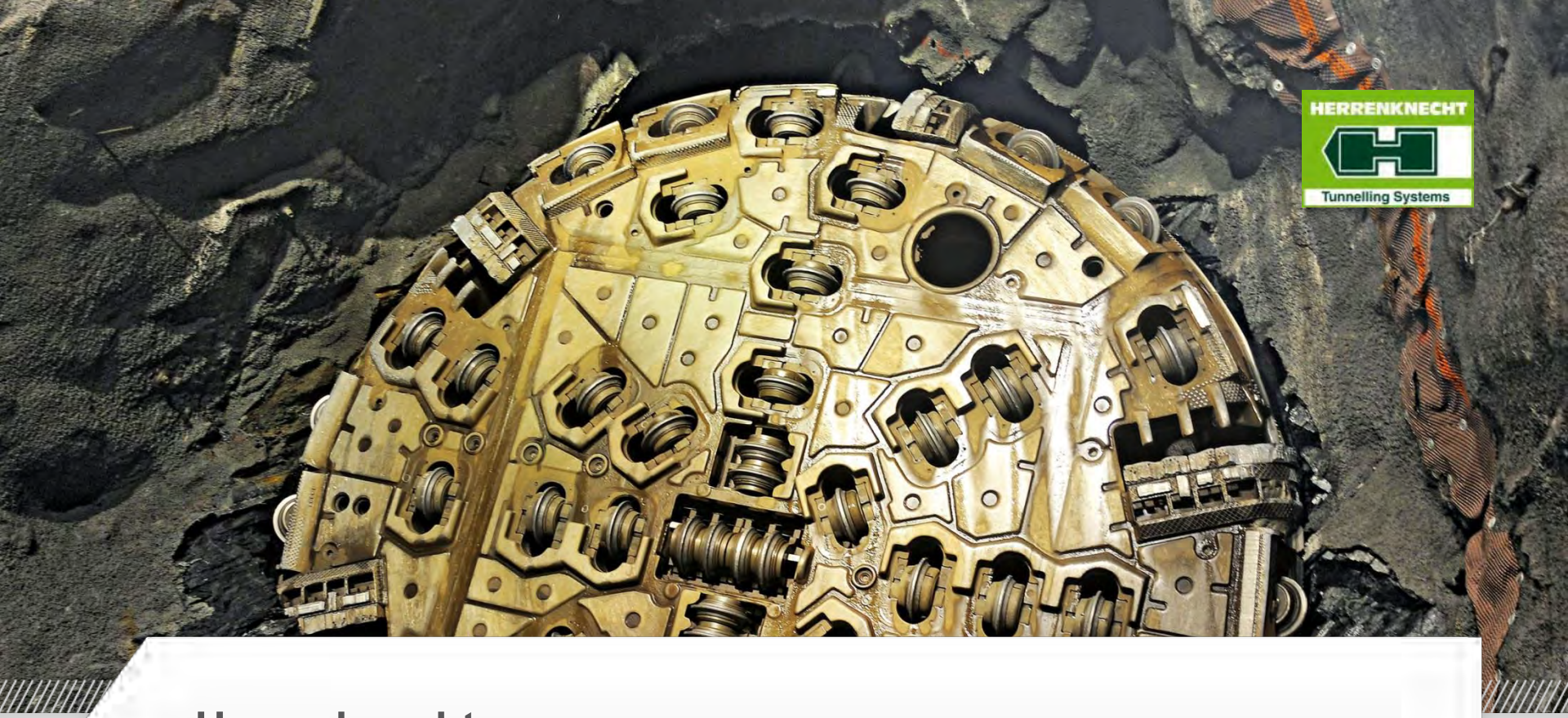


Herrenknecht
Pioneering Underground Technologies

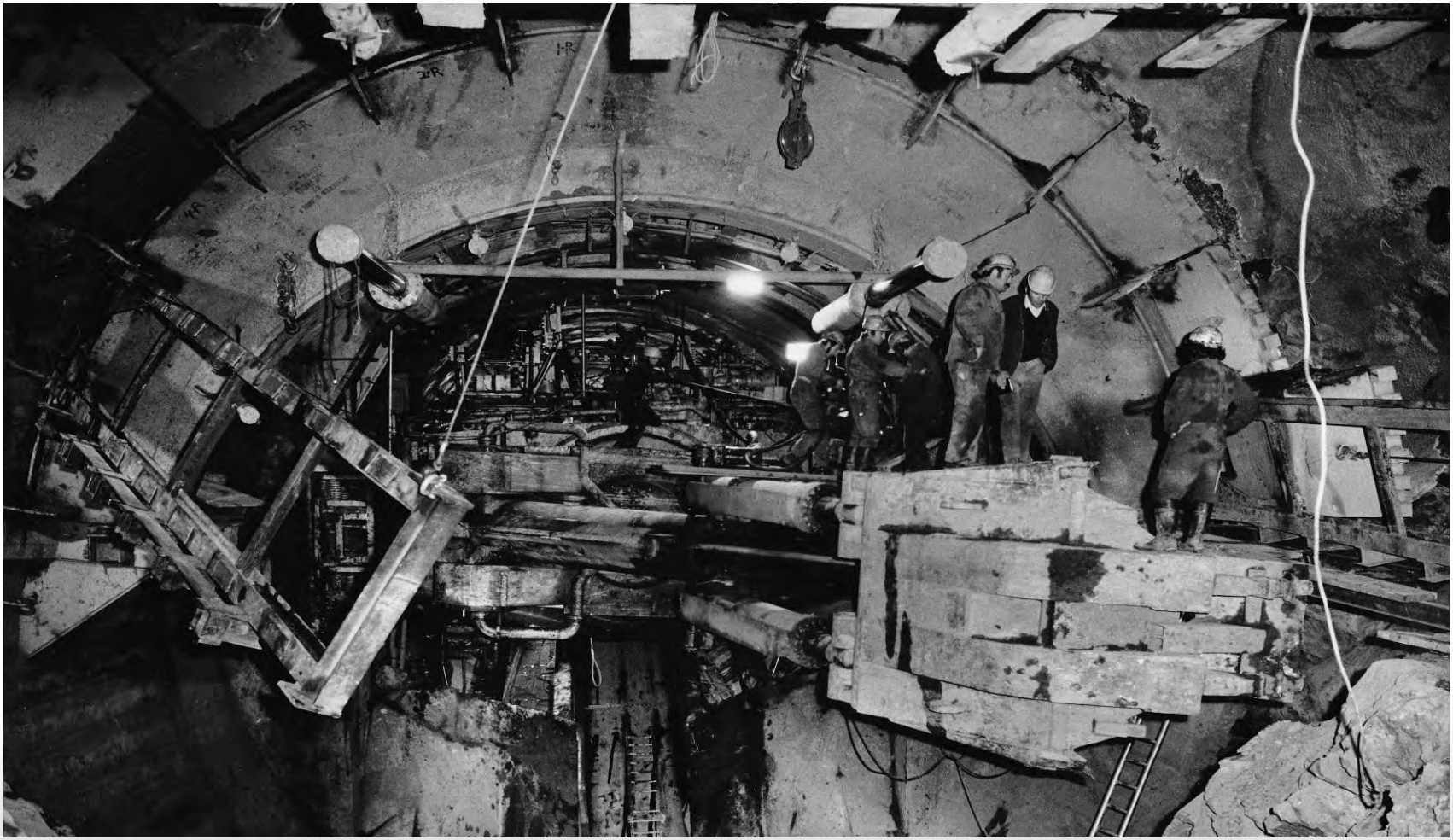
Visit of Herrenknecht AG by KIVI Engineering Society **TTOW**

Martin Forster, Technical Manager Sales | Traffic Tunnelling

Schwanau, 22.09.2016

Seelisberg Tunnel: Big John.

1971 the world‘s largest TBM with a diameter of 11.8m.



Herrenknecht.

Milestones of the company history.

1977
Foundation of Herrenknecht GmbH

1980
Office and assembly plant in Schwanau

1998
Conversion of GmbH in AG

1999
Complete product range TBM

2002
Market leader in mechanized tunnelling technology

2005
Assembly in China (Guangzhou)

2008
Total output of **1.013 bn €**
3,632 employees

2011
Final breakthrough at **Gotthard Base Tunnel**

2014
World‘s largest TBM for Hong Kong, Ø 17.6m

2015
Breakthrough at **Eurasia Tunnel** in Istanbul

- Founded in 1977
- Conversion to Herrenknecht AG in 1998
- Today around 5,000 employees worldwide, 2,000 in Schwanau, around 160 young people in training

A strong perspective.

The Herrenknecht AG Board of Management.

Dr.-Ing. E.h. Martin Herrenknecht
Chairman of the Board of Management

Dipl.-Ing. (FH) Gebhard Lehmann
Vice Chairman of the Board of Management

Betriebswirt (VWA) Kurt Stiefel
Member of the Board of Management

Dipl.-Ing. (FH) Günter Richter

Dipl.-Ing. (FH) Ulrich Schaffhauser

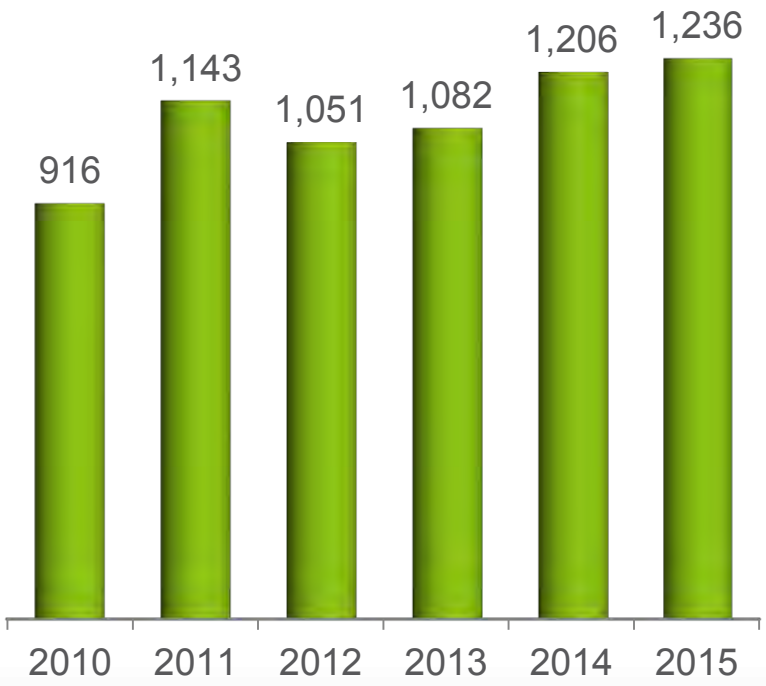
Dipl.-Wirtsch.-Ing. Michael Sprang

Deputy Members of the Board of Management

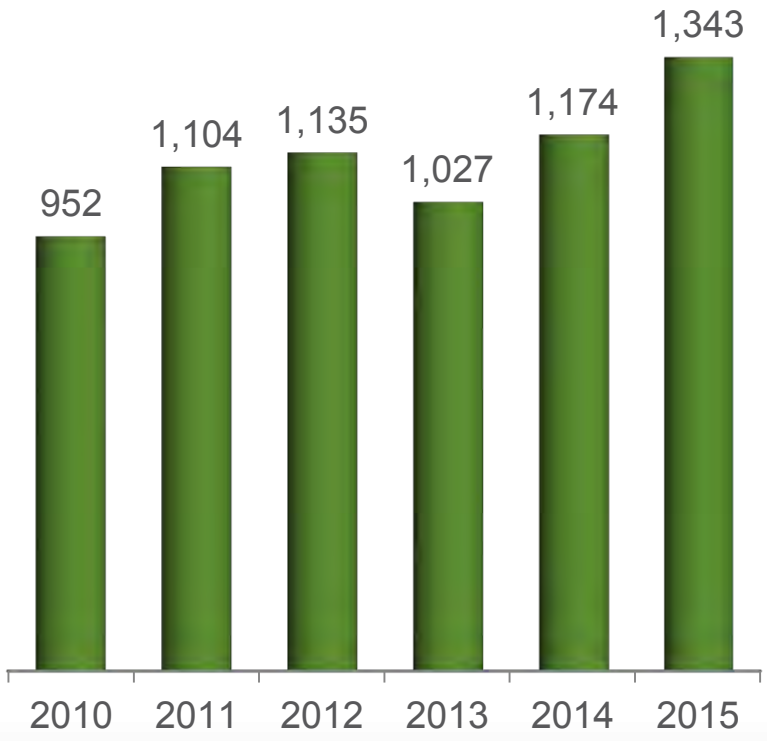
Herrenknecht Group.

