROTUNNELLING METHODS WITH CONSTANT BOREHOLE SUPPORT

PIPE JACKING

AVN — reinforced concrete pipes

Jacking frame
compact jacking frame or main jacking station

DIRECT PIPE

AVN/AVNS — steel pipeline (prefabricated)

Pipe Thruster
with clamping unit, tested for various coatings

E-POWER PIPE

AVNS — temporary steel jacking pipes (1)

Product pipe/bundle (all pipe types, prefabricated) (2)

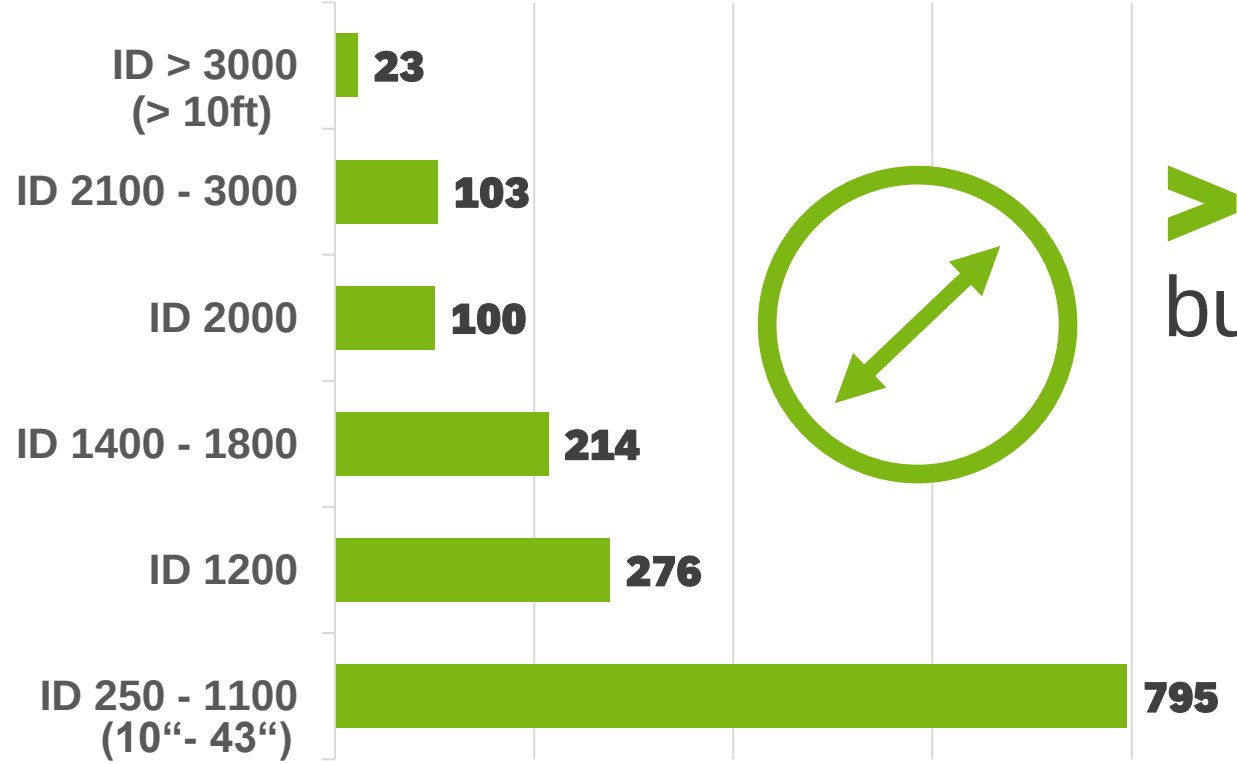
Rack & Pinion Jacking frame
pushforce pilot bore (1), pullforce pipe pullin (2)

UTILITY TUNNELLING

PIPE JACKING

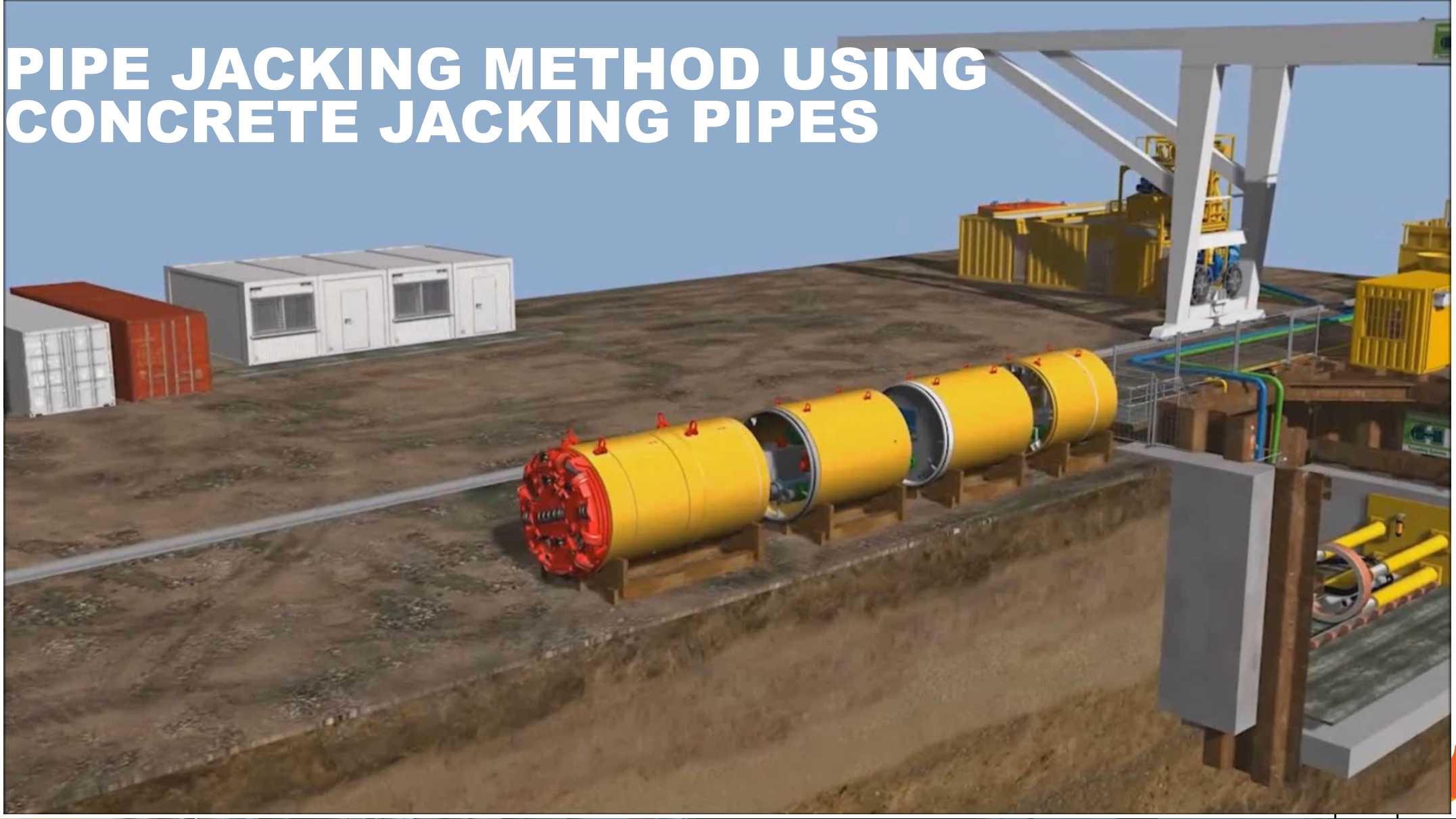
SLURRY MICROTUNNELLING AVN EQUIPMENT BUILT

PER DIAMETER



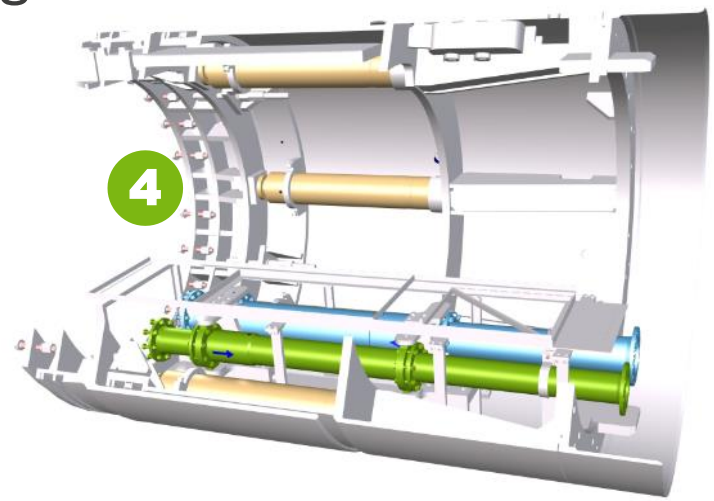
>1500 AVN/AVND
built by end of 2024

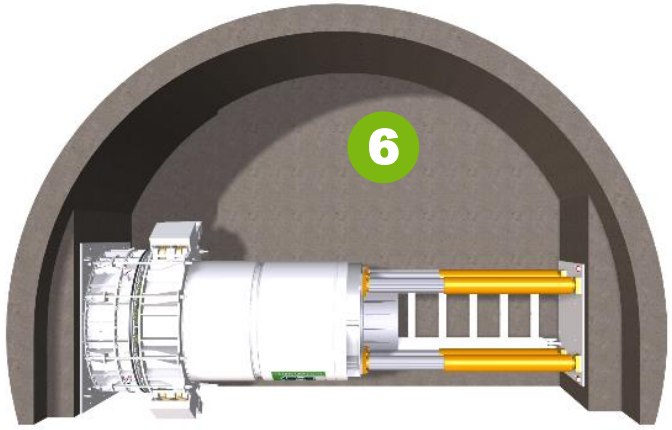
PIPE JACKING METHOD USING CONCRETE JACKING PIPES



