



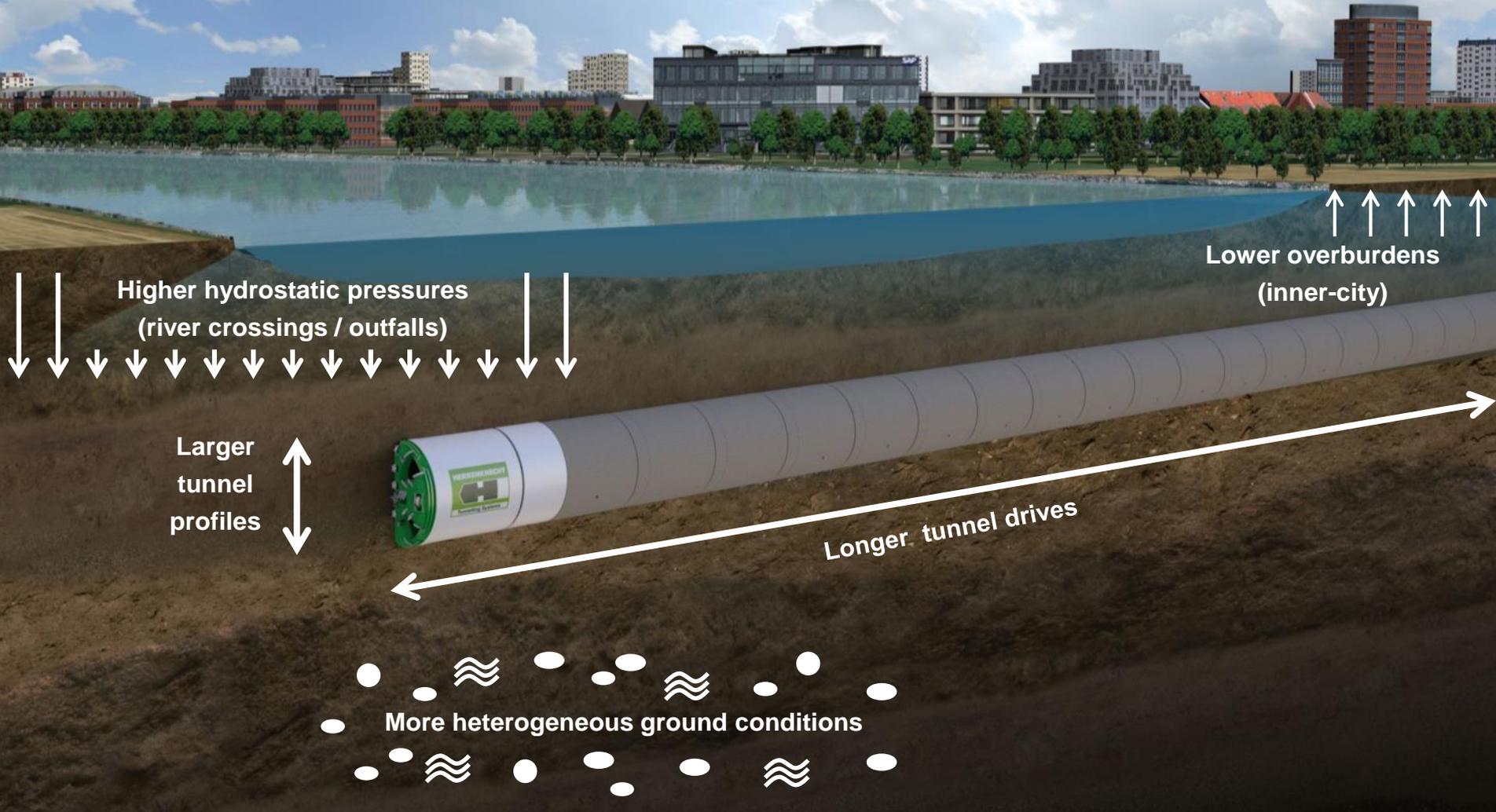
New developments and applications of Direct Pipe® & E-Power Pipe®.

No-dig infra yearly gatherring, Thursday 28th of March 2019

NoDig Infra Konference og Årsmøde 2019 Gl. Avernæs, Sydfyn

Lutz zur Linde

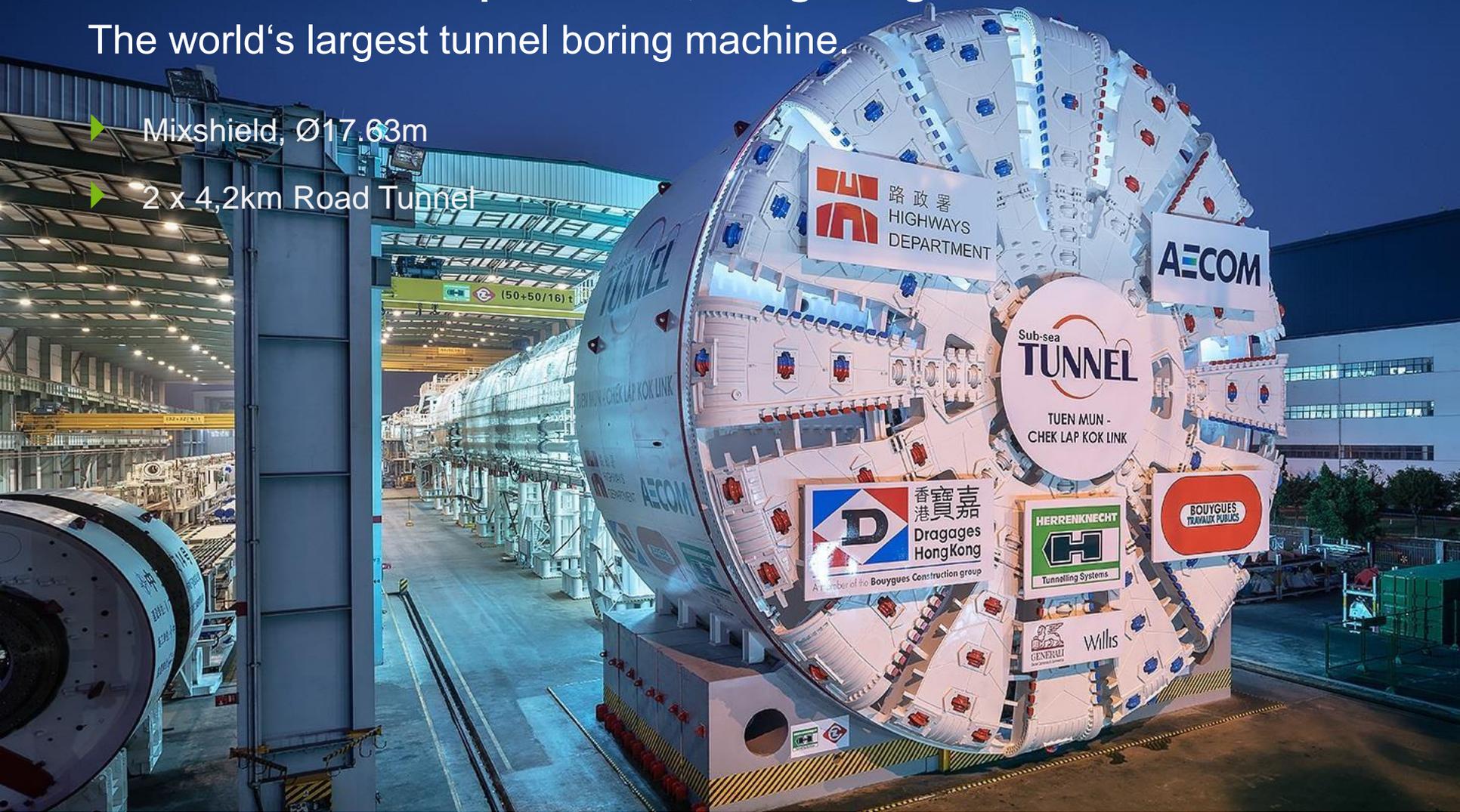
Trends in Pipe Jacking.