Company figures.

- Sales in million Euro



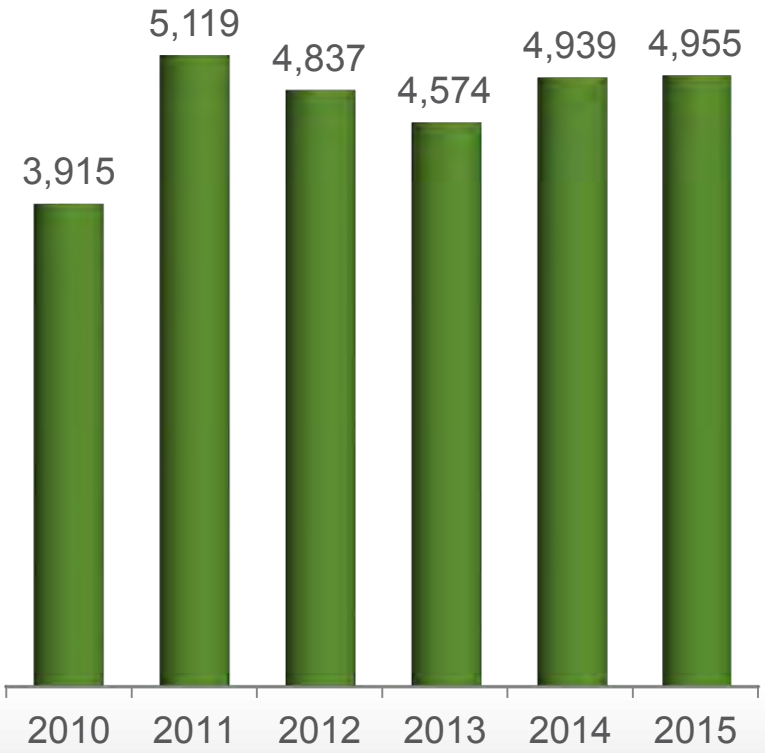
- Total output in million Euro



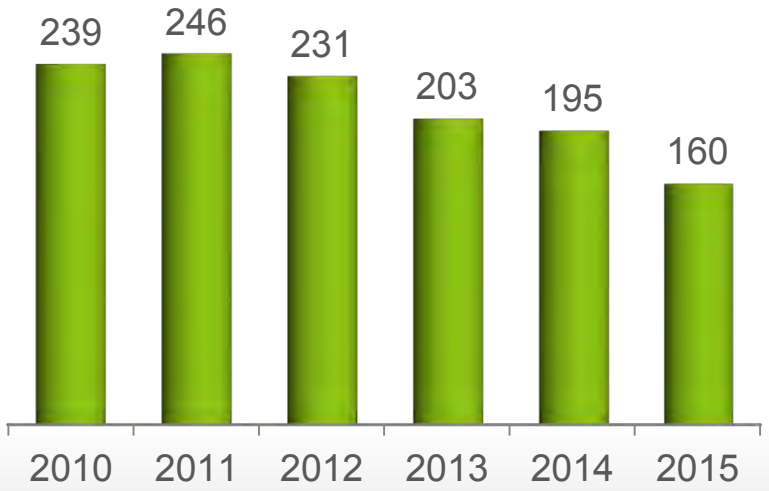
Herrenknecht Group.

Company figures.

- Employees*



- Trainees



* Without trainees, including temporary staff

Herrenknecht worldwide.

The most important growth markets.

The development of infrastructure and global trends.

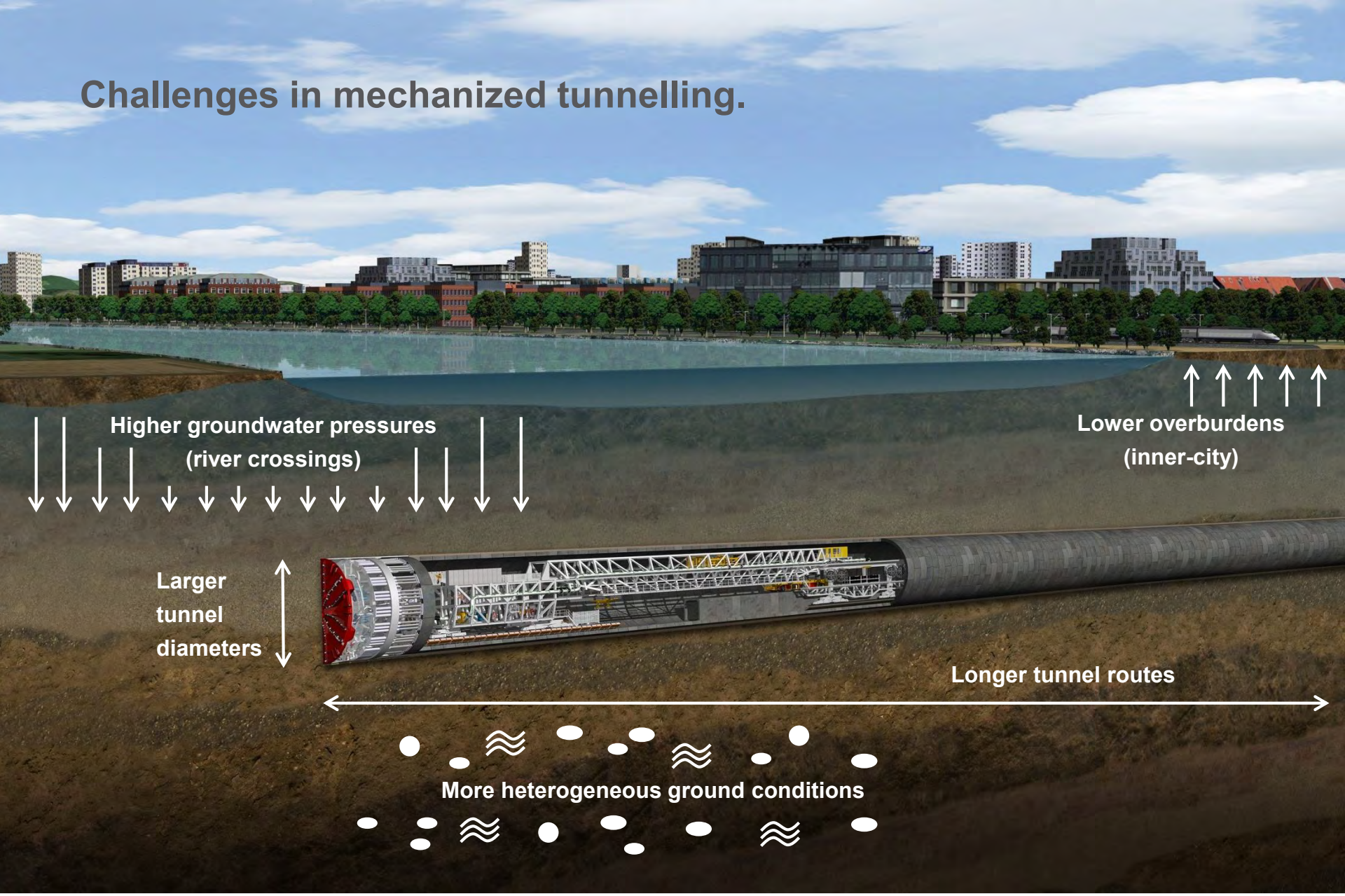
- Population growth and urbanization
- Shortage of resources
- Industrialization and automation
- Increasing demand of mobilty for people and goods
- Need for new supply and disposal tunnels
- Large, multi-level infrastructure projects

Tunnelling, mining and exploration.

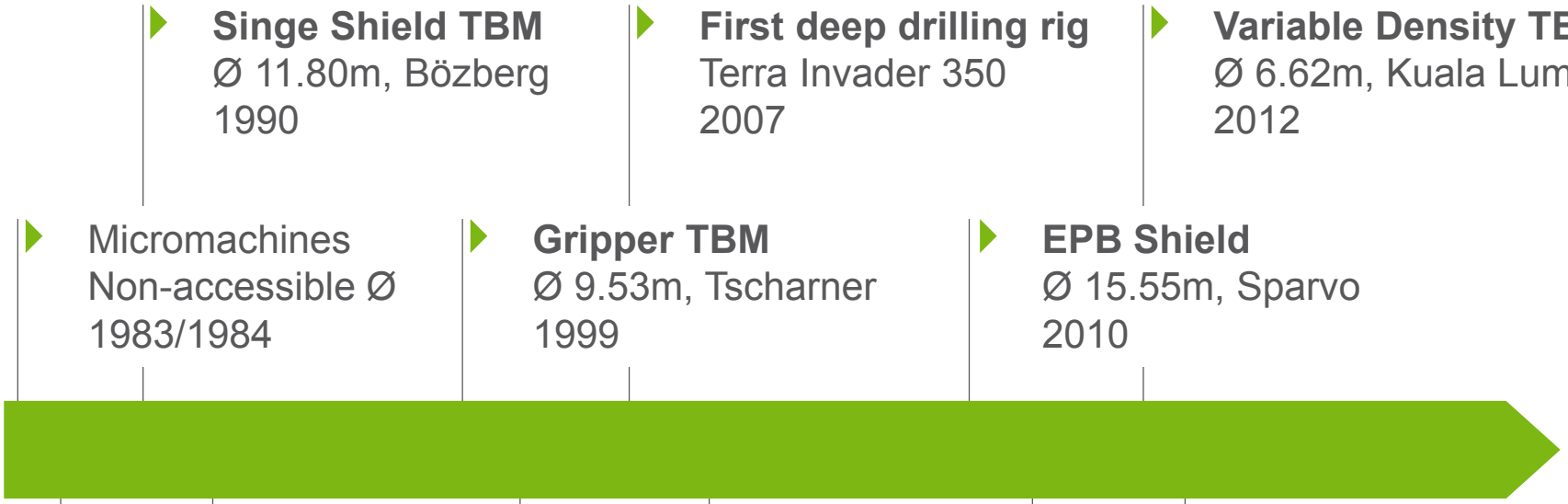
Safely advancing in all areas of application.