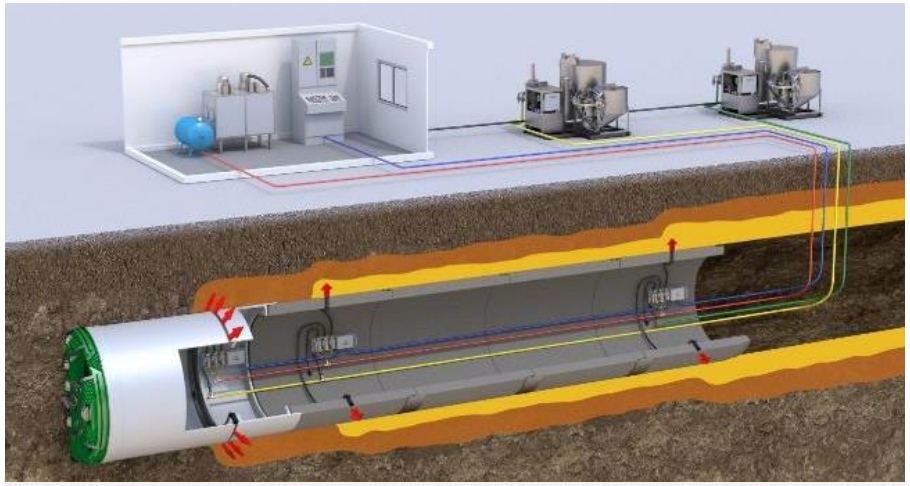
SLURRY MTBM MACHINE DESIGN

1. Cutting wheel and cutter tools
2. Main bearing and main drive
3. Steering cylinders
4. Telecopic station
5. Intermediate jacking stations
6. Main jacking station
7. Jacking pipes



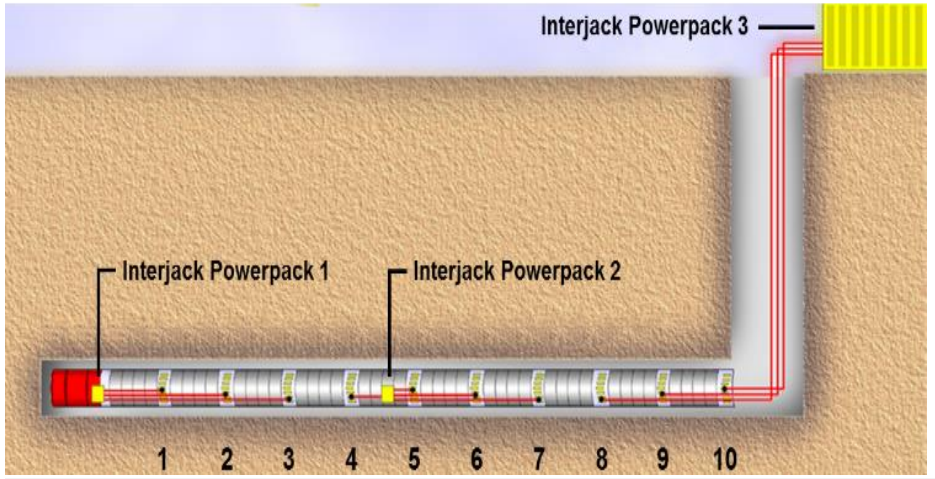


KEEPING JACKING AND FRICTION FORCES LOW



Bentonite lubrication system

- reduce skin friction
- adapt to changing geology



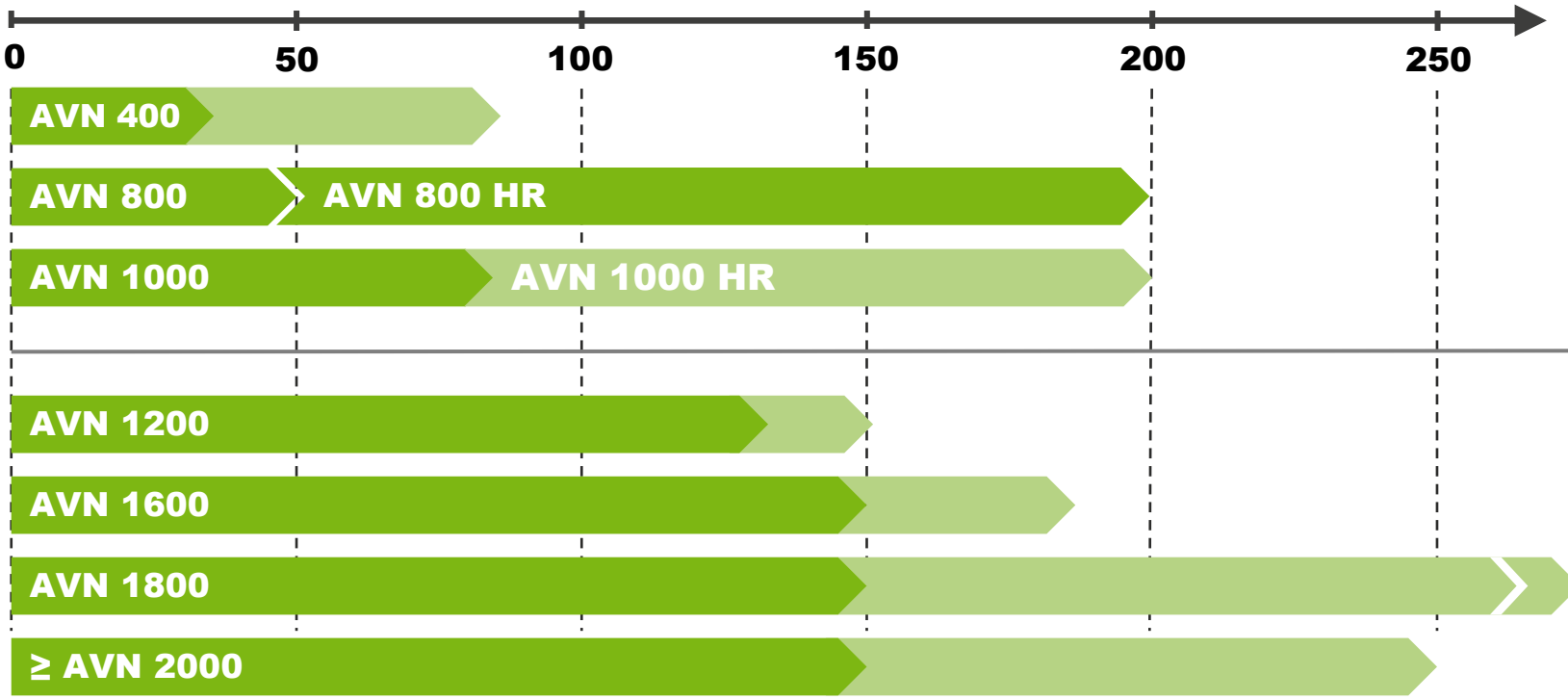
Interjacking stations

- regular intervals
- reduce jacking forces
- dismantled when finished

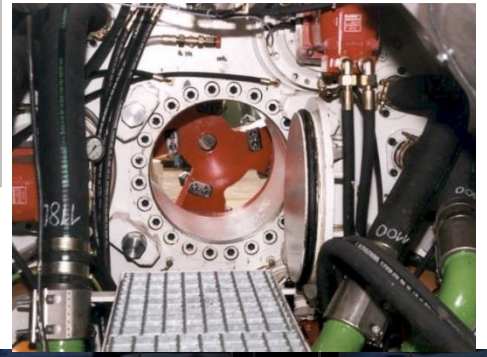
CUTTING WHEEL AND WEAR RESISTANCE

- Cutting wheel design and tooling adapted to ground conditions
- Hardfacing for cutter wear protection

AVN MACHINE RANGE FOR SLURRY PIPE JACKING IN HARD ROCK



47“ **With access** to excavation chamber for tool change



Recommended Feasible, with special design

DIAMETERS AND DRIVE LENGTH

Drive length in ft	650	1300	2000	2600	3300		6500		≥ 9800
Drive length in m	200	400	600	800	1000		2000		≥ 3000
Pipe Jacking									
AVN 400	AVNS with jet pump								
AVN 600	AVNS with jet pump and interjacking station								
AVN 800	Interjacking station and power pack behind machine								
AVN 1000	Interjacking station and power pack behind machine								
AVN 1200									
AVN/AVND 1600									
AVN/AVND 1800									
AVN AVND ≥ 2000									