Tuen Mun – Chek Lap Kok Link, Hong Kong.

The world's largest tunnel boring machine.

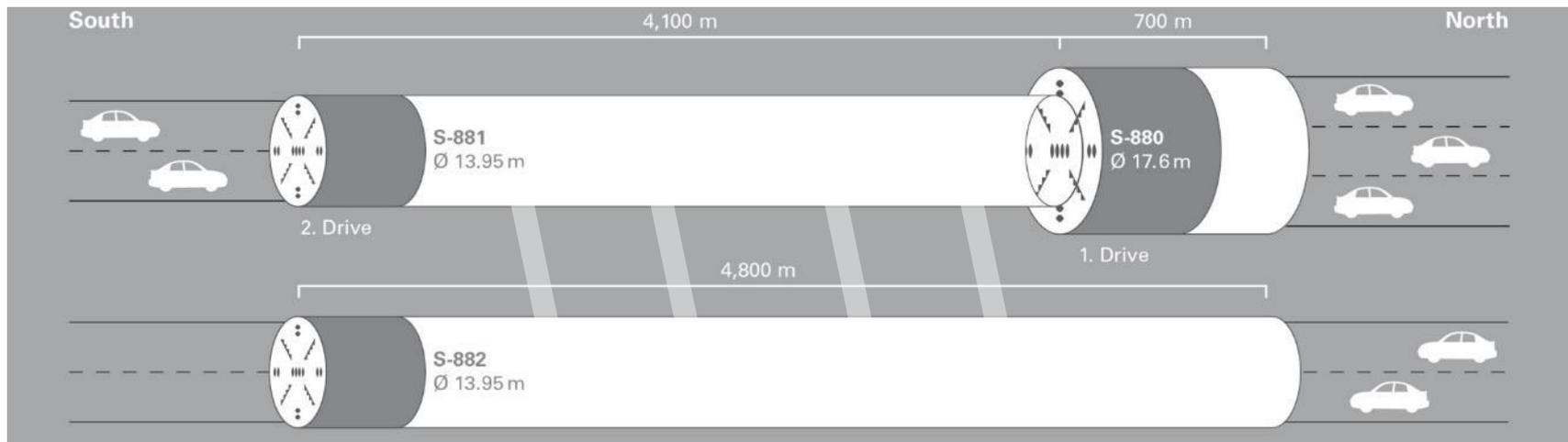
- ▶ Mixshield, Ø17.63m
- ▶ 2 x 4.2km Road Tunnel



Tuen Mun - Chek Lap Kok Link.

Herrenknecht technology involved.

- ▶ **2 road tunnels** (Traffic Tunnelling)
 - ▶ **3 x Mixshields** supplied by Herrenknecht
 - ▶ S-880 Ø 17.6m, world's largest TBM
 - ▶ S-881 Ø 14m
 - ▶ S-882 Ø 14m
- ▶ **46 cross passages** built by Mini-TBM
 - ▶ **2 x AVN 3000** with special equipment



Herrenknecht. Pioneering Underground Technologies



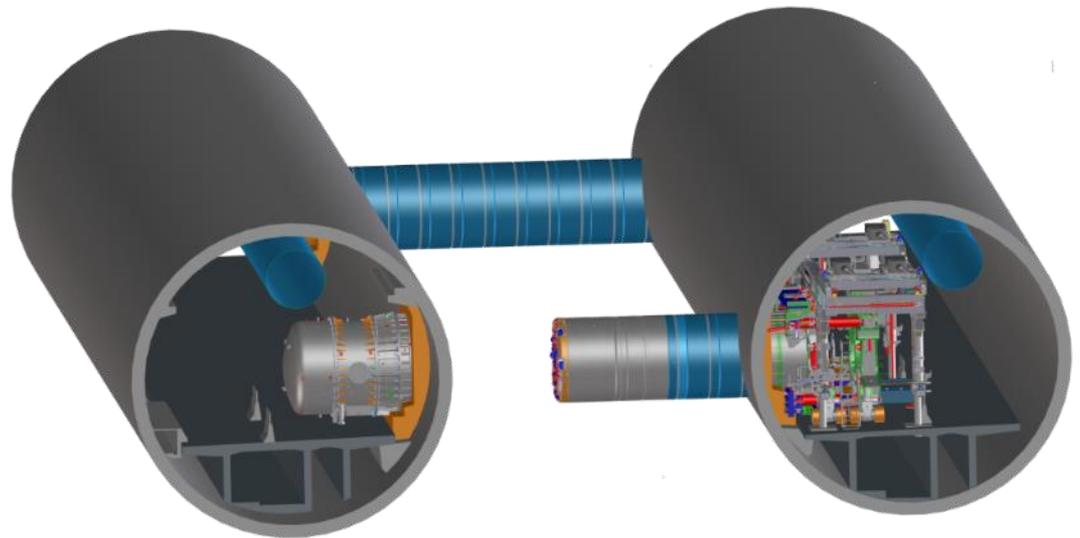
A member of the Bouygues Construction group
Dragages - Bouygues Joint Venture 寶嘉 - 布依格聯營



Tuen Mun - Chek Lap Kok Link.

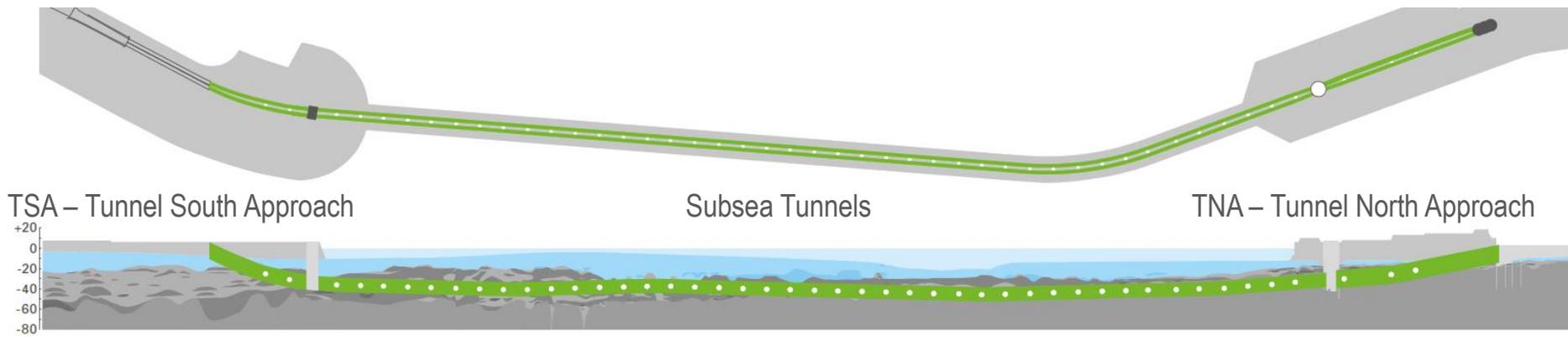
Cross passage technology.