- High-quality and high-capacity **traffic tunnels** for metro systems, road and railway networks
- Efficient **supply and disposal infrastructures** for water, sewage, electricity and hydropower
- Underground **pipeline systems** for resources, e.g., oil, gas and district heating
- Precise **infrastructures** like shafts and galleries in all directions for **mining**
- **Deep wells** for the exploration of new oil and gas deposits and for geothermal energy sources - onshore and offshore

Challenges in mechanized tunnelling.



Milestones of the product development at Herrenknecht.



Singe Shield TBM
Ø 11.80m, Bözberg
1990

First deep drilling rig
Terra Invader 350
2007

Variable Density TBM
Ø 6.62m, Kuala Lumpur
2012

Micromachines
Non-accessible Ø
1983/1984

Gripper TBM
Ø 9.53m, Tscharner
1999

EPB Shield
Ø 15.55m, Sparvo
2010

1985/1986
Mixshield
Ø 6.0m, Hera

1993/1994
EPB Shield
Ø 6.26m
Taipei

2005/2006
Mixshield
Ø 15.43m
Shanghai

2008/2009
Mining equipment
SBM & RBR

2012
First successful
offshore project
Development BBM & SBR

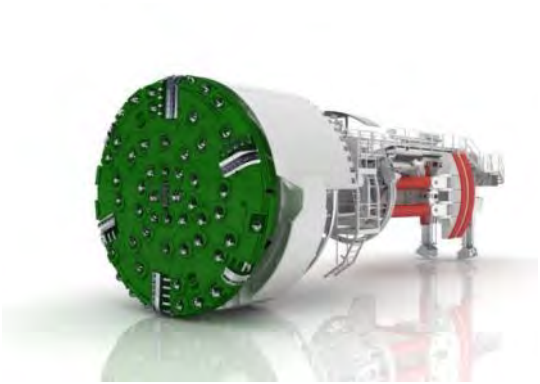
2014
Mixshield, Ø 17.6m
Hong Kong

All Around Tunnelling Solutions.

Our core products for Traffic Tunnelling.

- EPB Shield

- Mixshield



- Gripper TBM

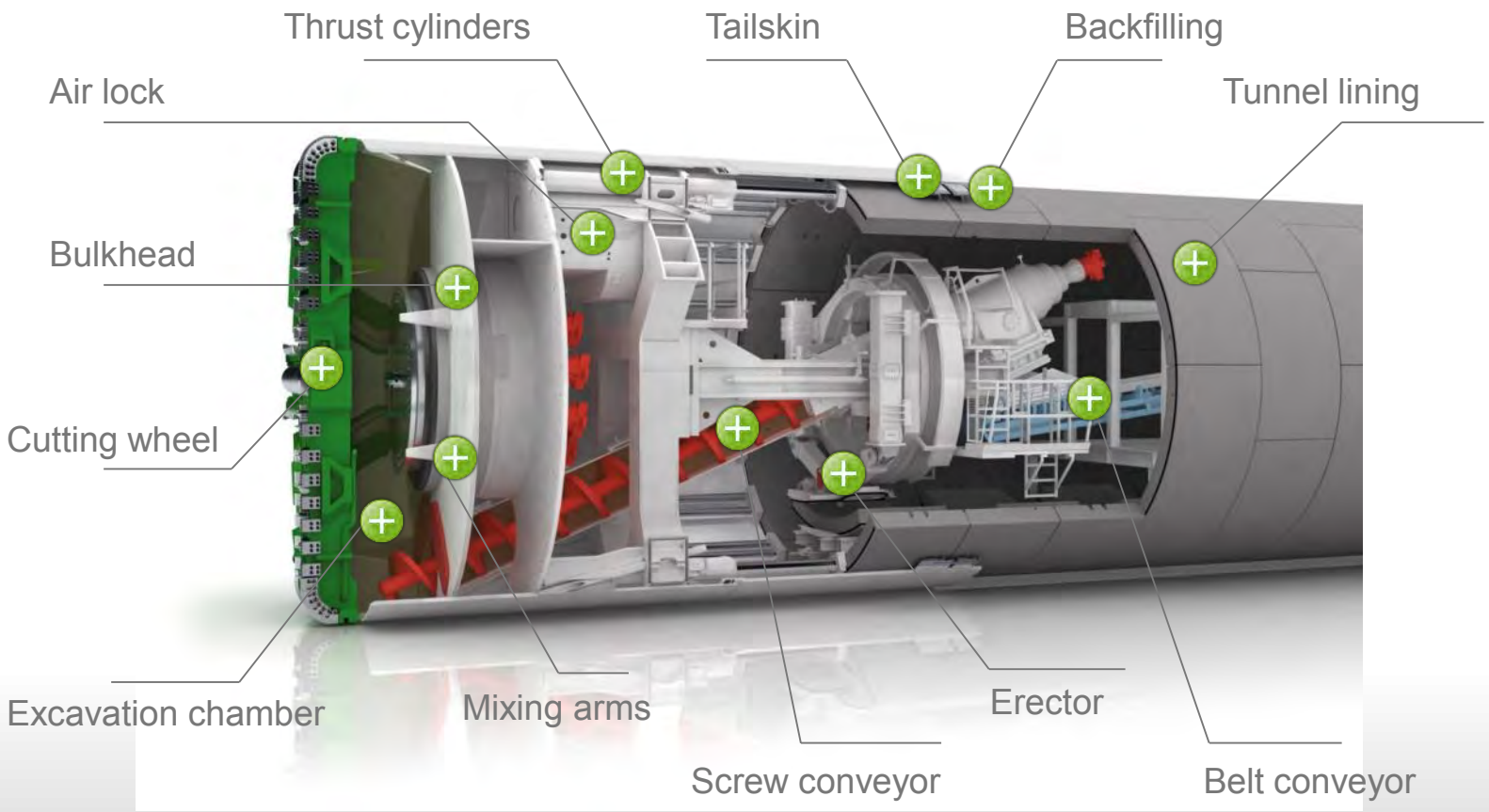
- Single Shield TBM

- Double Shield TBM

All Around Tunnelling Solutions.

Our core products.

- Illustration of the functional principle of an EPB Shield

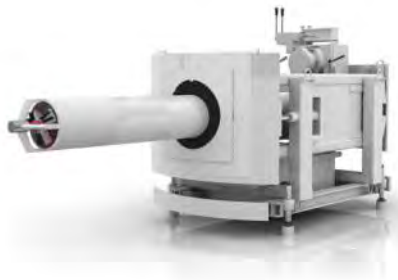


All Around Tunnelling Solutions.

Our core products for Utility Tunnelling.

- AVN Machine

- Partial-face Excavation Machine



- Auger Borig Machine

- HDD Rig

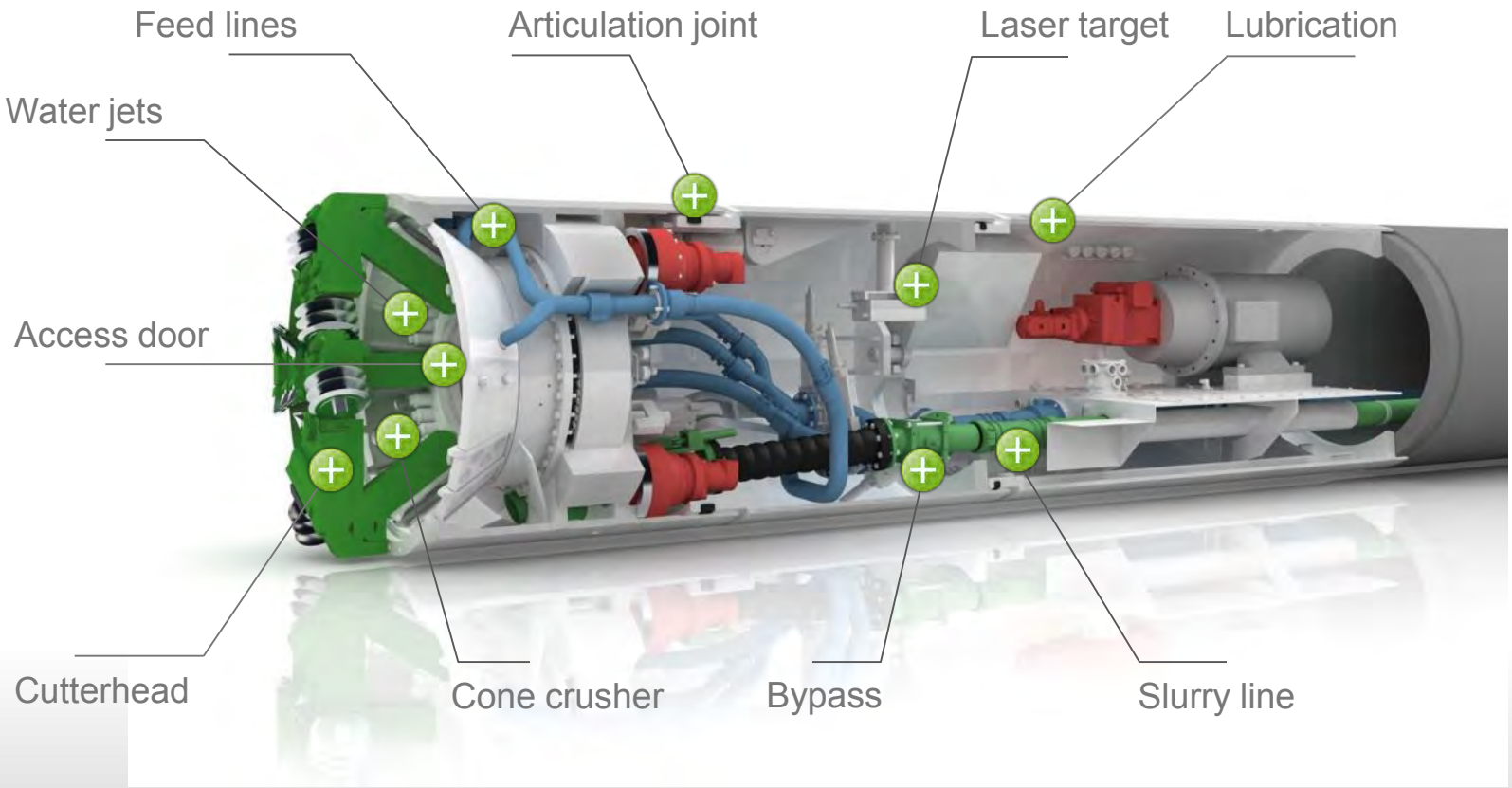
- Direct Pipe®

- Vertical Shaft Sinking Machine

All Around Tunnelling Solutions.

Our core products.