With Push Module

UTILITY TUNNELLING

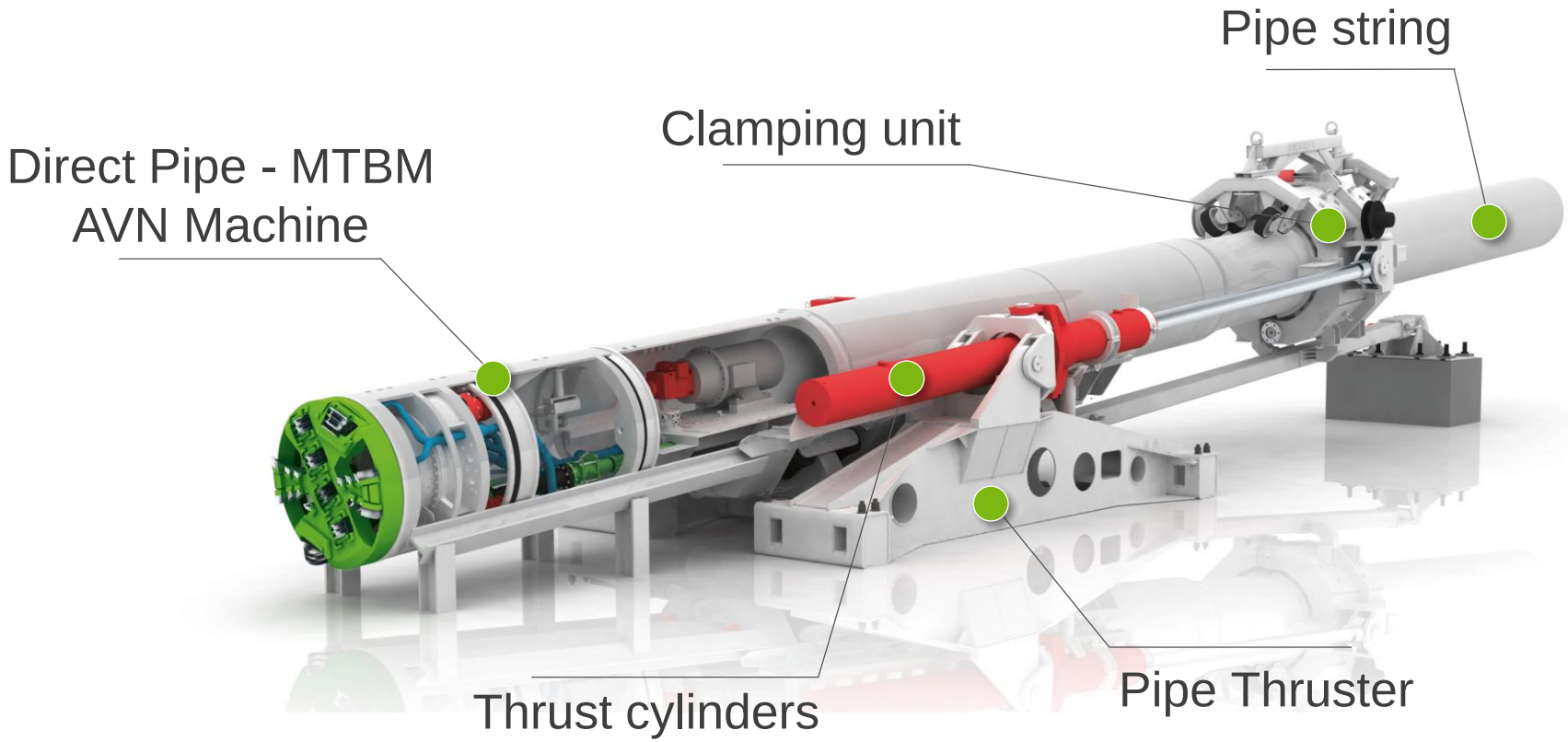
DIRECT PIPE

DIRECT PIPE® TECHNOLOGY

- one-pass installation
- min. frac out risk | borehole supported
- high accuracy

24“ up to 60“ steel pipeline installations

MTBM AND PIPE THRUSTER AS DIRECT PIPE® KEY COMPONENTS



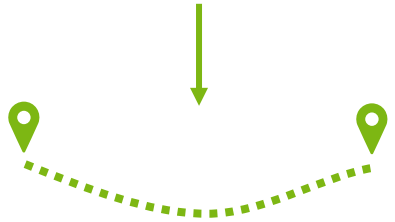
DIRECT PIPE®
APPLICATION RANGE

DIAMETER

24“ / 600mm

~ 1000 m
~ 3300 ft

60“ / 1500mm

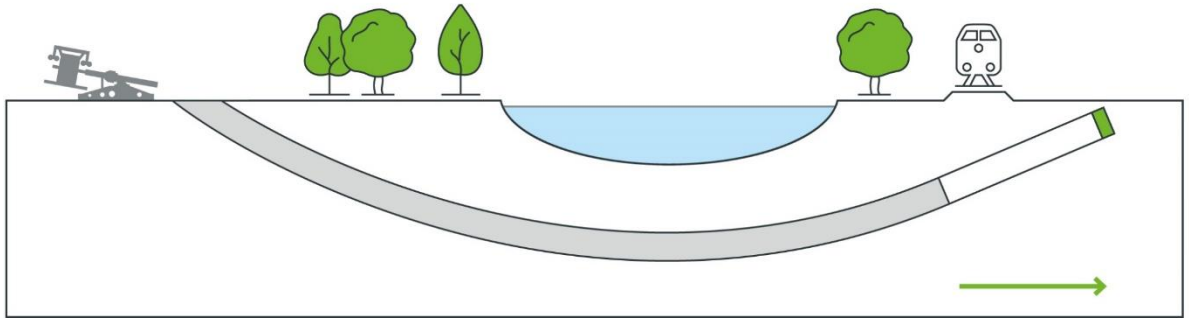


~ 2000 m
~ 6600 ft

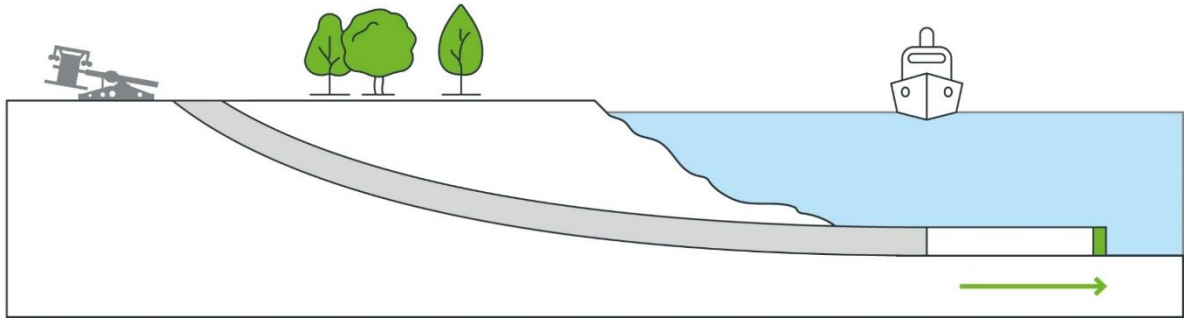
- **Safe & Fast**
  - on-surface or near-surface launch & exit pits
  - high advance rates
- **Flexible**
  - almost all conditions up to 150 MPa (21750 psi)
- **Precise**
  - guided & controlled drilling, incl. spatial curves and uphill/downhill elevation changes

DIRECT PIPE® INSTALLATION OF STEEL PIPE

RIVER CROSSING



SEA OUTFALL



*Simultaneous excavation of borehole and installation of steel pipeline.

- one-pass / single-step installation
- permanent borehole support
- high accuracy
- minimum risk of inadvertent fluid returns (i.e. frac-outs)
- less cover resulting in shallower crossings
- less soil excavation compared to HDD or Pipe Jacking
- single side entry means land-based operation
- launch side = pipe side
- independence from marine conditions at all times
- minimum fluid release to marine environment

DIRECT PIPE® SOLUTIONS FOR ALL GEOLOGIES

Pipeline Diameter	Direct Pipe® System	Drilling Distance	Geology
			Clay | Sand < 2mm | Gravel <63mm | Cobbles <256mm | Boulders >256mm | Rock <100MPa | Hard Rock <200MPa
24“	AVNS 500	3,300 – 4,900 ft*	AVNS-DP / AVNS-HR
28“	AVNS 600	3,300 – 4,900 ft*	AVNS-DP / AVNS-HR
32“	AVNS 700	3,300 – 4,900 ft*	AVNS-DP / AVNS-HR
36“	AVN 800B	3,300 – 4,900 ft*	AVN-DP / AVN-HR
42“	AVN 800A	3,300 – 4,900 ft*	AVN-DP / AVN-HR
48“	AVN 1000	4,900 – 6,500 ft* *	AVN-DP / AVN-HR
56“	AVN 1200	4,900 – 6,500 ft* *	AVN-DP
60“	AVN 1200	4,900 – 6,500 ft* *	AVN-DP

WORLD RECORD LENGTH NEW ZEALAND

- M-2170M, AVN1000 + HK750PT Pipe Thruster
- 48“ Casing Snells Algies Wastewater Pipe and Outfall Replacement (Watercare, Auckland)
- Drilling length: **2,021 m / 6,600 ft**
- Shore approach with offshore recovery
- Best Performance: Daily: 42.5 m / Weekly: 211 m
  Daily 140 ft / Weekly: 690 ft

DIRECT PIPE®
SMALLEST DIAMETER IN ITALY

- SNAM - Gas Network Adriatic Coastline
  - #1 Tratto Recanati – S. Elpidio Geology: sand, clay, gravel
  - #2 Metanodotto Recanati – Chieti Geology: sand, silt, sandy clay, clay, some gravel
- Pipeline: 26” w/ PE/GRP Coating
- Distance: 310m + 521m
  1,010ft + 1,710ft

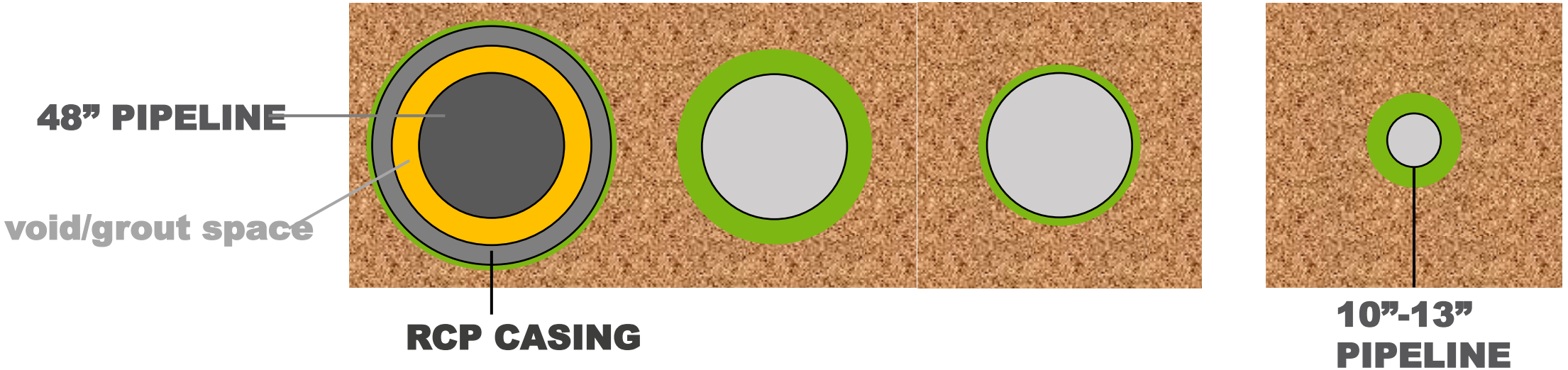
DIRECT PIPE®
SMALL DIAMETER IN POLAND

28”