- ▶ M-2001M + M-2003M, 2 x AVN 3000, OD 3605
- ▶ 46 Cross passages built by Mini-TBM
- ▶ Length of cross passages: up to 13m
- ▶ Max. confinement pressure: **5,5 bar**
- ▶ Geology: sand, silt, clay, gravel, granite



Tuen Mun - Chek Lap Kok Link. Cross passage technology.

- ▶ **46 CPs finished** by Mini-TBM
- ▶ **Performance: Ø 20 days per CP**
 - ▶ Advance cycle: including assembly, advance, disassembly and transport in tunnel



Herrenknecht. Pioneering Underground Technologies



Dragages - Bouygues Joint Venture 寶嘉 - 布依格聯營



Curved Pipe Jacking.

Rainwater collector.

- ▶ M-1909M, AVN2000, OD2425
- ▶ Location: Livry-Gargan, France
- ▶ Bassin du Rouailler - Rainwater collector
- ▶ Drive length: 412m
- ▶ **Curve drive: radius = 110m**
- ▶ Total tunnel length: 620m
- ▶ Geology: clay
- ▶ Contractor: Bessac, Sade



Inclined Pipe Jacking.

Uphill pipe jacked sewage tunnel Bad Liebenzell, Germany.

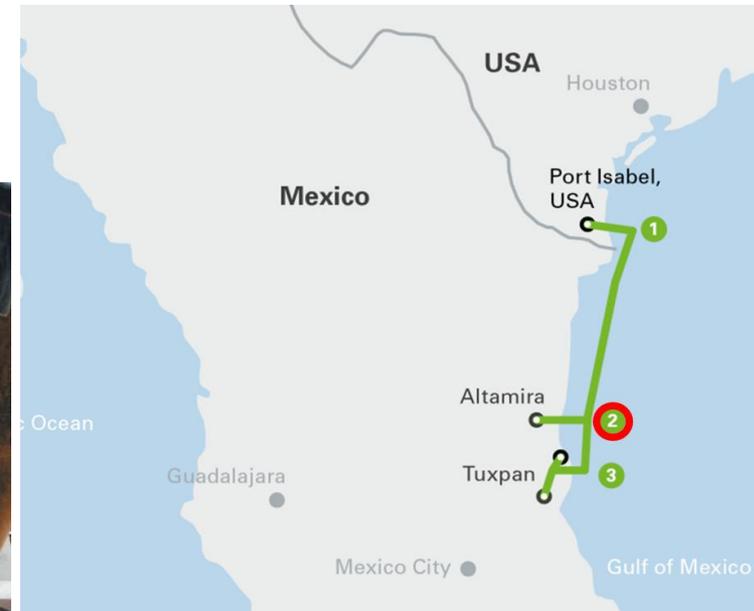
- ▶ M-576M, AVN1200, OD1505.
- ▶ Tunnel length: 126m
- ▶ **Slope: up to 52%**
- ▶ Geology: cohesive ground, boulders, claystone, sandstone, quartzite



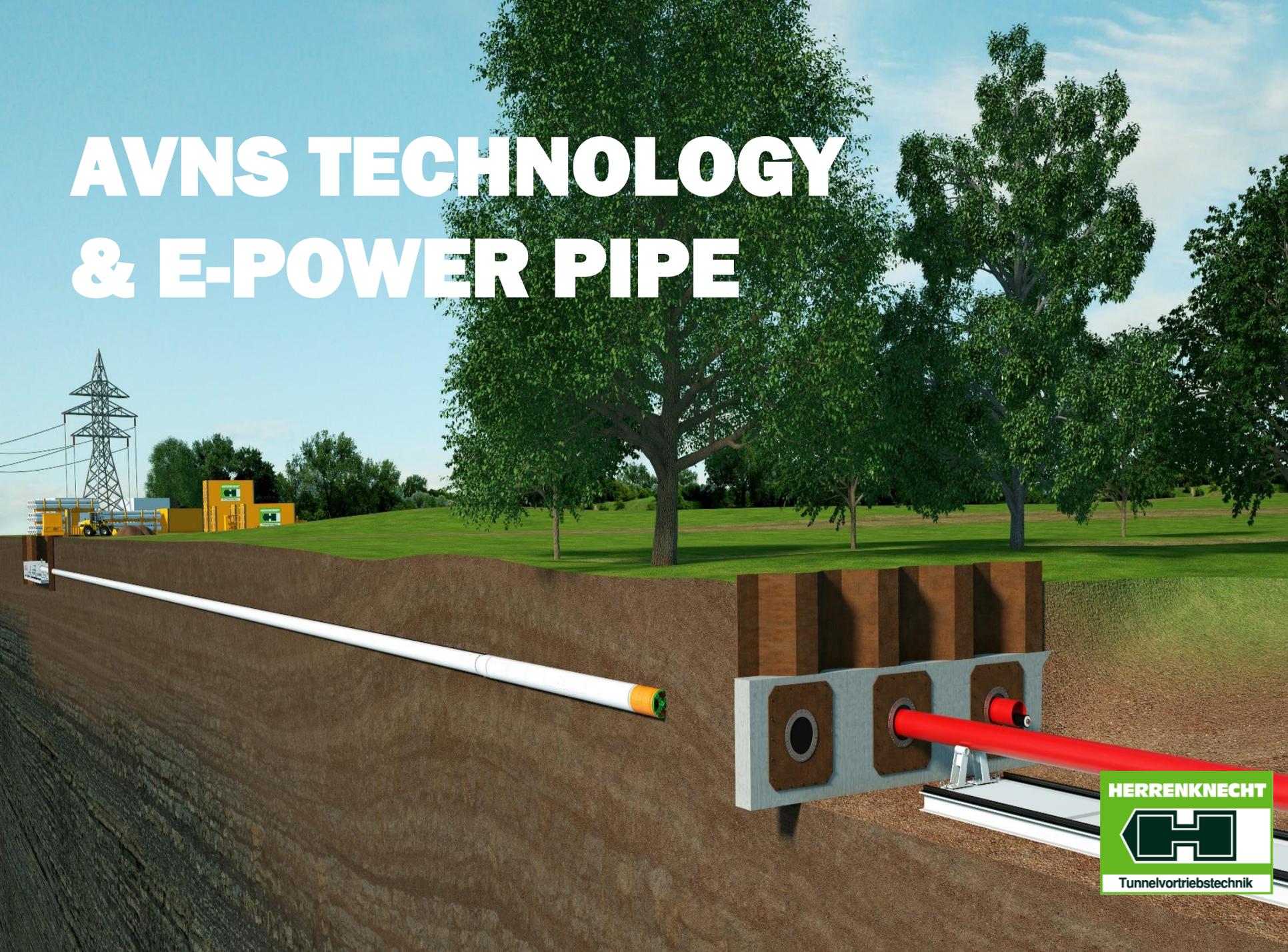
Long-distance Pipe Jacking.

Altamira Landfall, Sur de Texas – Tuxpan Pipeline.