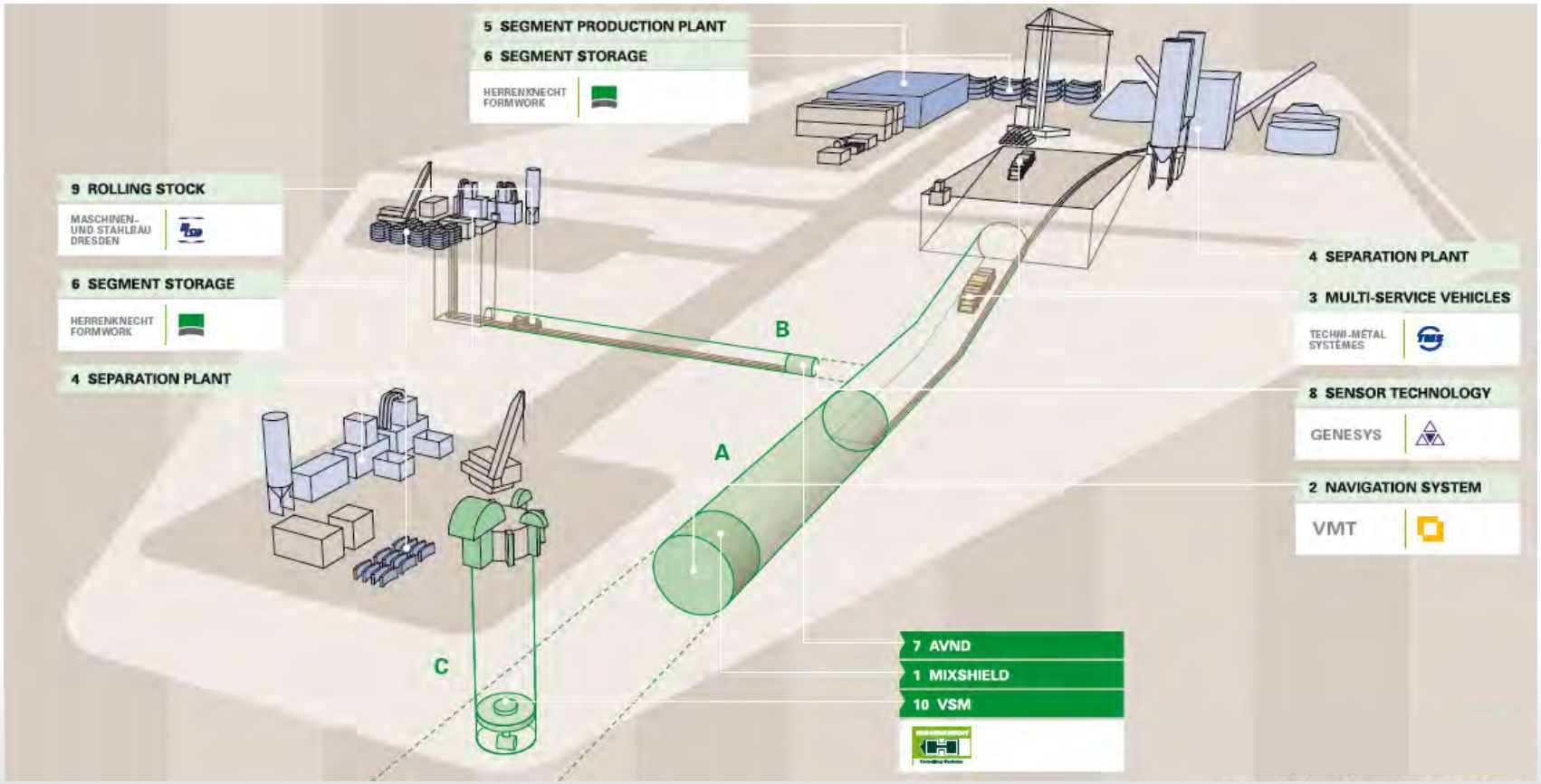
- Illustration of the functional principle of an AVN Machine



All Around Tunnelling Solutions.

Our additional equipment.

- Full-Range Tunnelling for optimized construction site logistics



All Around Tunnelling Solutions.

Our services.

- Construction site services
- TBM personnel
- Spare and wear parts
- Excavation tools
- Refurbishment
- Rental equipment & used machines

HERRENKNECHT REFERENCES

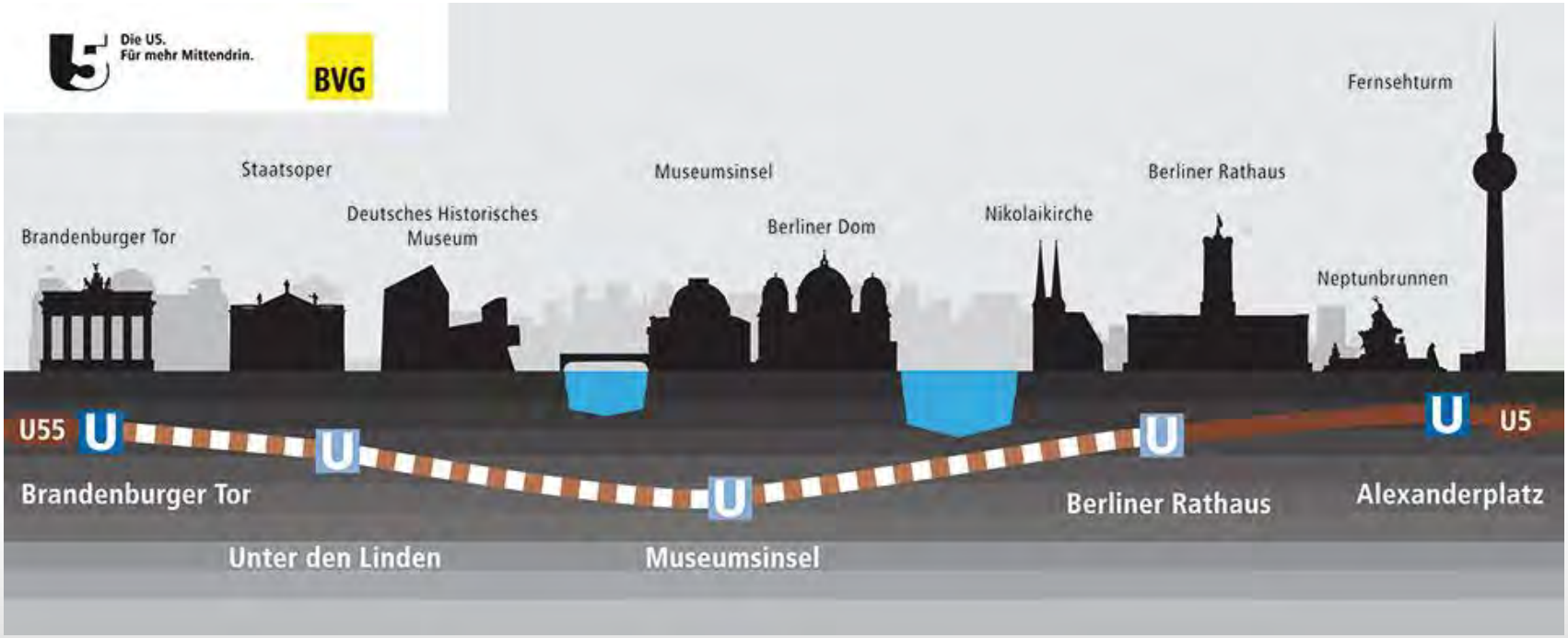
- All diameters
- All grounds
- All applications

S-300 for Madrid – diameter 15.20 meters.

Maximal torque125,268kNm.

Closing the gap in Berlin.

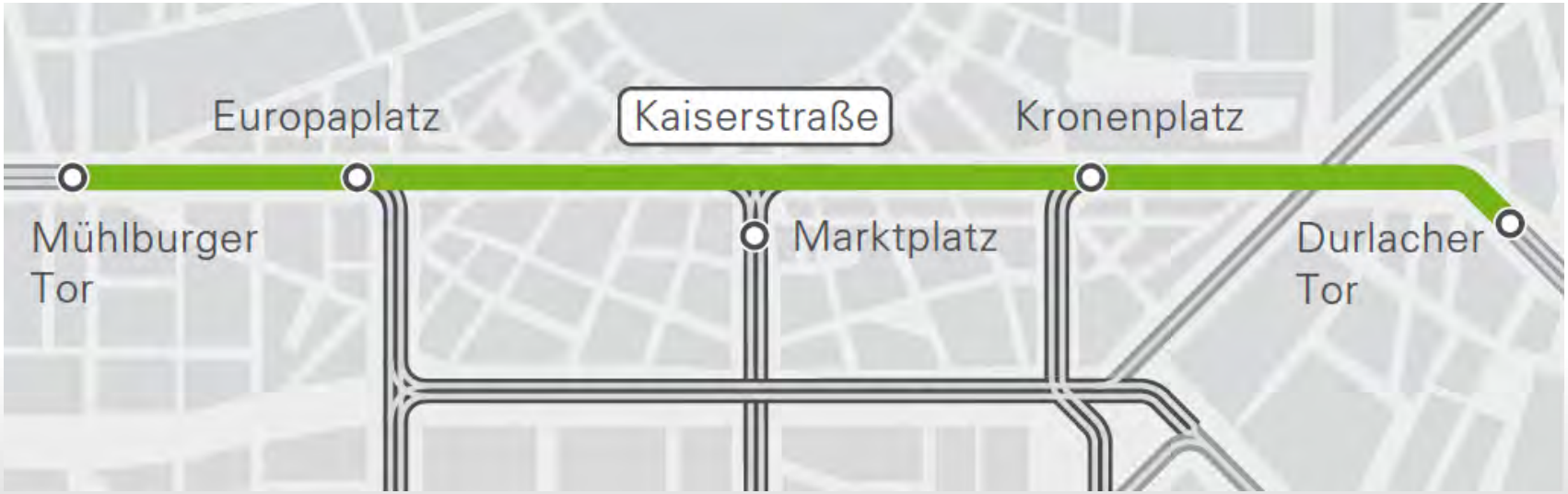
- Mixshield (Ø 6.670 mm) for 2x 1,620m of metro tunnel
- Breakthrough October 14, 2015



The Kombilösung

for Karlsruhe.

- Mixshield, Ø 9,290mm
- 2.4 kilometer of tunnel for the light rail from Europaplatz to Durlacher Tor
- Breakthrough September 7, 2015



Tunnel Rastatt.