- Projects: 3x GAZ-System
  2x GIPL (Gas Interconnector Poland-Lithuania)
- All 5 crossings completed successfully:
  - # 1 River Czarna Hancza: 342m (1120 ft)
  - # 2 River Narew: 884m (2900ft)
  - # 3 Sosnowiec: 220m (720 ft)
  - # 4 Oswiecim Park: 372m (1220 ft)
  - # 5 River Wisla: 878m (2880 ft)
- Geology: sand, gravel, boulders, silt, clay

DIRECT PIPE® BOREHOLE DIAMETER

48” PIPELINE INSTALLATION	PIPE JACKING (RCP CONCRETE PIPE)	HDD	DIRECT PIPE®		E-POWERPIPE® 11” EXTRAPOLATED TO 48”
Usual Size of Overcut in Relation to Pipeline Size	65 %	30 %	< 10%		**45 %** *> 15 %*
Borehole Diameter	~ 2,0 m (79 in)	~ 1,6 m (63 in)	~ 1,3 m (51 in)		**~ 0,5 m (20 in)** *~ 1,45 m (57 in)*
Excavation Volume (per meter)	~ 3,2 m³ (113 cu.ft)	~ 2,1 m³ (74 cu.ft)	~ 1,4 m³ (49 cu.ft)		**~ 0,2 m³ (7 cu.ft)** *~ 1,6 m³ (56 cu.ft)*



PIPE THRUSTER STEEL PIPE COATINGS

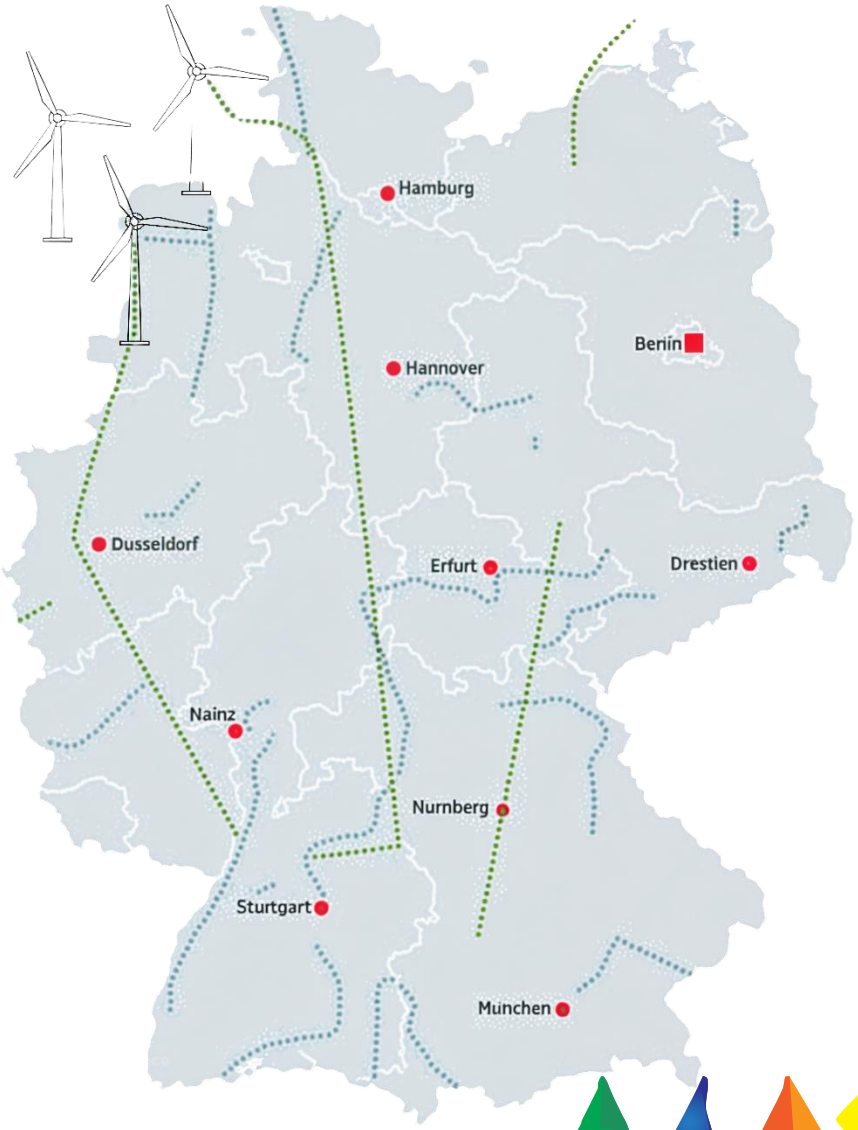
- Polyethylene (PE)
- Polypropylene (PP)
- Polyurethane (PUR)
- Fusion Bonded Epoxy (FBE)
- Glass-Fiber-Reinforced Plastic (GRP)
- Concrete Coating (limited feasibility)

- CWC, HDPE, PVC, District Heating Pipes (Pipe Insertion)

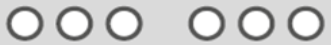
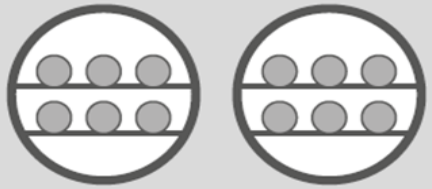

KOUWENBERG Infra
DENYS
Tennet
HERRENKNECHT
NRG
Alsema Denys Van Vulpen
HERRENKNECHT AG
HERRENKNECHT
Tunnelling Systems
E-POWER PIPE
MICROTUNNELLING

UNDERGROUND CABLE INSTALLATION, GERMANY

- Offshore wind parks in the North
- Extensive transmissiongrid construction
- Open-cut approach

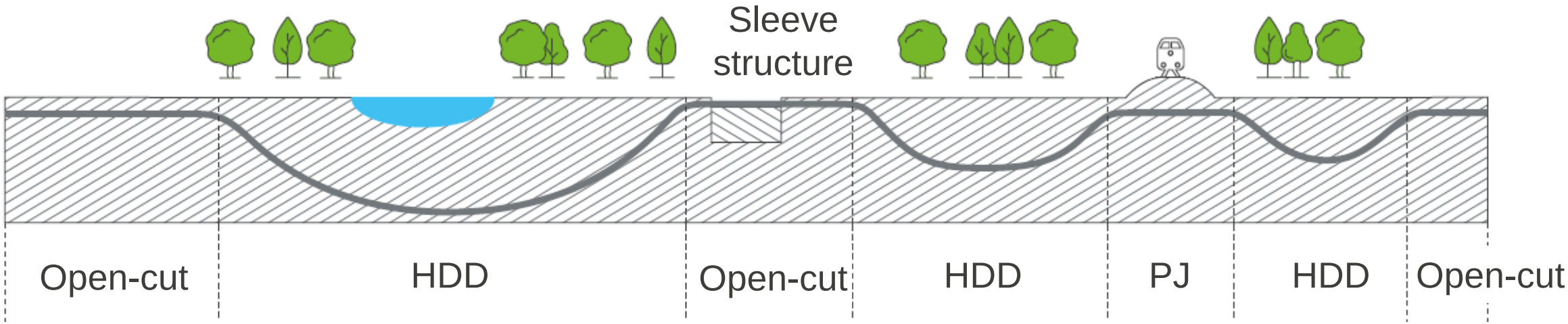


CLOSING THE TECHNOLOGY GAP FOR UNDERGROUND CABLE INSTALLATION

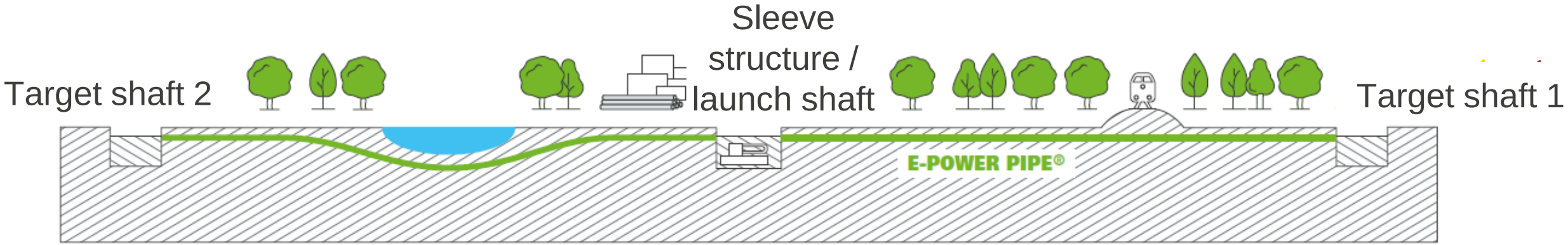
		SEPARATE INSTALLATION 250 mm			CASING TUNNELS Ø 1,500 mm			CASING TUNNEL Ø 3,000 mm		
										
Technology:	**Ø in mm**	**Shallow**	**Accuracy**	**Length > 1,000 m**	**Shallow**	**Accuracy**	**Length > 1,000 m**	**Shallow**	**Accuracy**	**Length > 1,000 m**
› Pipe Jacking	250-4,000	■	■		■	■	■	■	■	■
› Segmental Lining	2,300-4,000							■	■	■
› HDD	250-1,500			■			■			
› Direct Pipe®	700-1,500				■	■	■			
› Pipe Express®	900-1,500				■	■	■			