- ▶ M-1275M, AVND2000, OD3200 (Pipe ID 2600)
- ▶ Location: Altamira, Mexico
- ▶ Tunnel length: **2,246m Sea Outfall**
- ▶ Geology: sand, silt, clay
- ▶ Best daily performance: 25.5 m



AVNS TECHNOLOGY & E-POWER PIPE



HERRENKNECHT



Tunnelvortriebstechnik

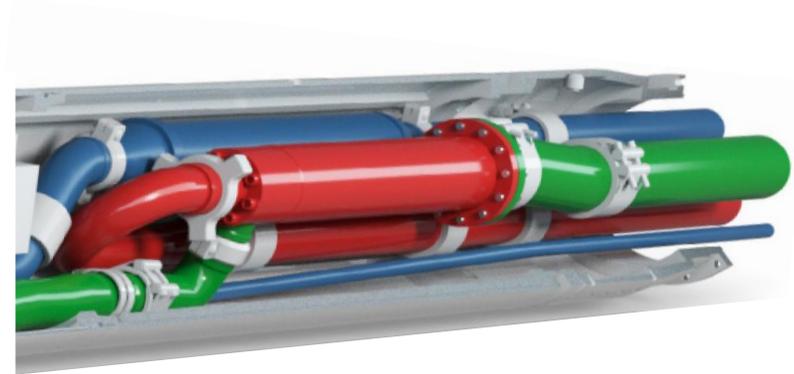
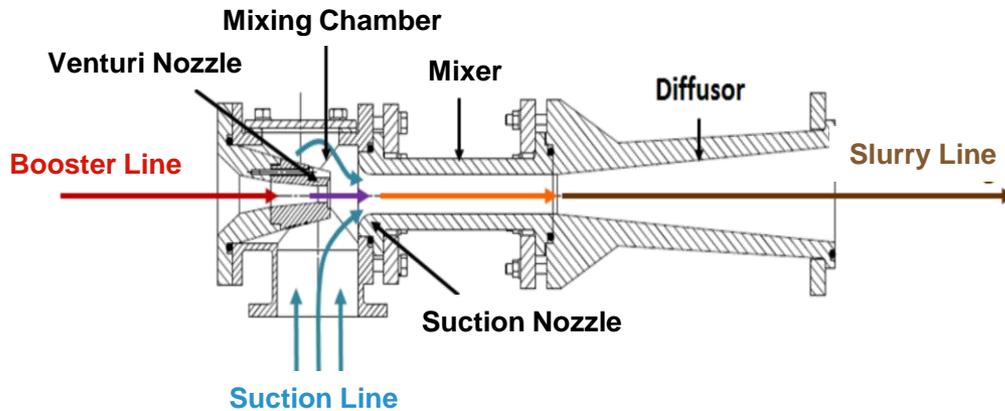
Long-distance Pipe Jacking for small diameters.

EPOWER PIPE

- ▶ Development of **AVNS** microtunnelling machine (for ID 400 – 1200)
- ▶ **Drive length: 1,000m – 1,500m**
- ▶ Special requirement for **underground cable installation**
 - ▶ Depth/ low coverage: 1,5m to 4m, constant
 - ▶ High precision: constant distance between lines 1m – 2m



Direct Pipe®. Small Diameter Trenchless Technology. Newly-developed Jet Pump.



Booster Line – High Pressure

Booster Line – High Flow Speed

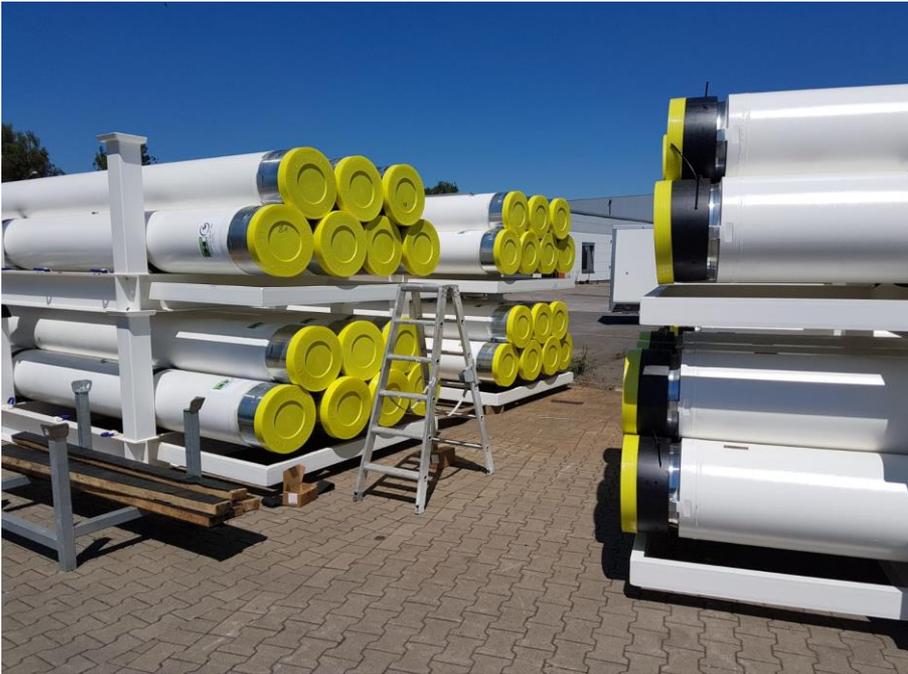
Suction Side – Low Pressure

Mixing of Boost Flow & Suction Stream

Build-Up of Slurry Pressure



Underground cable construction.
Steel jacking pipes & coupling system.



E-Power Pipe®

Animation.

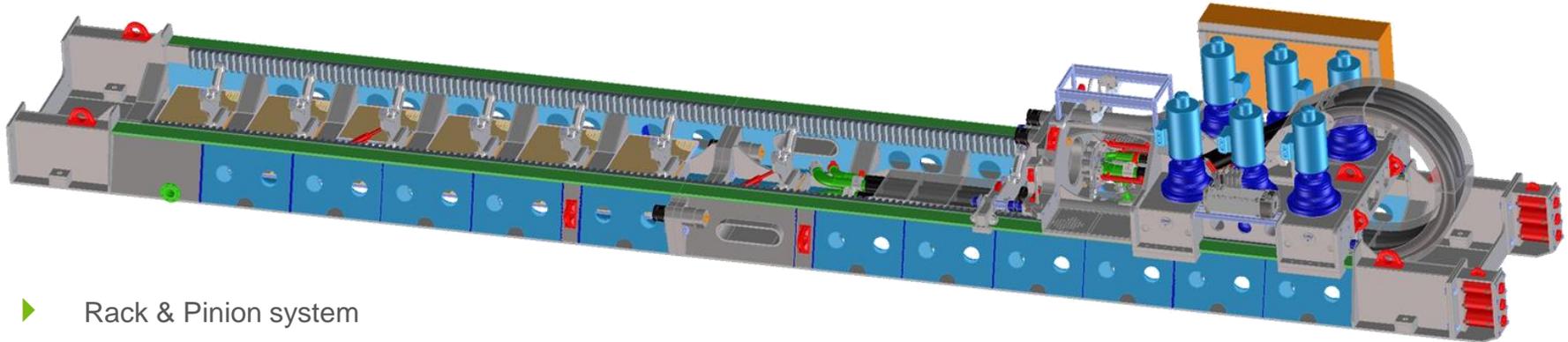
EPOWER PIPE



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Underground cable construction. New E-PowerPipe® push & pull unit.