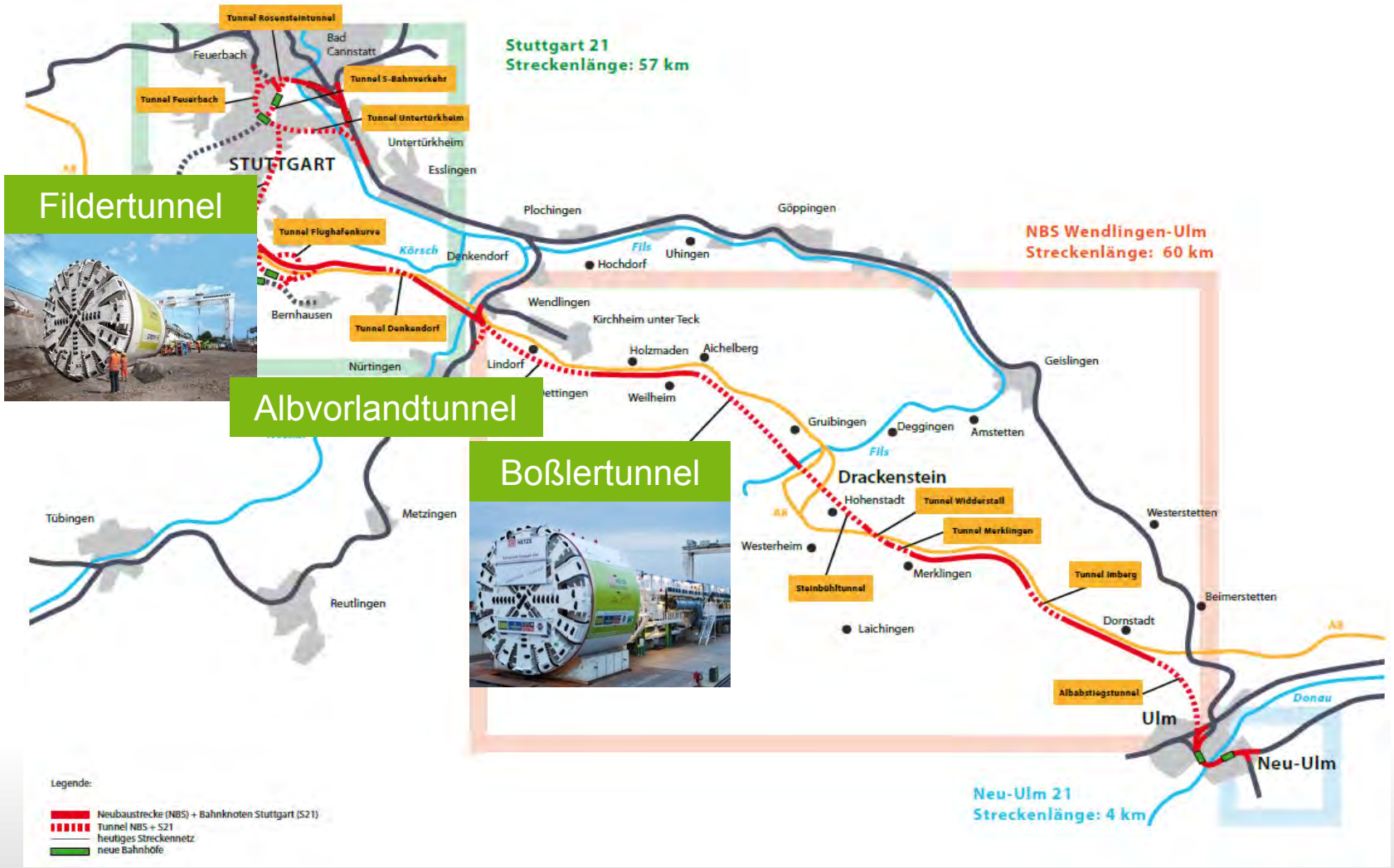
- Railway tunnel for the upgrade of the Rhine valley transit route
- 2x Mixshield, Ø 10,940mm
- Start of advance in July 2016

Tunnelling under the Vosges.

2 x 4km of tunnel for the TGV.

- S-670 Tunnel de Saverne, France
- Multi-mode TBM (EPB / Open-face), Ø 10.01m
- Breakthrough on February 25, 2013

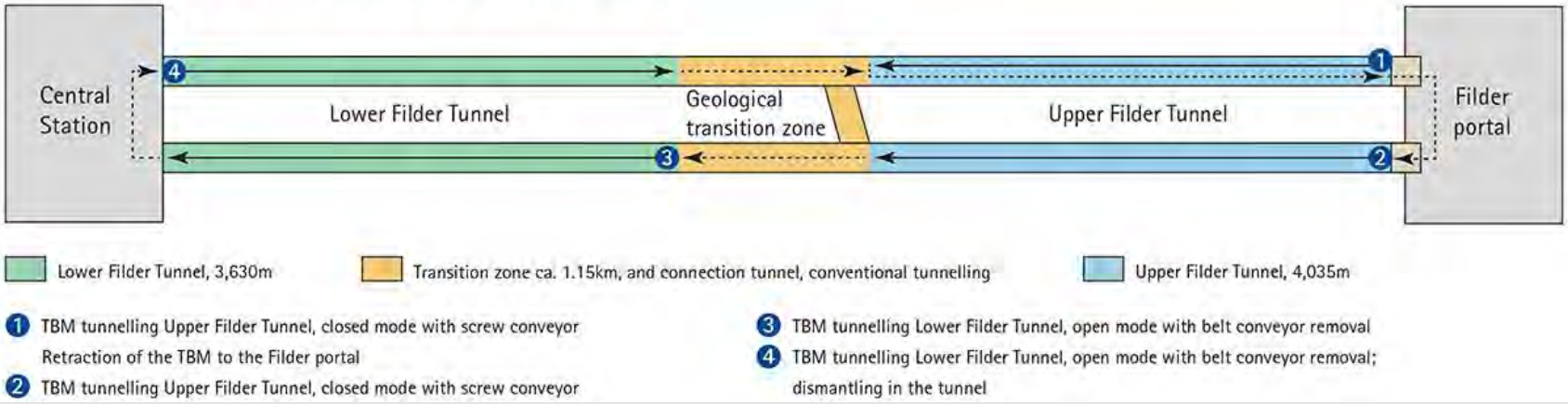
Railway project Stuttgart-Ulm.



Stuttgart 21 – Fildertunnel.

- Multi-mode TBM, Ø 10,820mm
- TBM currently tunnelling on second section

Planned construction phases of the Filder Tunnel



Stuttgart 21 – Boßlertunnel.

- S-833, EPB Shield, Ø 11,340mm
- Start of tunnelling end of April 2015
- Currently more than 8,000 of 8,800 m completed

Final breakthrough of Herrenknecht‘s largest EPB Shield.

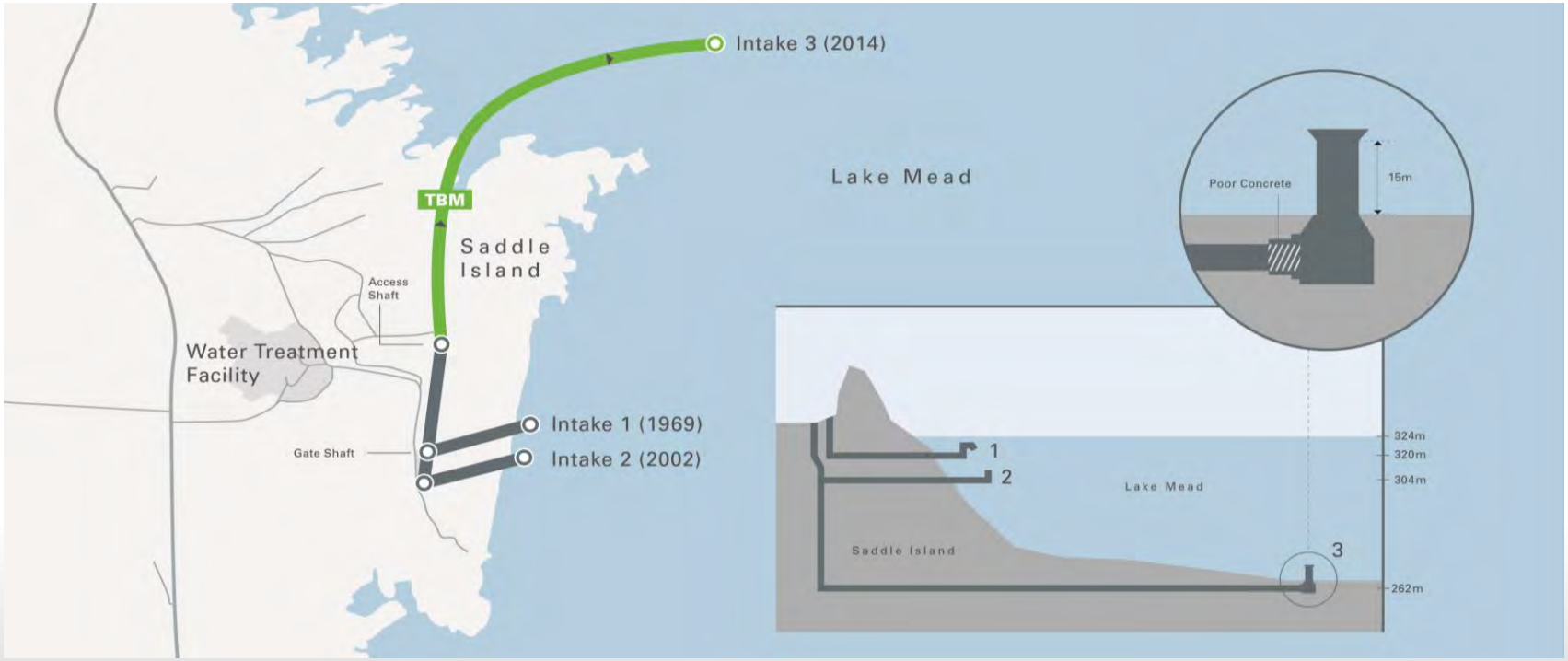
S-574 Galleria Sparvo, Ø 15.55m.

- Best performances of 24m per day and 126m per week
- Tunnelling of 4.9km in total successfully finished after only two years

World record for Las Vegas.

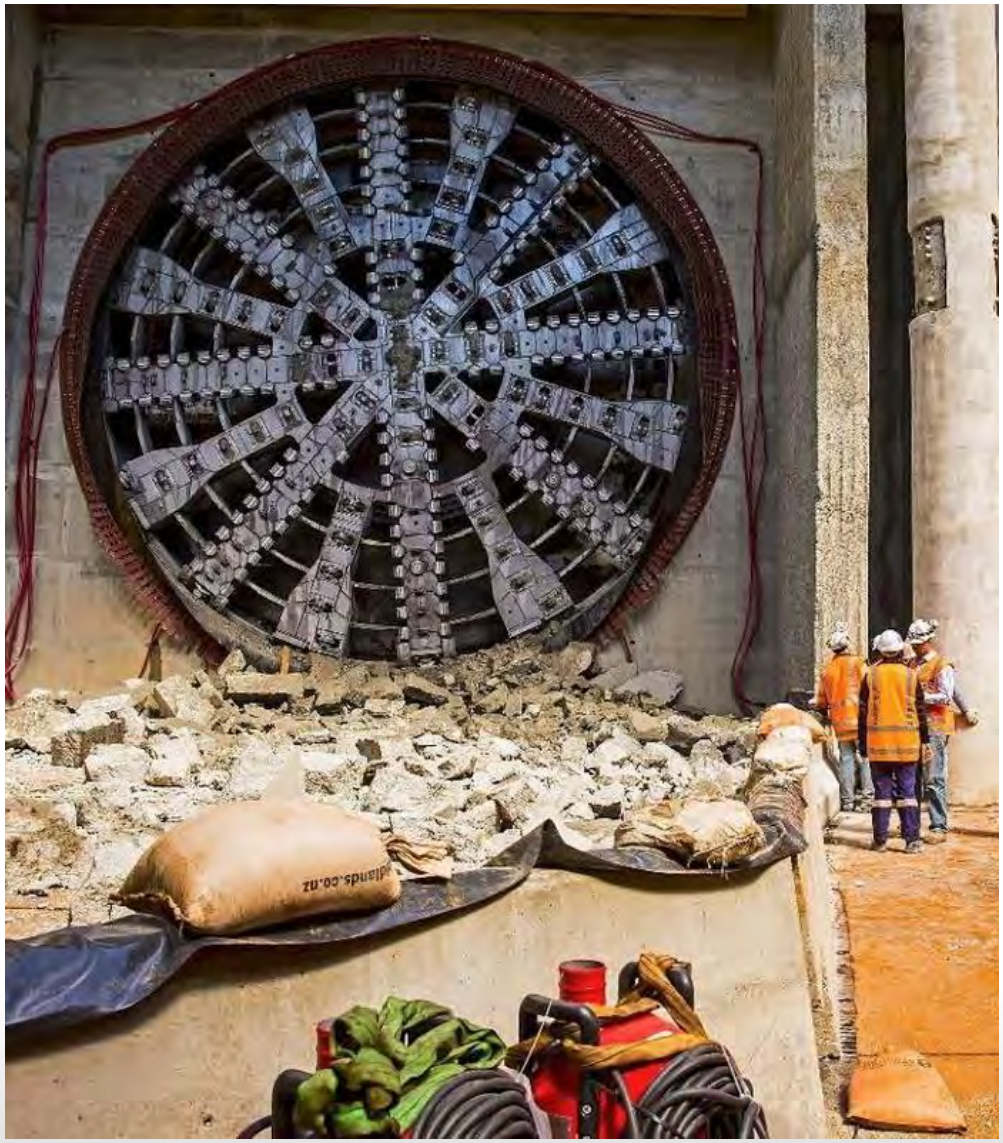
Mechanized tunnelling under highest pressure.