TRENCHLESS OPTIONS FOR UNDERGROUND CABLES

Planning of 12,000 ft. for cable protective pipe with METHOD MIX

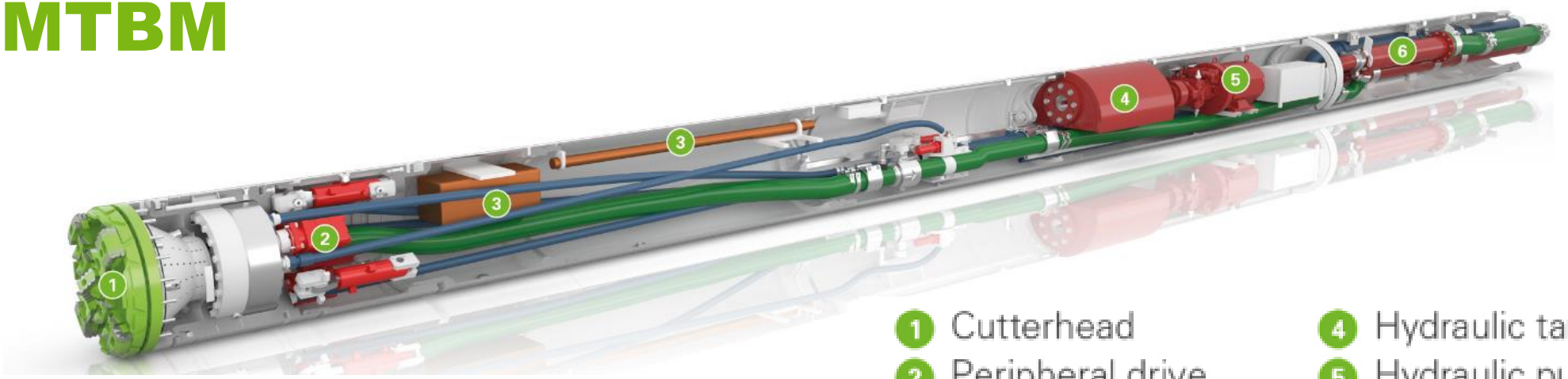


Alternative with E-POWER PIPE

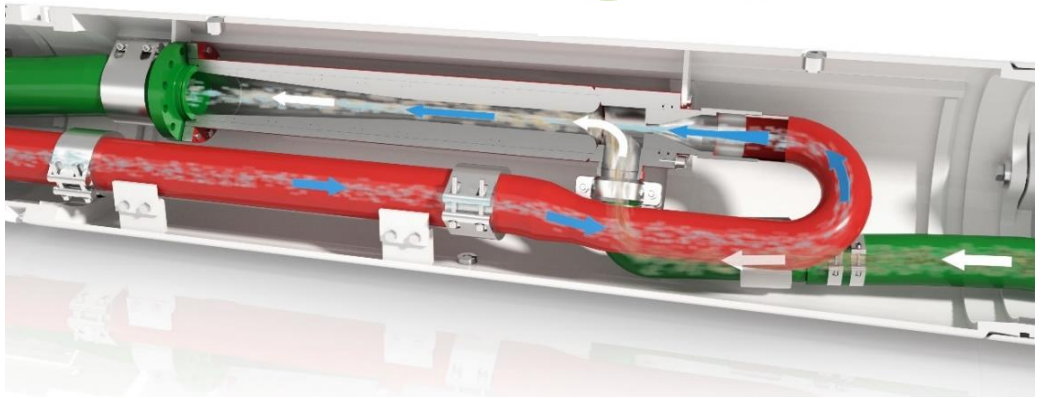


SLURRY MICROTUNNELLING WITH JET PUMP

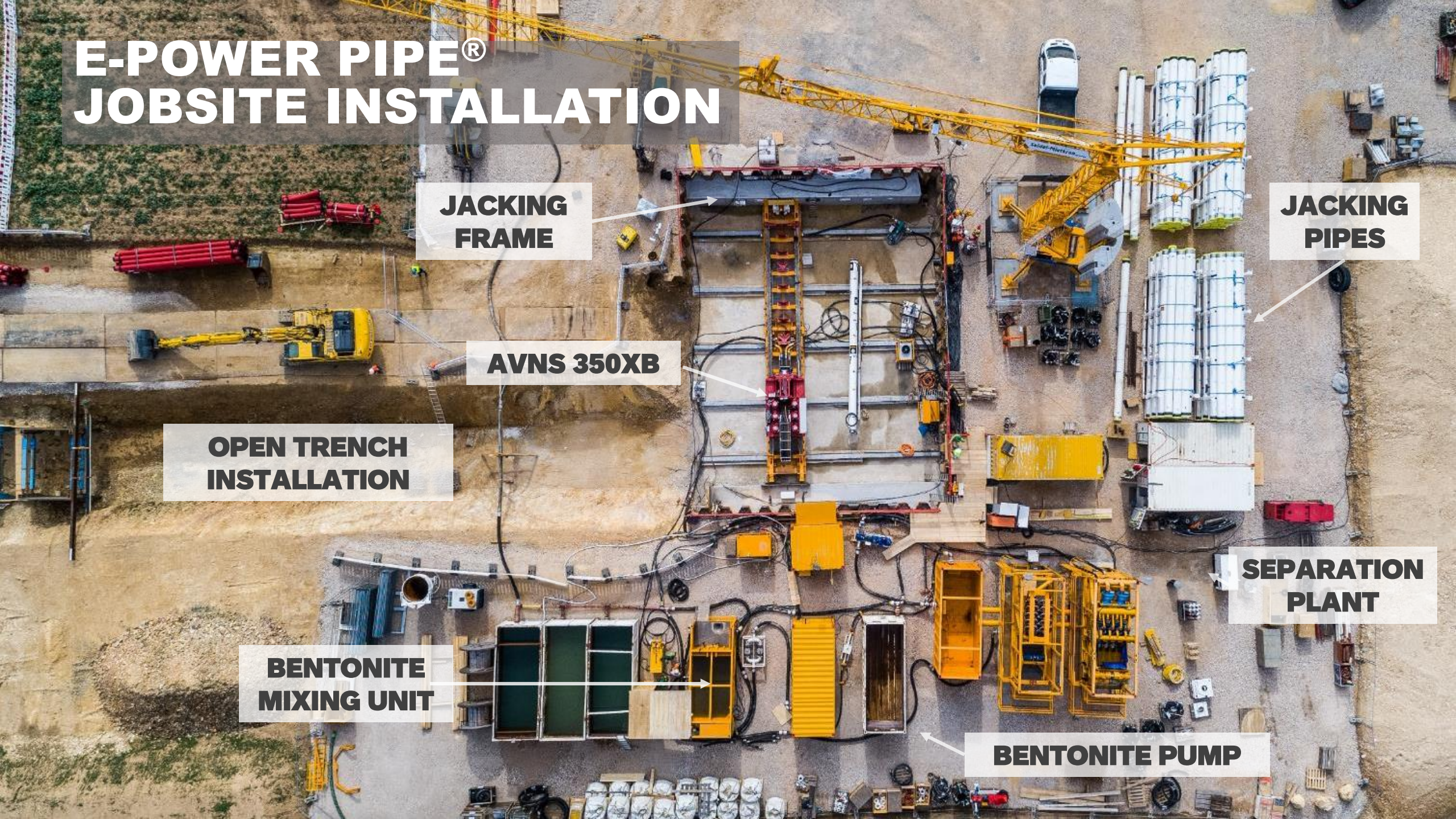
AVNS MTBM



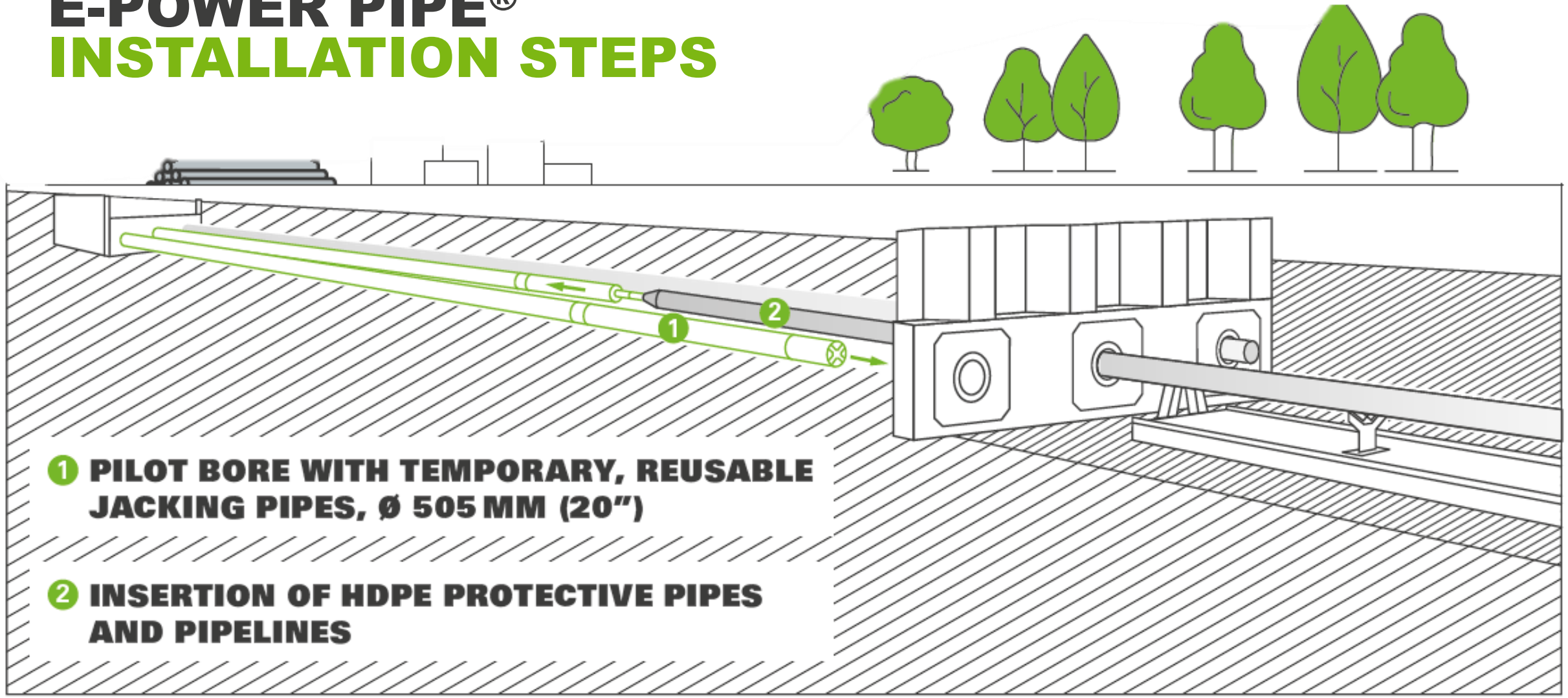
1. Cutterhead
2. Peripheral drive
3. Navigation system
4. Hydraulic tank
5. Hydraulic pump
6. Jet pump