EPOWER PIPE



- ▶ Rack & Pinion system
- ▶ 6 electric drives, total. 66KW
- ▶ High performance in both directions: max. 5m/min
- ▶ Max. thrust & pull force: 340to

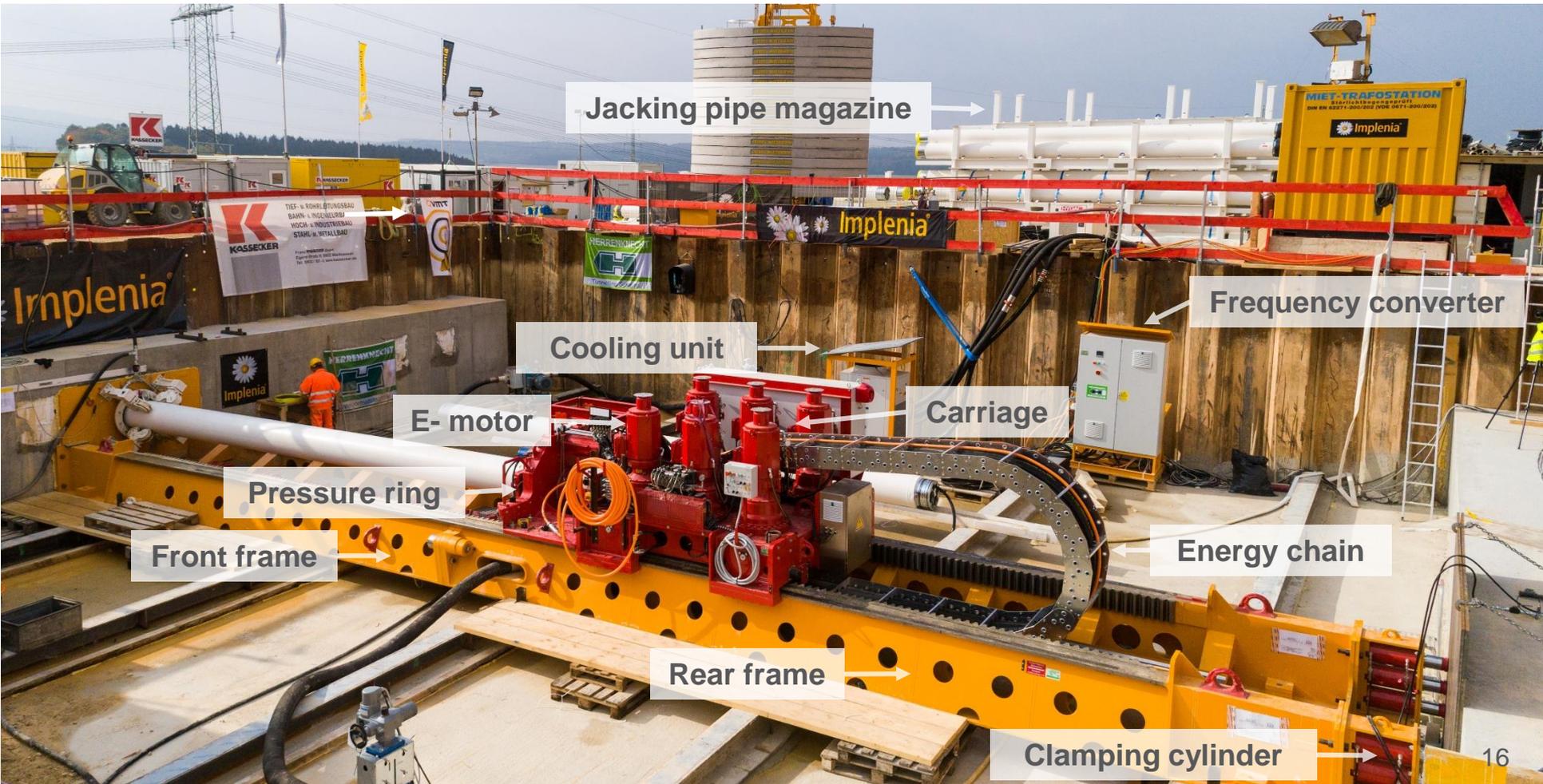
Advantages:

- ▶ All couplings of lines and cables in one process step
 - ▶ Combination of new push & pull unit and new steel pipes:
Reduction coupling times 30min >>> 5 -10min !!!



E-Power Pipe®

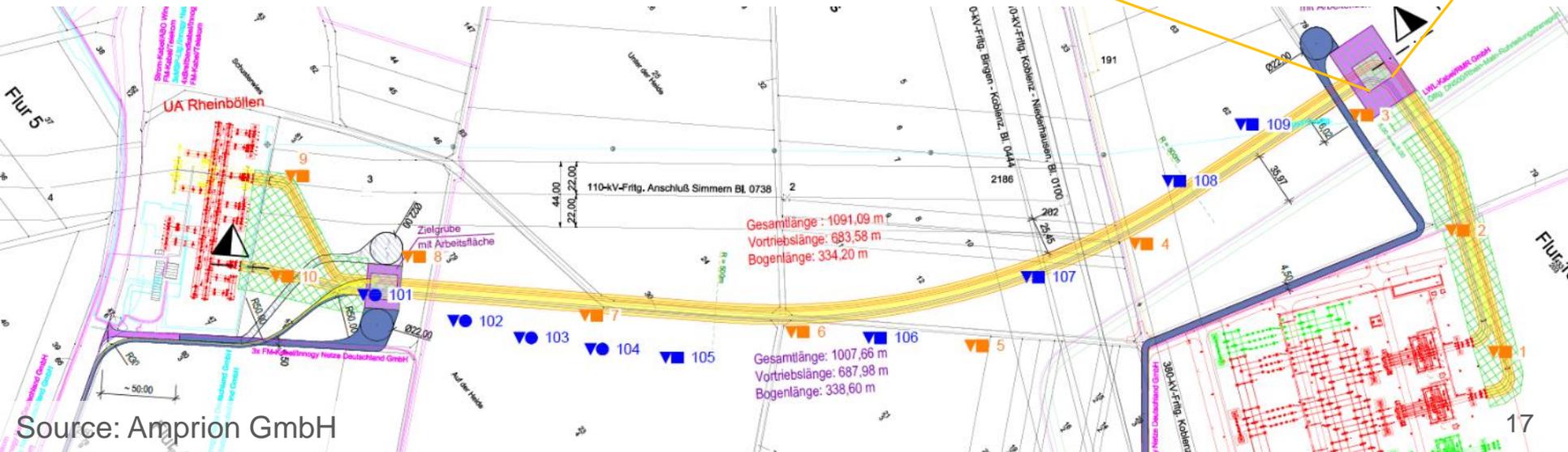
Rack and pinion jacking frame: Main parts



E-Power Pipe®

Amprion Project in Bacharach: Key facts

- ▶ 6 drillings of 688 m length each (total: 4.128 m)
- ▶ Average coverage of approx. 2 m
- ▶ Curve with a radius of 500 m
- ▶ Drilling downwards with a height difference of 17 m



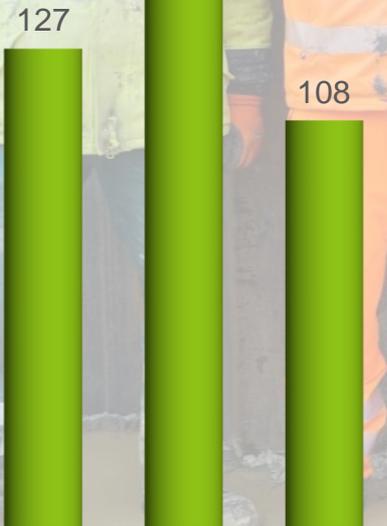
Source: Amprion GmbH

E-Power Pipe®

Project in Bacharach: Achievements

Best daily performance m/day [Pilot Bore]