- 4,400m for Lake Mead Intake No.3
- Up to 15bar pressure
- Breakthrough December 2014



Breakthrough in Auckland.

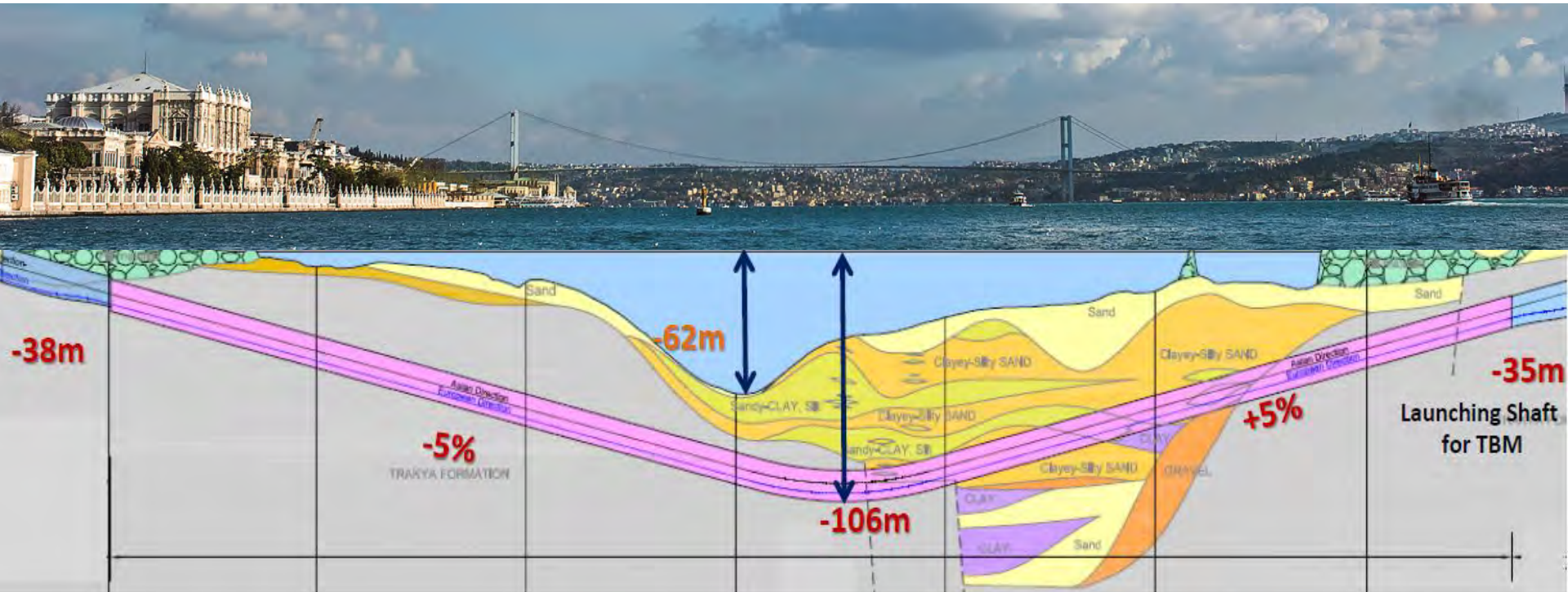
- Two tunnel tubes excavated
- EPB Shield S-764
- Ø 14,410mm



Creating connections between Europe and Asia.

Istanbul Strait Road Tunnel Crossing Project.

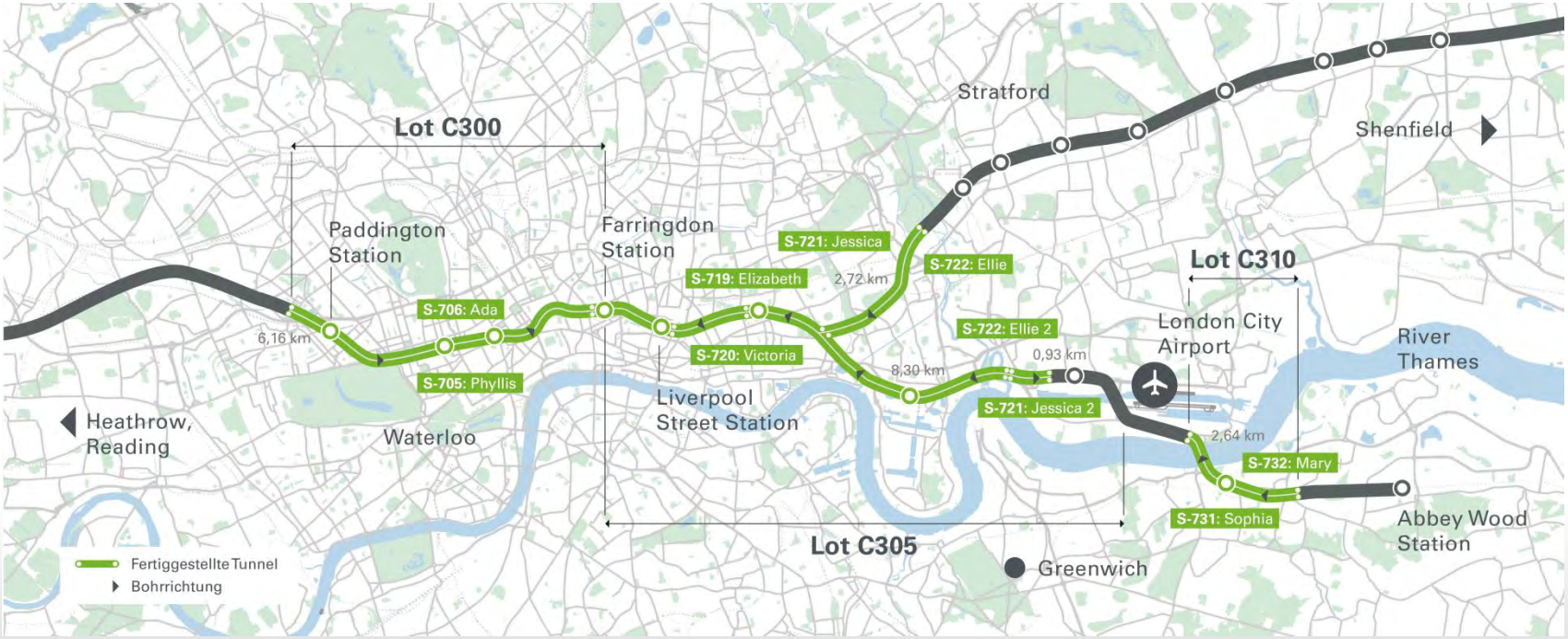
- Mixshield, Ø 13,660mm
- First road tunnel (3.34km) under the Bosporus
- Up to approx. 100m below sea level
- Custom-made solutions for extreme water pressure



London: Crossrail.

One of Europe‘s largest construction projects.

- Herrenknecht delivers all TBMs: 6 x EPB Shield + 2 x Mixshield
- 42km of railway tunnel in total
- Final breakthrough May 26, 2015



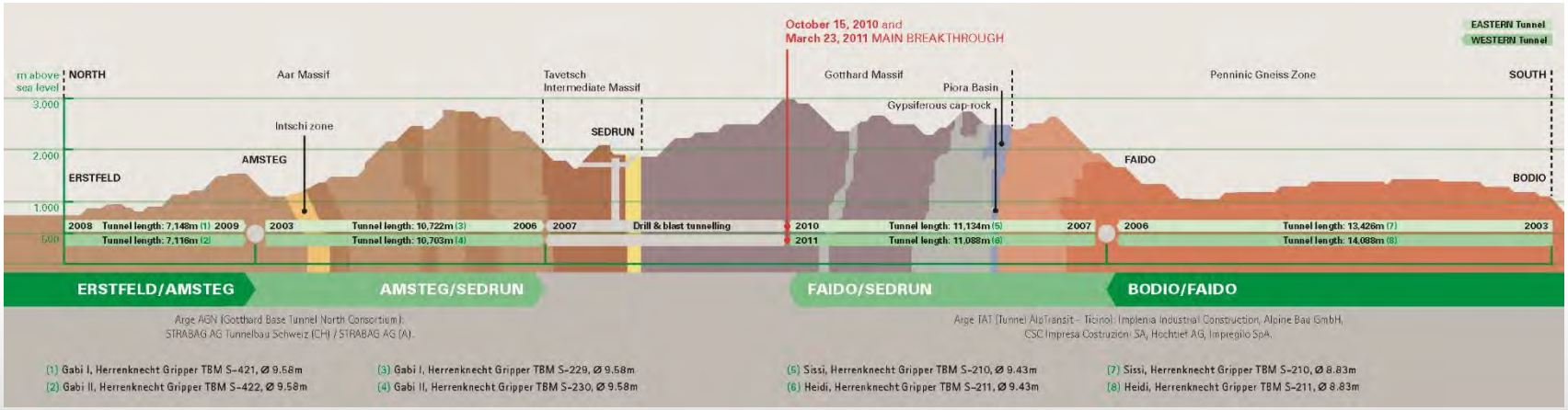
Gotthard Base Tunnel.

The Champions League of tunnel construction.

Gotthard Base Tunnel.

Drilling together for progress.

- 4 x Herrenknecht Gripper TBM
- Ø 8.83 – 9.58m, length up to 450m, weight up to 2,700t
- 85km of hard-rock tunnelling in total
- Up to 56 meters of tunnel in 24 hours



Milestones of the project of the century.

Swiss federal resolution for the funding of the NEAT

1995 1998 1999 2000 2001 2003 2006 2009 2010/2011 2016

Subsidiary Herrenknecht Switzerland

Contract Tscharner

Tunnelling Lötschberg Base Tunnel

Contract Gotthard

Start of tunnelling at the Gotthard

Breakthough Faido

Breakthrough Amsteg

Breakthrough Sedrun

Conclusion of tunnelling

Commissioning of Gotthard Base Tunnel

Sedrun, March 23, 2011:

Main breakthrough western tube.

Port of Miami Tunnel.

Relief for downtown Miami.

- EPB Shield, Ø 12,860mm
- Innovative „Water Control Process“ (WCP): EPB mode + water-slurry mode possible
- Final breakthrough May 6, 2013
- Tunnel commissioning mid-2014

Abu Dhabi: Strategic Tunnel Enhancement Programme (STEP).