E-POWER PIPE®
JOBSITE INSTALLATION

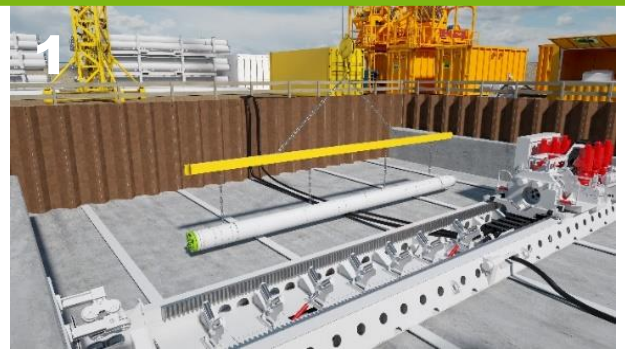


E-POWER PIPE®
INSTALLATION STEPS



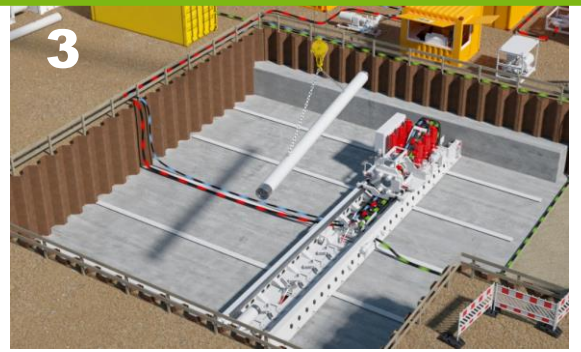
E-POWER PIPE® INSTALLATION STEPS

I PILOT BORE with AVNS and temporary jacking pipes



Installation of jacking frame in launch shaft

Soil excavation with AVNS & pipe jacking process



Handling & coupling of temporary steel jacking pipes

Precise breakthrough at target point

II PULL-IN

E-POWER PIPE® INSTALLATION STEPS

I PILOT BORE

II PULL-IN of protective pipe or pipeline

Dismantling of AVNS and connection of pullhead

Connection of prefabricated pipe to pullhead

Pullback process by jacking frame in launch shaft

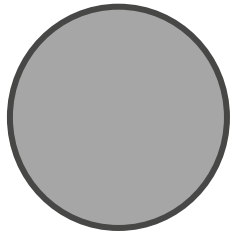
Pulling completed

E-POWER PIPE® APPLICATION FIELDS

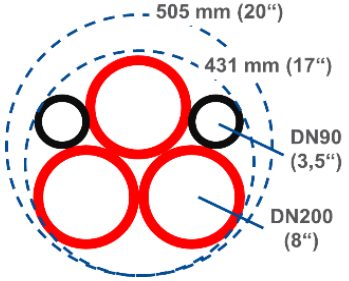
10“-18“

- Drilling diameter: **505 mm | 20”**
- Drive length: **≤ 2,000 m | 6,500 ft**
- Near surface installation: overburden **≥ 1.5 m | 5 ft**
- Precise, parallel installation: distance **≥ 1.0 m | 3 ft**
- Grouting of annulus during pullback