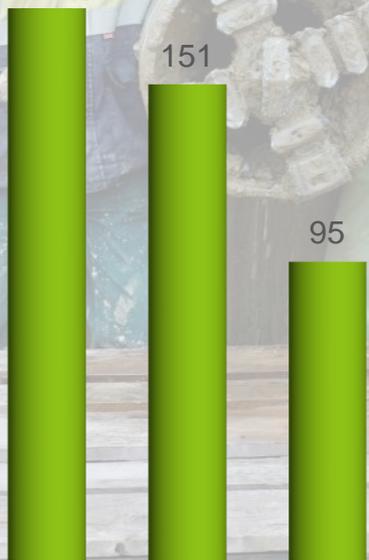
144



Bore 1 Bore 2 Bore 3

Average advance rate mm/min [Pilot Bore]

175

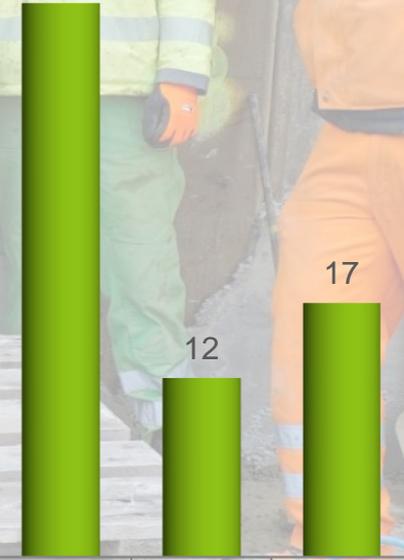


Bore 1 Bore 2 Bore 3

Days per drive

[in total: Pilot Bore and pull-in of casing]

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Bore 1 Bore 2 Bore 3

Direct Pipe®. **Animation.**

Trenchless pipeline crossings and landfalls.



Direct Pipe® Shore approach. Leviathan Gas Field, Israel.

32" Gas Pipeline with 56" Direct Pipe®.

- ▶ M-2246M, AVN1200DP + 2 x HK750PT Pipe Thruster (one standby)
- ▶ Location: Dor, Israel
- ▶ Drilling length: 1,123m | 3,690ft
- ▶ Pipe section length: 60m
- ▶ Geology: sands, clays, Kurkar
- ▶ Client: Noble Energy
- ▶ Contractor: A. Hak Drillcon B.V.
- ▶ Best daily performance: 61,8m



Direct Pipe® Shore approach. Leviathan Gas Field, Israel.

32" Gas Pipeline with 56" Direct Pipe®.



Remote-controlled subsea recovery



World Record Direct Pipe® Project.

48" Shore Approach with wet recovery.

- ▶ M-2170M, AVN1000DP + 1 x HK500PT & 1x HK750PT Pipe Thruster
- ▶ Use of Pipeline: Army Bay Wastewater Treatment Plant Outfall Replacement
- ▶ Location: Auckland, New Zealand
- ▶ **Drilling length: 1,930m World Record**
- ▶ Geology: sandstone, mudstone
- ▶ End position reached: August 02, 2018
- ▶ Client: Water Care
- ▶ Contractor: McConnell Dowell

Performance:

- ▶ Best daily performance: 42.5m
- ▶ Best monthly performance: 210.7m



Microtunnelling in hard rock.

New AVN800 | OD975.

- ▶ For rock with **high compressive strengths**: up to 200MPa
- ▶ High wear-resistance of **TCl cutter discs**
- ▶ Extended **drive length**: up to 200m
- ▶ **Torque equal** to current machine AVN800B (55kNm)
- ▶ Increased **rotation speed** of cutting head: up to **36rpm** @ 360l/min
- ▶ **Compact jacking frame** to achieve a small launch shaft of \varnothing 3,2m
- ▶ Operation by **standard control container C20** possible
- ▶ **Flushing ring**: fine rock particles to be kept away from annulus



Microtunnelling in hard rock.

New AVN800 | OD975.

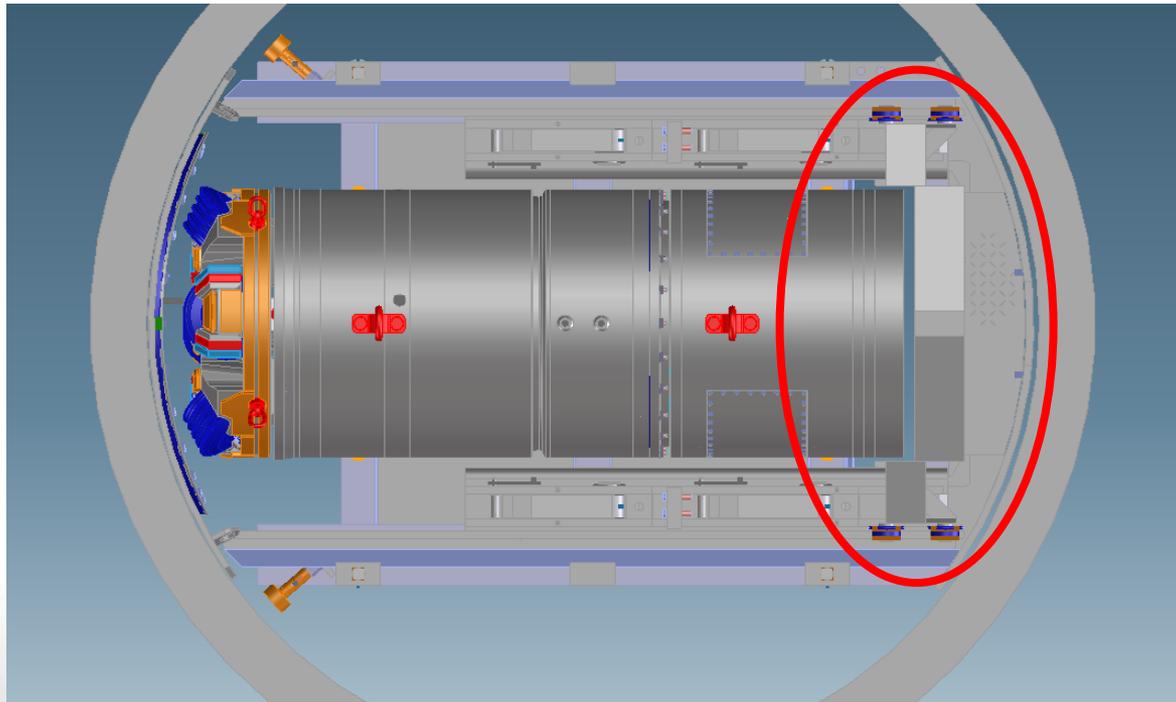
	AVN800B <i>current</i>	AVN800B <i>Rock!</i>
Cutting head	7 x 2-ring disc	5 x TCI disc
Hydraulic pump	55 kW, 130 l/min	min. 90 kW, 260 l/min
Max. rotation speed	7.4 rpm	up to 36 rpm
Max. compressive strength	50 MPa	200 MPa
Max. drive length	100 m	200 m



Microtunnelling in hard rock.