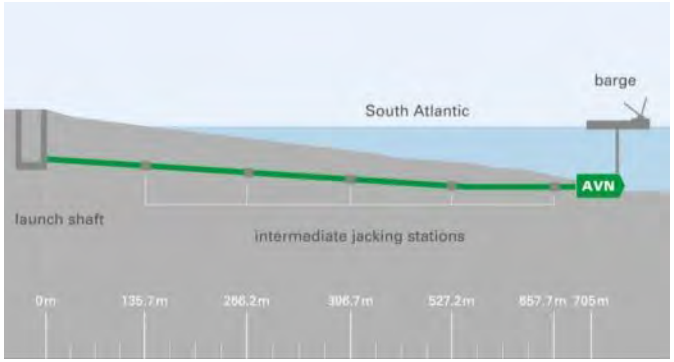
Lots LS-01 and LS-02.

- 9 Utility Tunnelling machines for 43km of supply tunnels
- November 2012: Foundation of a service subsidiary for optimum costumer support

Brazil: Santos Sea Outfall.

Pipe jacking directly under the sea.

- AVN1500TB, Ø 1,810mm
- Tunnel length 2,126m



Amudarja River Crossing in Turkmenistan.

The ultimate pipeline crossing.

- Pipeline length 1,705m; pipeline diameter 56“ and 8“
- 2 x HDD Rig + Pipe Thruster

Traffic Tunnelling in Qatar.

Doha Metro.

- 21 x EPB Shield for 4 new lines
- More than 110 kilometers of tunnel in total
- Herrenknecht only TBM supplier
- Full Range Solution from the Group: navigation systems, belt conveyors, segment moulds, multi-service vehicles and comprehensive services


Xinjiang
CHINA
Shenyang
Liaoning
Dalian
Beijing
Tianjin
Zhengzhou
Nanjing
Wuxi
Suzhou
Shanghai
Hangzhou
Shaanxi Province
Chengdu
Chongqing
Jinping
Changsha
Wuhan
Yingjiang
County
Kunming
Guangzhou
Donguan
Fuzhou
Taishan
Shenzhen
Hongkong

Shanghai Changjiang Under River Tunnel Project.

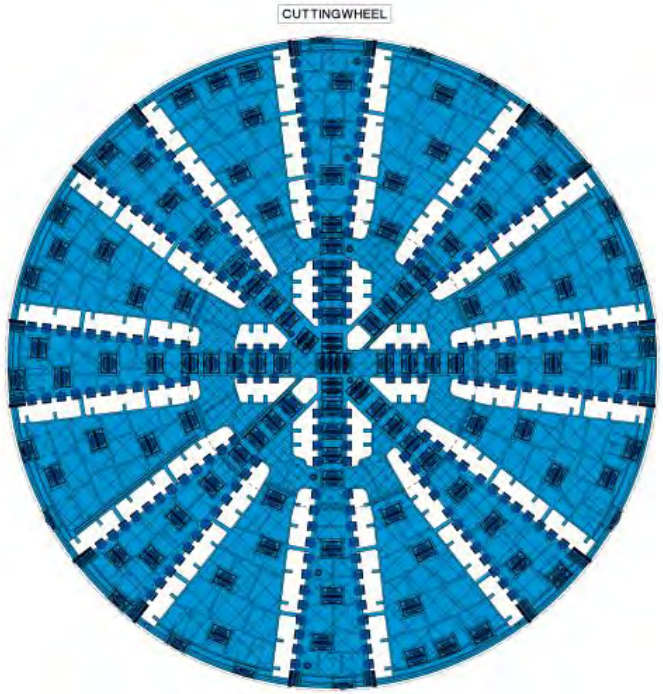
A milestone in the development of the Mixshield technology.

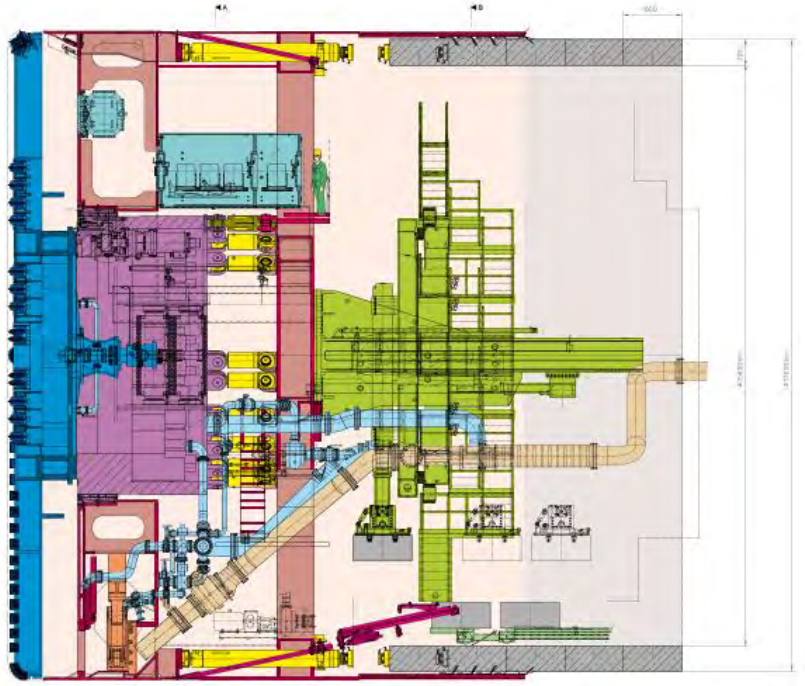
- Diameter: 15,430mm
- Tunnel length: 2 x 7,470m
- Tunnel route up to 65m deep under the Yangtze river (groundwater pressure up to 6.5 bar)
- Breakthrough 12 and 10 months earlier than planned

New diameter world record.

Hong Kong: Tuen Mun – Chek Lap Kok Link (TM-CLKL).

- Mixshield, shield-Ø 17.6m
- 2 parallel road tunnels with two lanes each



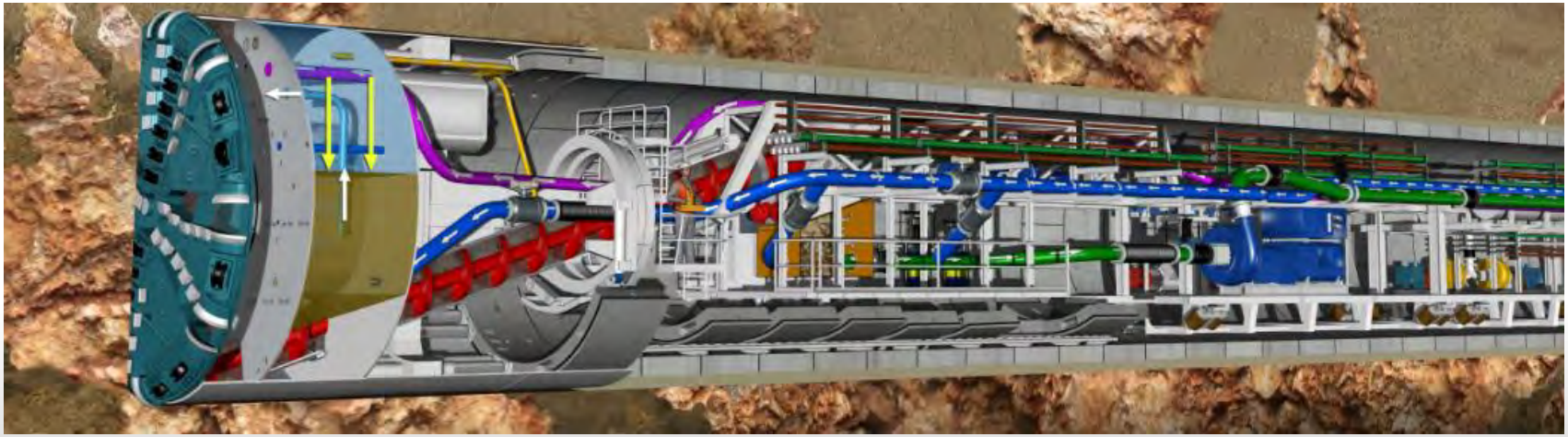



7Я семья

A world‘s first in mechanized tunnelling.

Variable density technology for Kuala Lumpur.

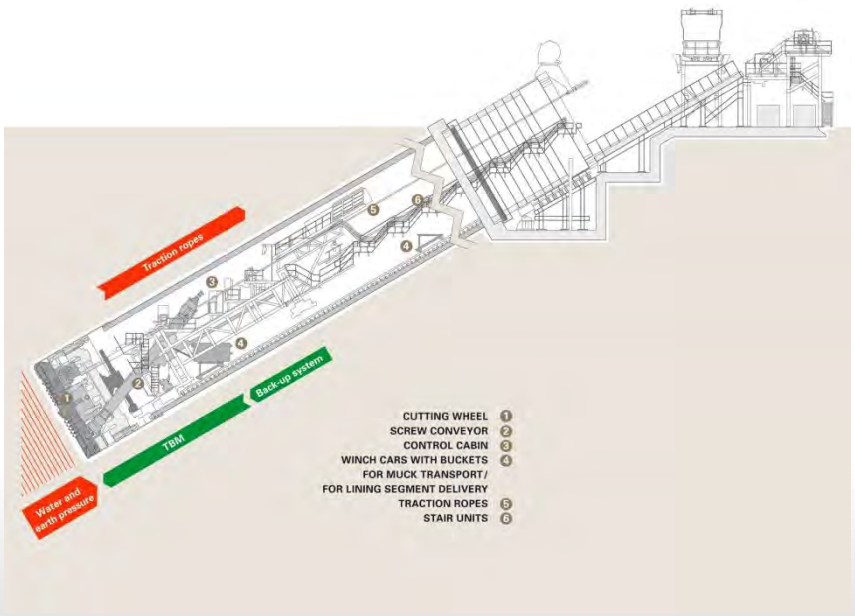
- 9.8km of tunnel for the Klang Valley MRT Project
- 6 x Variable Density TBM, Ø 6,620mm
- Combination of EPB Shield and Mixshield
- Variation of density of suspension possible
- Final breakthrough on April 11, 2015



Tailor-made solutions for special challenges.

Declined and inclined tunnels.

- St. Petersburg, EPB Shield, Ø 10.69m
- 30° decline, tunnel length 120m
- Escalator shaft for metro station
- Limmern, Gripper TBM, Ø 5.20m
- 40° incline, tunnel length 2 x 1,023m
- Shafts for pumped-storage power plant



The innovative Direct Pipe® technology.