SMALL-DIAMETER STEEL PIPELINES



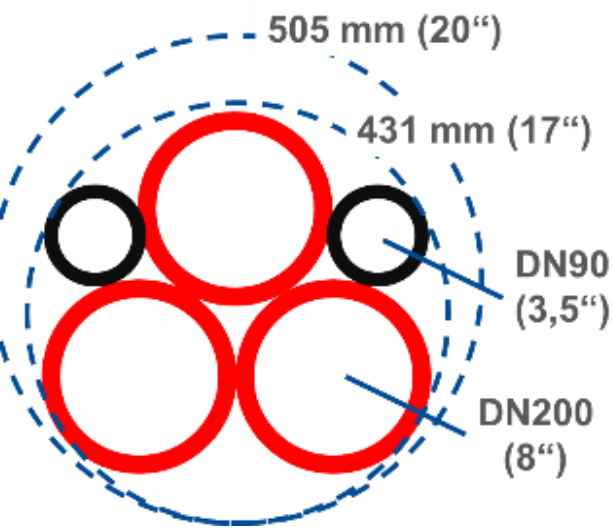
HDPE PROTECTIVE PIPE | SINGLE INSTALLATION OR BUNDLE PULLING IN BOREHOLE



RECORD CABLE PROJECT IN THE NETHERLANDS

POWER PIPE

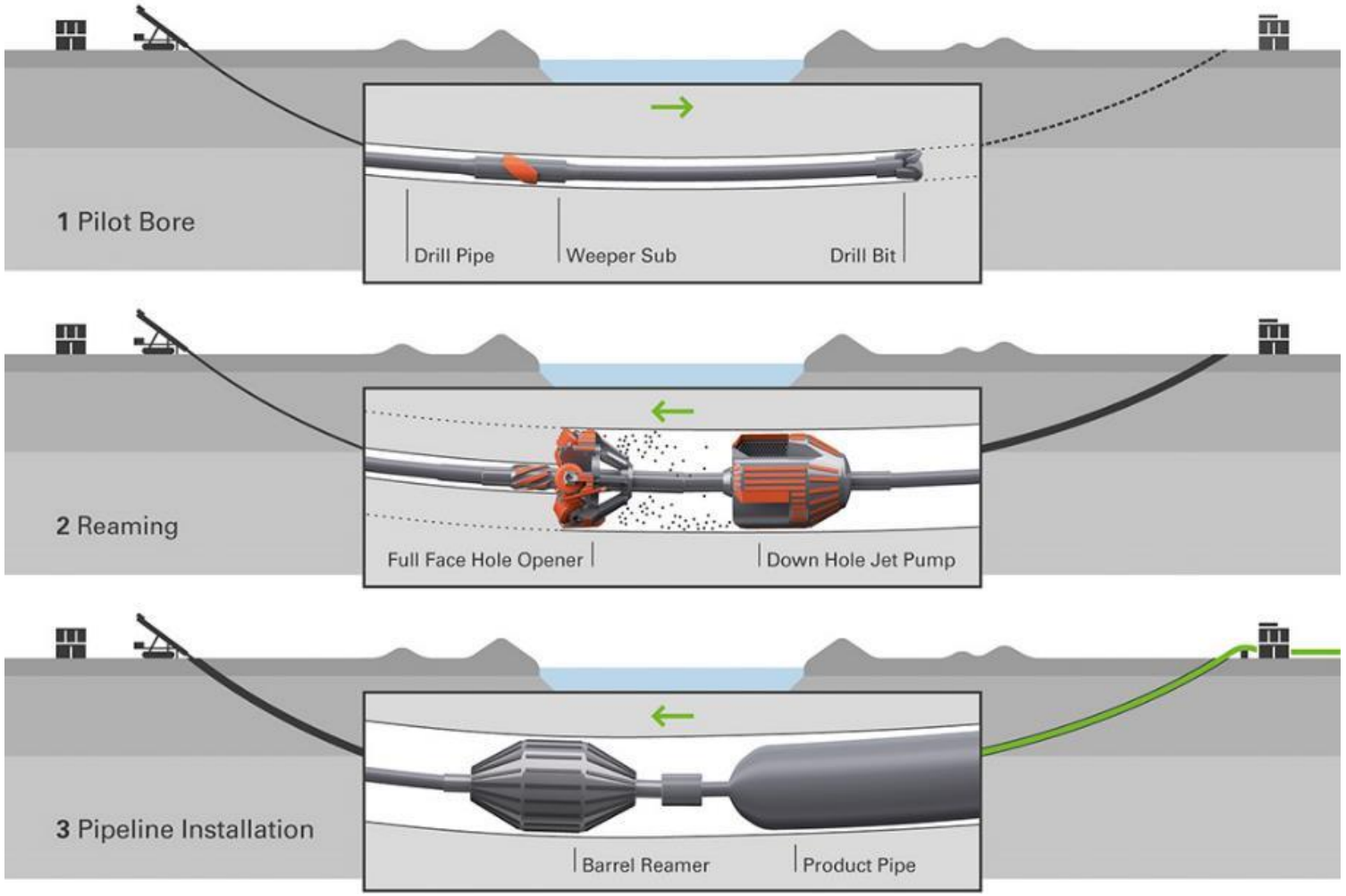
6,500ft



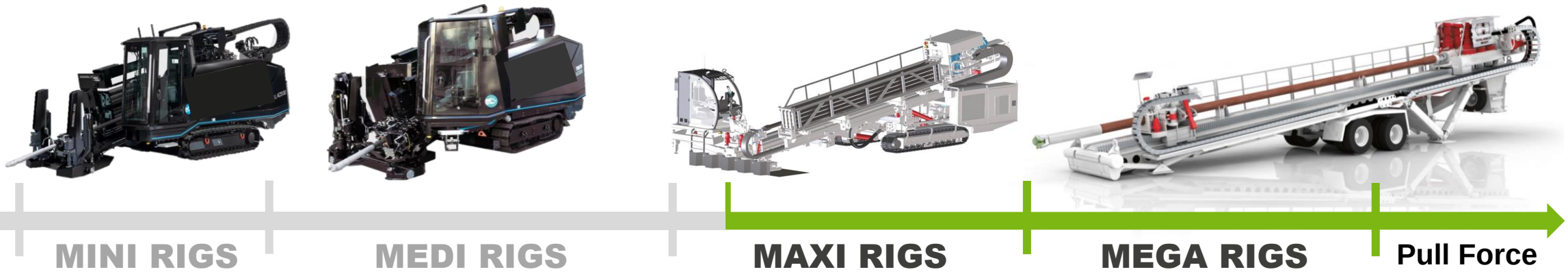
UTILITY TUNNELLING

HORIZONTAL DIRECTIONAL DRILLING

DRILLING METHOD

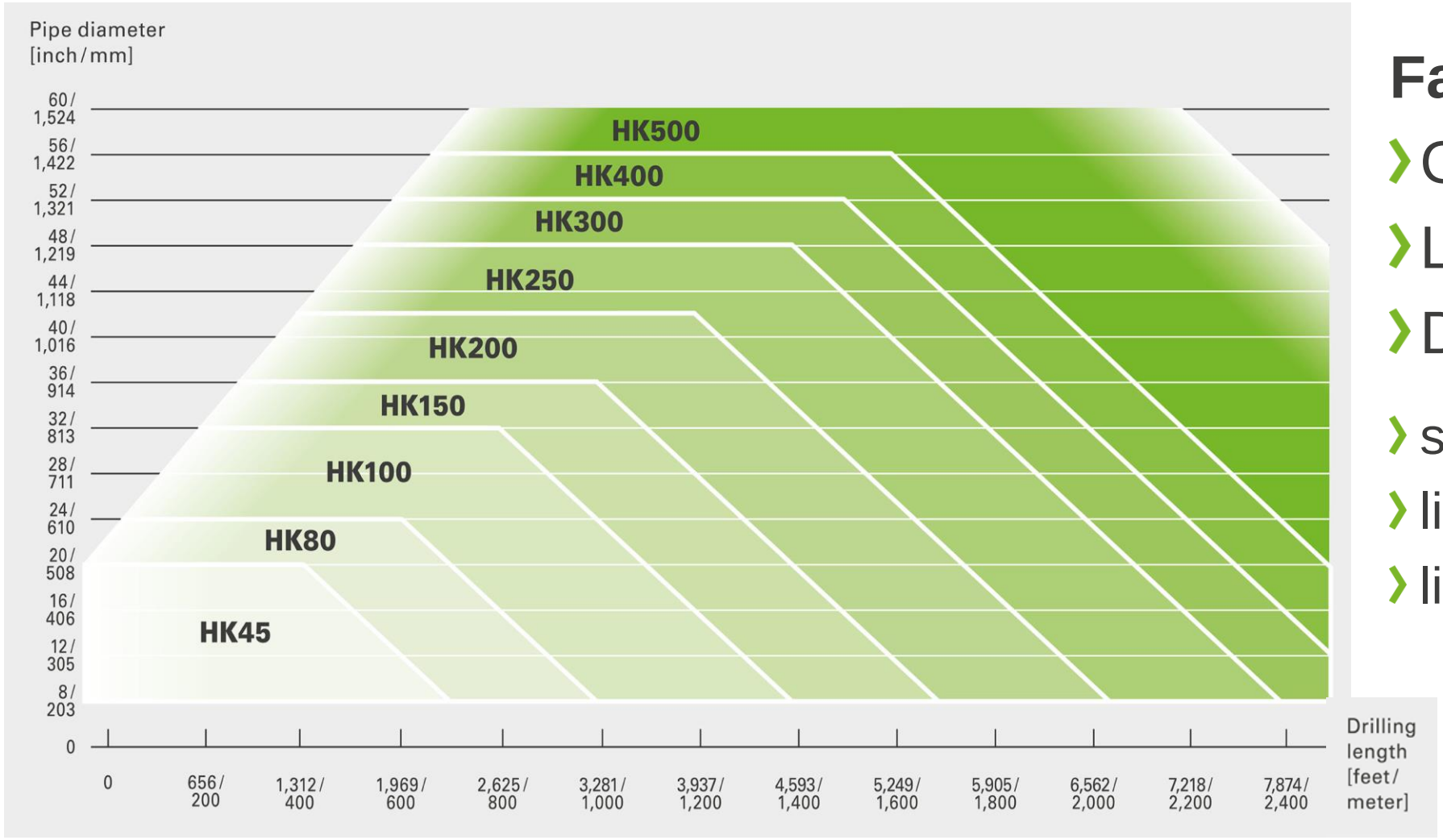


HDD RIGS AND THEIR SELECTION



CATEGORY	PULL FORCE	
Mini Rigs	≤150kN	Small scale drilling technology
Medi Rigs	150-400kN	
Maxi Rigs	400-2500kN	Large scale drilling technology
Mega Rigs	>2500kN	

HDD RIGS AND THEIR SELECTION



Factors for rig size:

- Geology
- Length
- Diameter

- stability of product pipe
- limits of drill pipe
- limits of tooling

RIG TYPES STANDARD

Compact Rigs CK

Trailer Rigs T

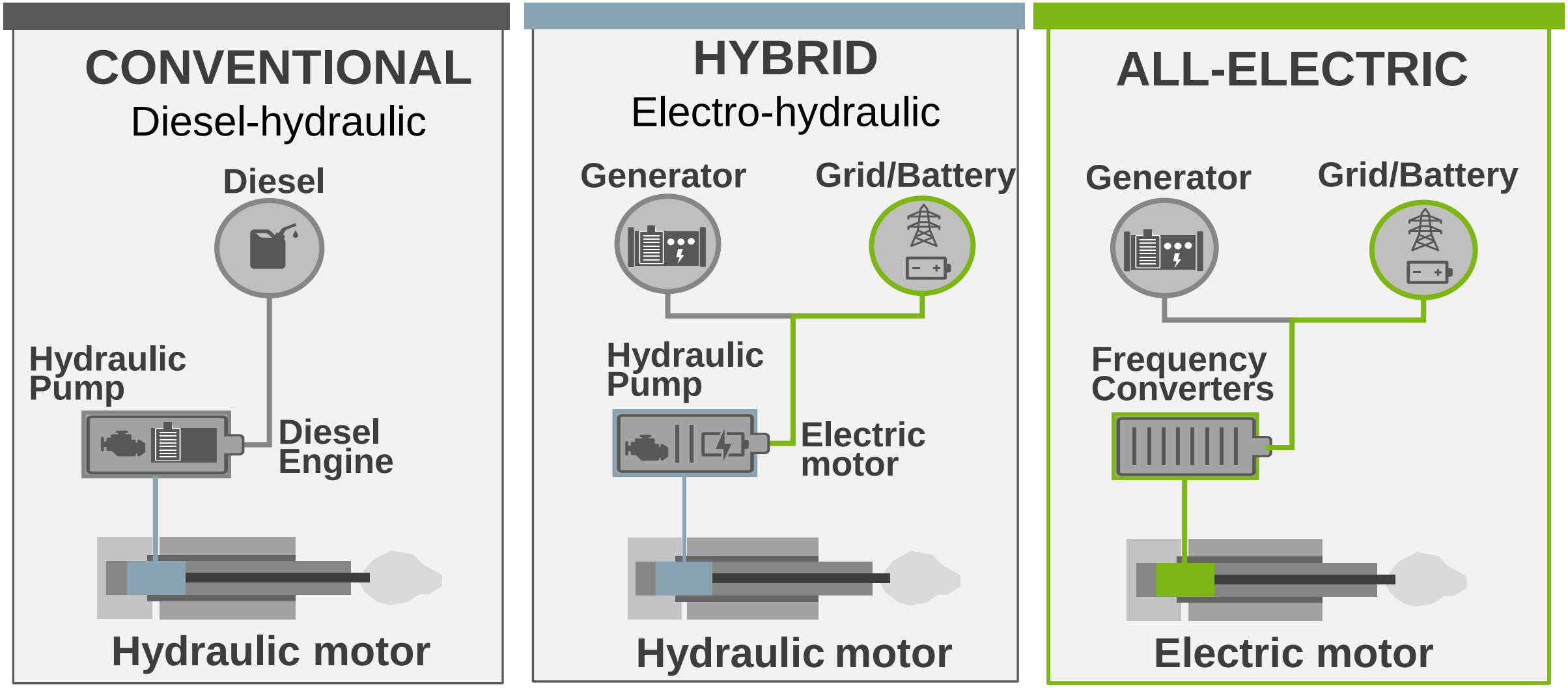
Modular Rigs M

100 ton | 200 ton | 300 ton | 400 ton | 500 ton

Crawler Rigs C

Frame Rigs F

DRIVE TECHNOLOGIES



HDD RIG RANGE COMPARISON

	CONVENTIONAL HDD RIG	HYBRID HDD RIG	ALL-ELECTRIC HDD RIG
Power source	Generator	Generator / Grid	Generator / Grid
Efficiency	+	+	+++
Emissions / Noise			
Investment Costs			
Maintenance Costs			