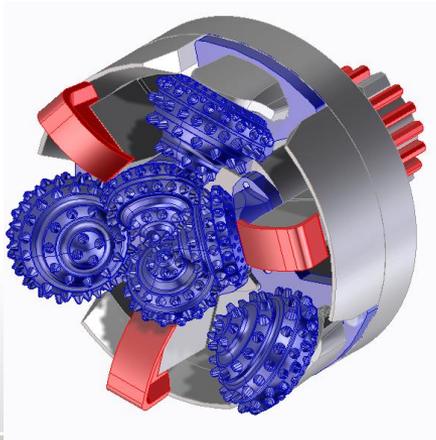
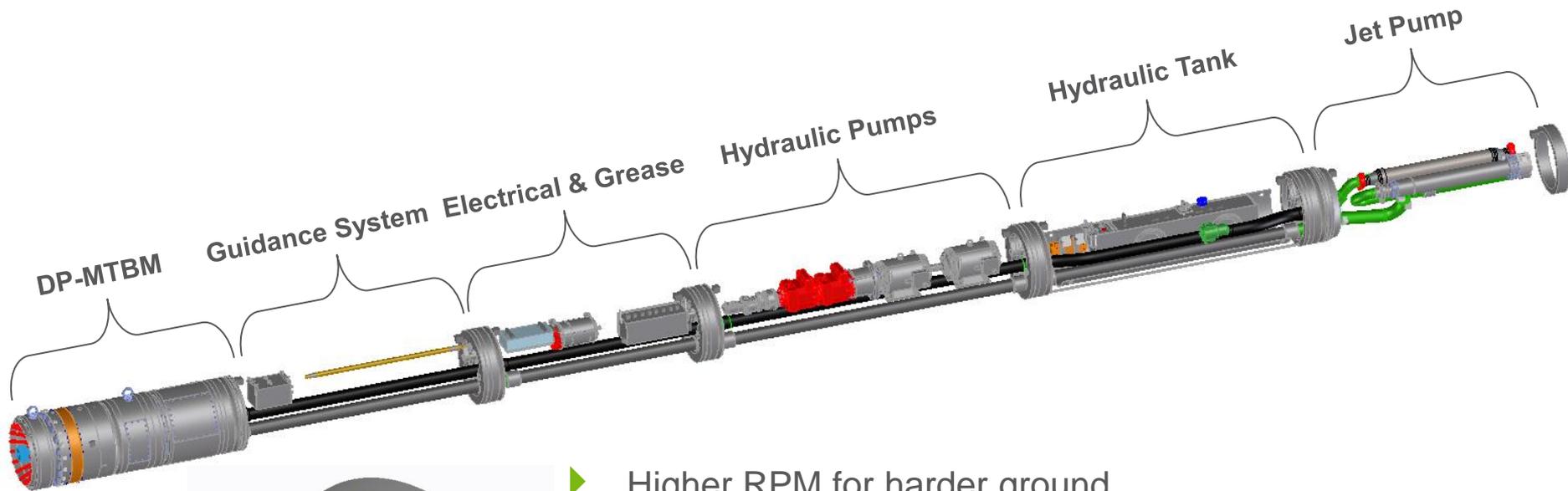
New AVN800 | OD975.

- ▶ Implementation of the requirements
 - ▶ Machine still fits in the small $\text{Ø}3,2\text{m}$ round start shaft in combination with the compact jacking frame and adapted new thrust ring



Direct Pipe®. Small Diameter Trenchless Technology.

New Design from 20" to 36" (up to 42" and 48").



- ▶ Higher RPM for harder ground
→ rock capabilities 130-200 MPa (depends on diameter)
- ▶ Jet pump integration
- ▶ Combination of gyro & walkover guidance system
- ▶ Interchangeable power packs (for smaller diameters)

Direct Pipe®. Trenchless Technology.

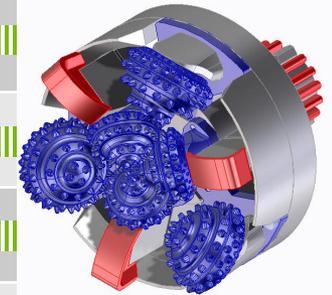
Operating Range.



DP-MTBM
"classic"

DP-MTBM
"Jet Pump & Rock"

Pipeline Diameter	Direct Pipe® System	Drilling Distance ¹	Geology ¹						
			Clay	Sand < 2mm	Gravel <63mm	Cobbles <256mm	Boulders >256mm	Rock <100MPa	Hardrock <200MPa
20"	AVN 400 DP	400 – 500 m 1,300 – 1,650 ft	[Green bar with vertical lines indicating geology compatibility]						
24"	AVN 500 DP	500 – 650 m 1,650 – 2,150 ft	[Green bar with vertical lines indicating geology compatibility]						
28"	AVN 600 DP	600 – 800 m 1,950 – 2,600 ft	[Green bar with vertical lines indicating geology compatibility]						
32"	AVN 700 DP	700 – 900 m 2,300 – 2,950 ft	[Green bar with vertical lines indicating geology compatibility]						
36"	AVN 800B DP	800 – 1,000 m 2,600 – 3,300 ft	[Green bar with vertical lines indicating geology compatibility]						
42"	AVN 800A DP	1,000 – 1,200 m 3,300 – 3,900 ft	[Blue bar with vertical lines indicating geology compatibility]						
48"	AVN 1000 DP	1,500 – 2,000 m 4,900 – 6,550 ft	[Blue bar with vertical lines indicating geology compatibility]						
56" – 60"	AVN 1200 DP	1,500 – 2,000 m 4,900 – 6,550 ft	[Blue bar with vertical lines indicating geology compatibility]						



■ onshore only ■ onshore & offshore

¹ best case scenario – no distinction between DP-MTBM "classic" and DP-MTBM "Jet Pump & Rock"

Horizontal Directional Drilling.

Complete HDD system is electrified – one power source



Separation Plant



Mud Mixing



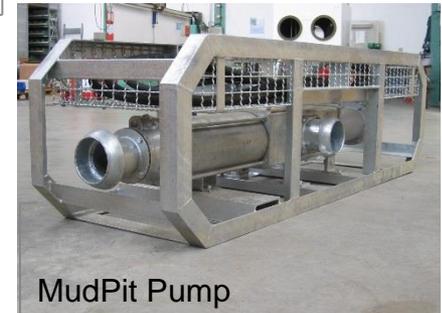
Mud Transfer Tank



HDD RIG



Break Out-Unit



MudPit Pump



Generators or – directly from the grid / STATNET



High Pressure Mud Pump

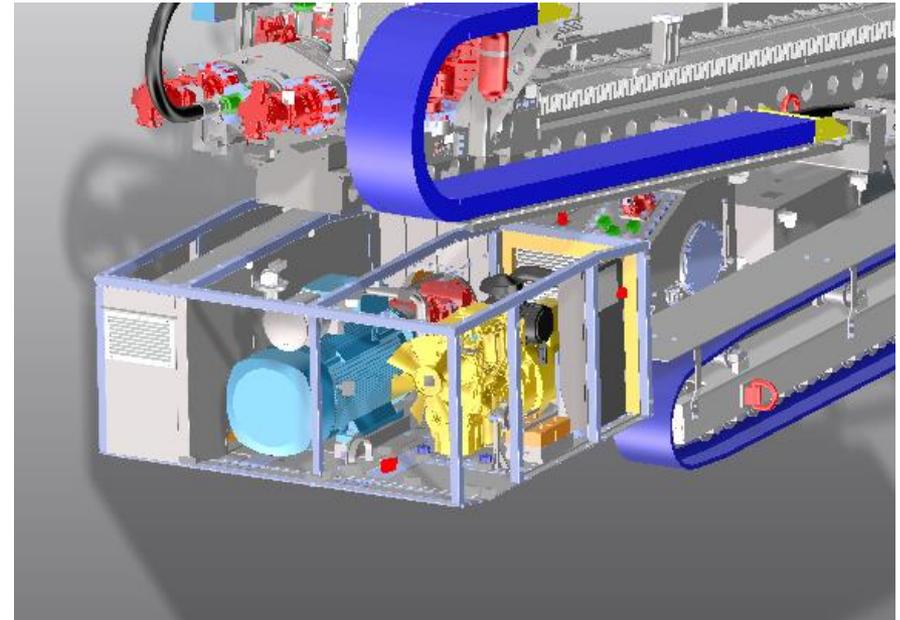
Hybrid HDD Rig.

First use of Hybrid-Rig in France.

- ▶ H-348, HK80CK-Hybrid
- ▶ Developed for inncer-city operation
- ▶ Quiet operation and minimal size ratio
- ▶ 250m River Crossing, nearby Paris, longtime client HDI



Horizontal Directional Drilling. HDD is getting electrified



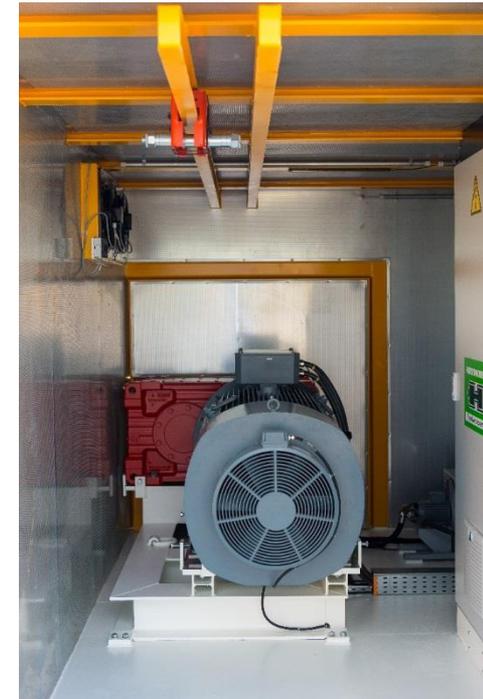
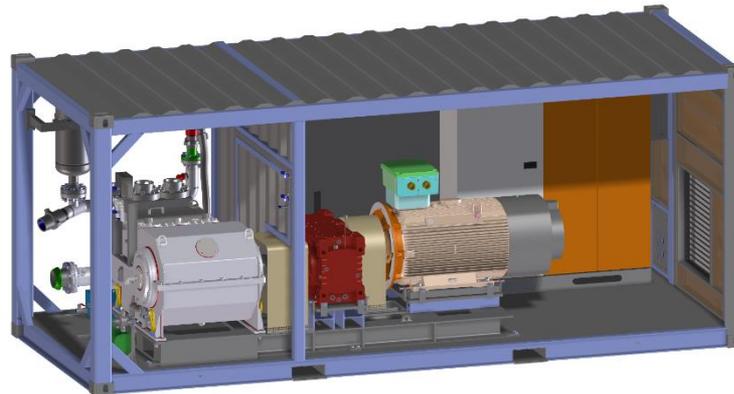
CAT 328 kW Engine → 250 kW E-Motor
+ add. small Motor to move Rig

Horizontal Directional Drilling.

HDD is getting electrified



High Pressure Mud Pumps



Horizontal Directional Drilling.

HDD is getting electrified



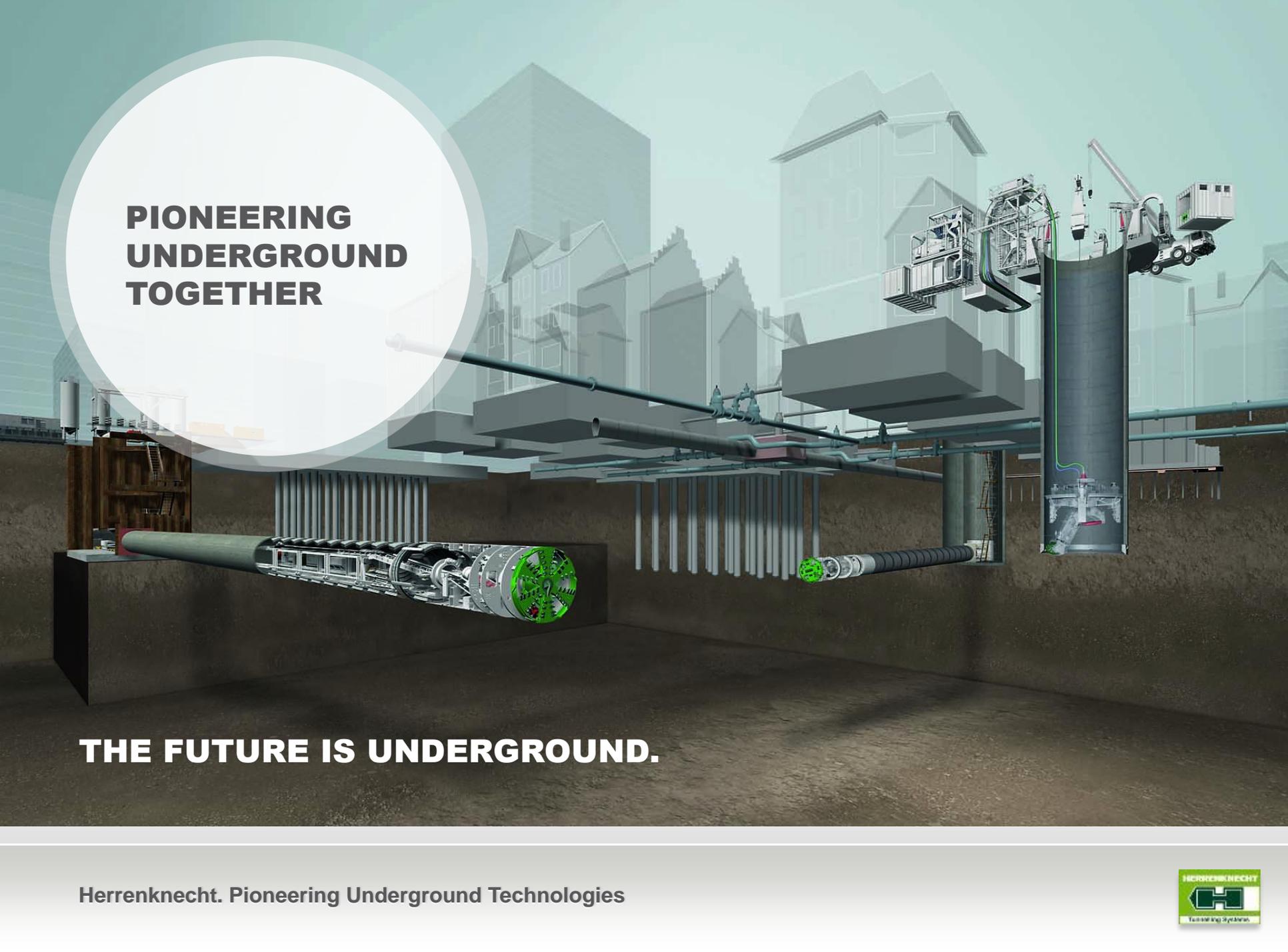
Power Packs





**PIONEERING
UNDERGROUND
TECHNOLOGIES**

▶ Thank you very much for your attention.



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UNDERGROUND
TOGETHER**

THE FUTURE IS UNDERGROUND.

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