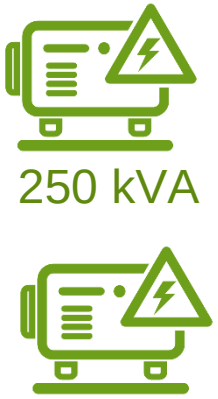
ADVANTAGES OF ELECTRIFICATION

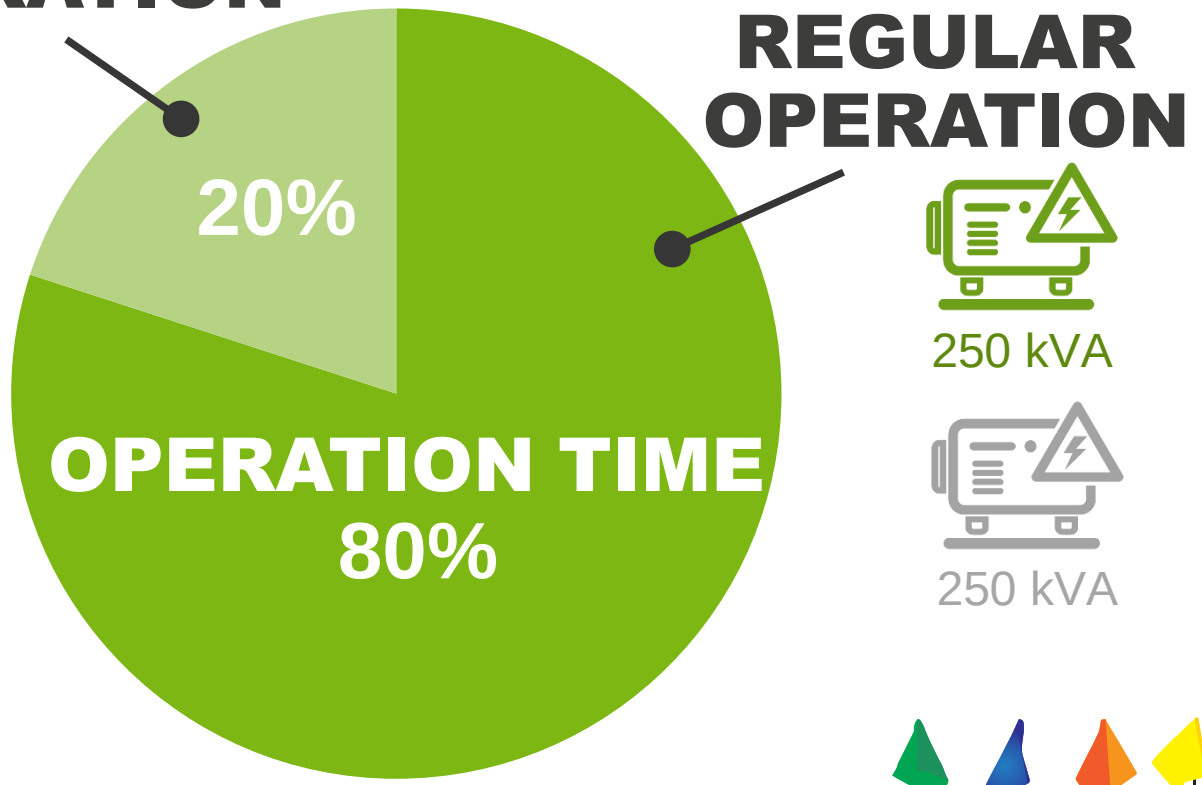
- **INCREASED EFFICIENCY**
- **REDUCED CONSUMPTION TO 50%**
- **REDUCED CO_2 EMISSIONS**
- **REDUCED COSTS**

ADVANTAGES OF ELECTRIFICATION

- LESS NOISE
- LESS LEAKAGE
- LESS MAINTENANCE

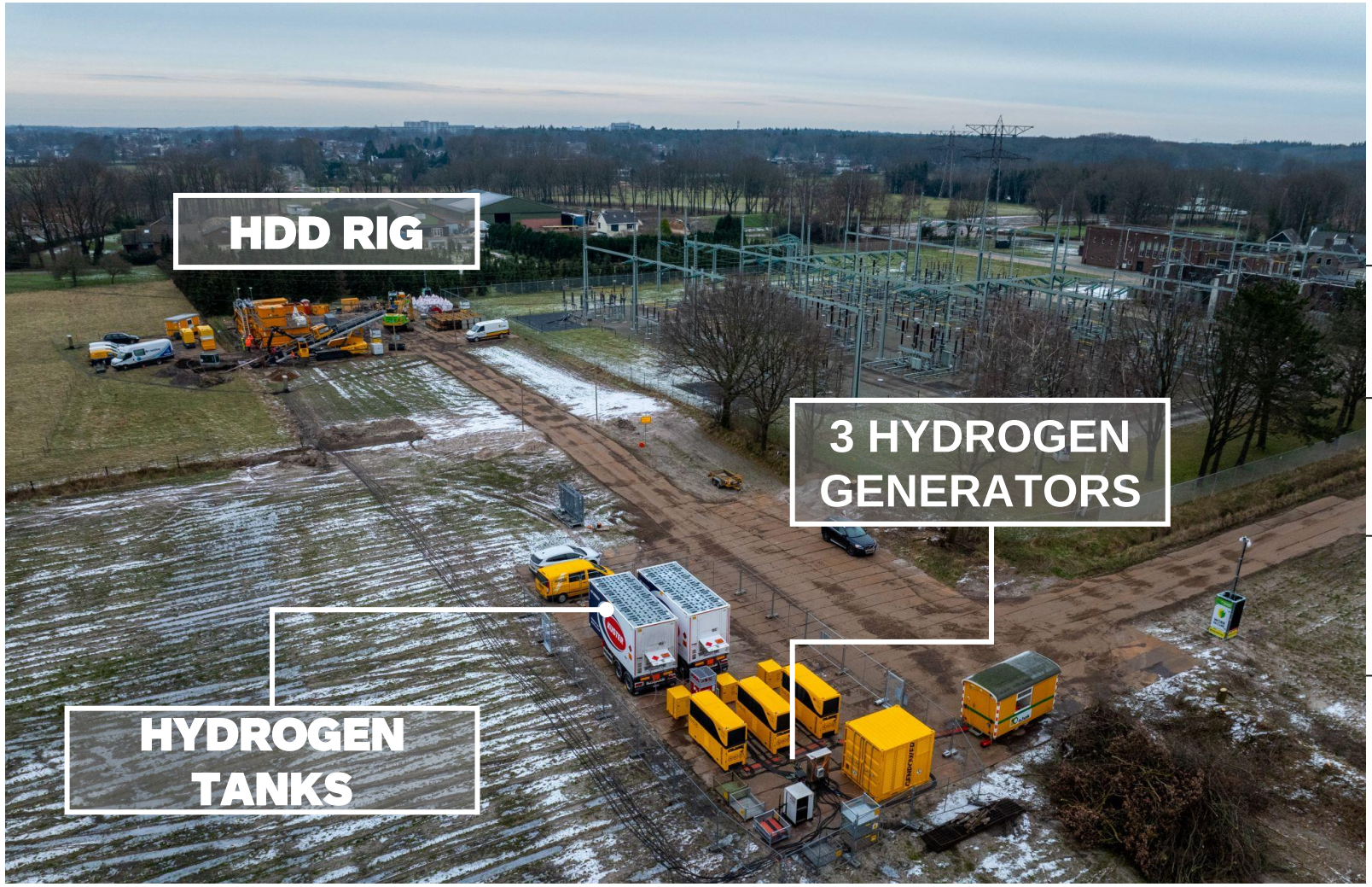
INTELLIGENT GENERATORS WITH E-RIGS





40 – 60 % REDUCTION OF FUEL CONSUMPTION

MODERN HDD JOBSITE



- **QUIET**
- **SUSTAINABLE**
- **CLEAN**
- **EFFICIENT**

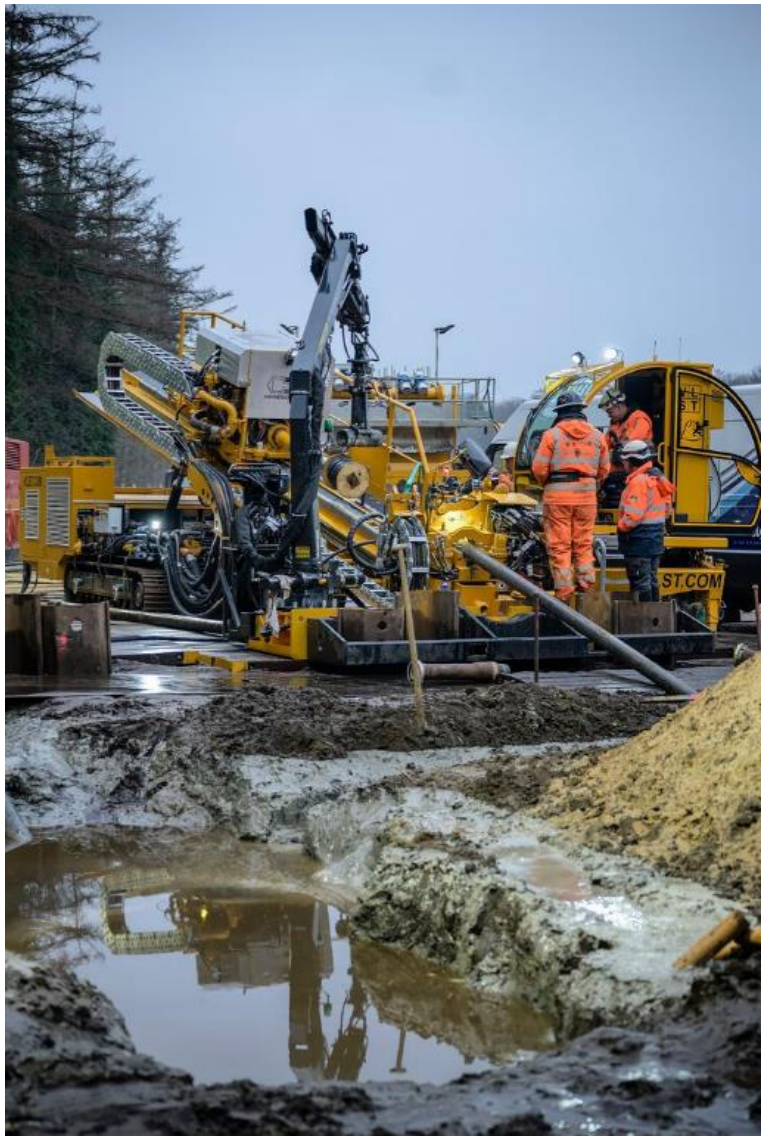
ALL-ELECTRIC HDD RIG HK300TE/FE

- Pullforce: 300 Ton / 660,000 lbs
- Torque: 120 kNm / 88,500 ft-lbs
- Drilling angle: 8° - 15°
- Drill pipe length: 9.8m / 32ft | Range 2

NEW ALL-ELECTRIC HDD RIG HK45CKE

- Pullforce: 45 tons / 100,000 lbs
- Torque: 24 000 Nm / 17,700 ft-lbs
- Rotation Speed: 0 – 150 rpm
- Drilling angle: 9-20°
- Drill Pipe length: 6m / 20ft

- High Pressure Pump:
  1000 l/min @ 40 bar
  260 gal/min @ 580 psi



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