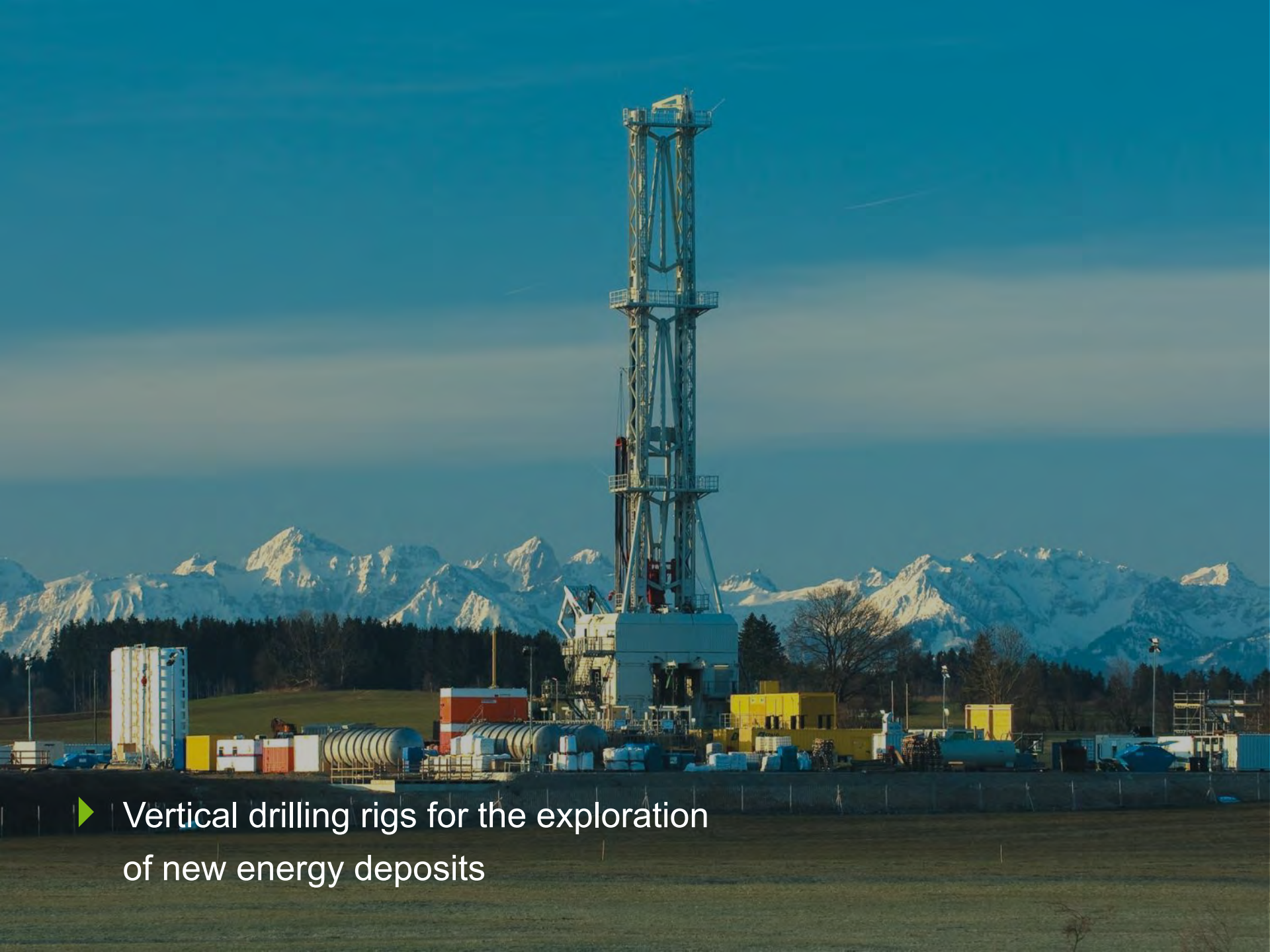
Single-step installation for pipeline crossings.

- Fast and safe installation of product pipes and pipelines

Direct Pipe®.

Project success in the USA.

- Crossing under a highway in Arcadia, Florida
- Installation of 215 meters of pipeline in only three days of tunnelling
- No settlement or heave above ground



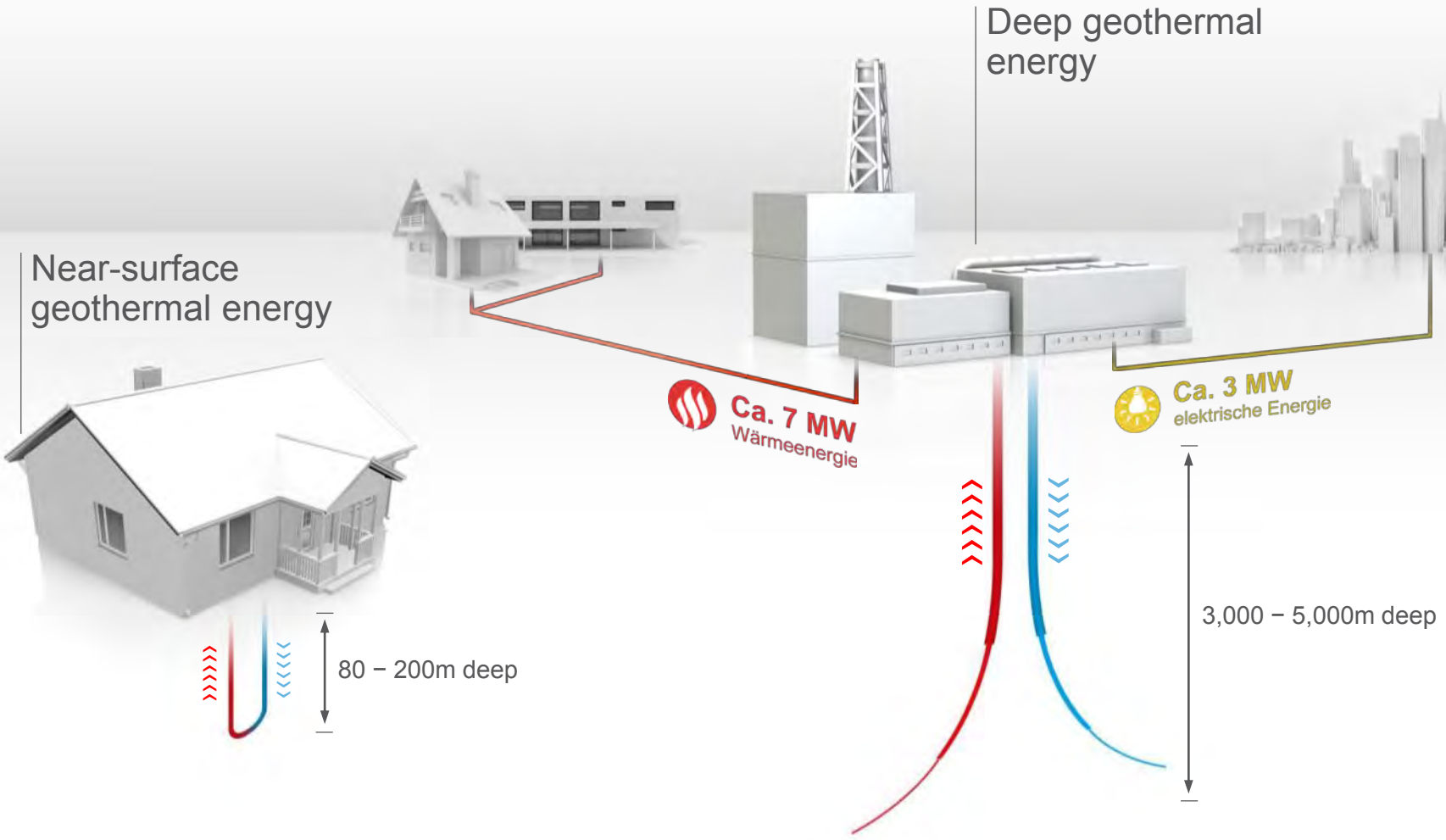
- Vertical drilling rigs for the exploration of new energy deposits

Herrenknecht Vertical GmbH.

- Subsidiary (100%)
  of Herrenknecht AG
- Founded March 2005
- Schwanau
- Deep drilling rigs for the exploration of oil and gas deposits as well as geothermal energy sources
- Advantage in technology thanks to hydraulic drive engineering
- Comprehensive automation
- Staff savings

Geothermal energy.

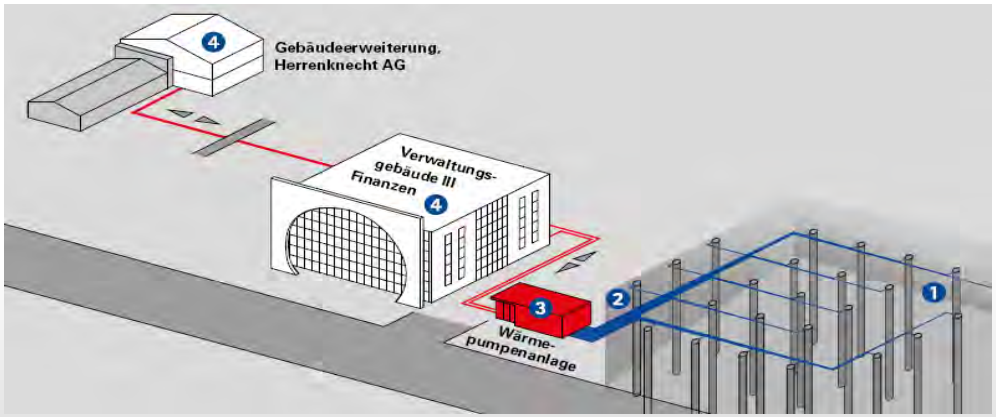
Potential for a clean and stable energy supply.



Utilization of near-surface geothermal energy.

Herrenknecht headquarters in Schwanau.

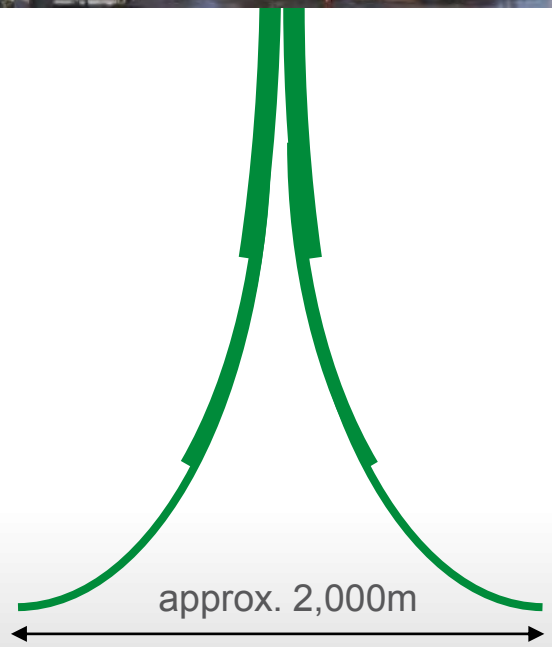
- Herrenknecht Office Building No. 3
  - 32 drills up to 100m in depth
  - Overall heat / cold release of heat pump system: 324,000kWh +/ year
  - Savings of 31 tons of CO_2 / year compared to conventional heat systems



Deep drilling for geothermal energy.

B-002 in Dürrnhaar.

- „InnovaRig“ Terra Invader 350
- Drilling depth, well no. 1: 4,393m
- Drilling depth, well no. 2: 4,530m
- Operation planed with 46,000MWh / year (18,000 households)
- Planed output: $5MW_{el}$; $50MW_{th}$



Deep drilling rigs Terra Invader 350 Slingshot.

In operation in Bahia, Brazil.

- 2 rigs (B-006/B-008) in operation since summer 2009
- More than 60 wells successfully drilled for the exploration of oil fields
- Self-erecting slingshot substructure and telescoping mast for fast rig up and rig down without heavy-duty crane

First offshore project for Swift Drilling.

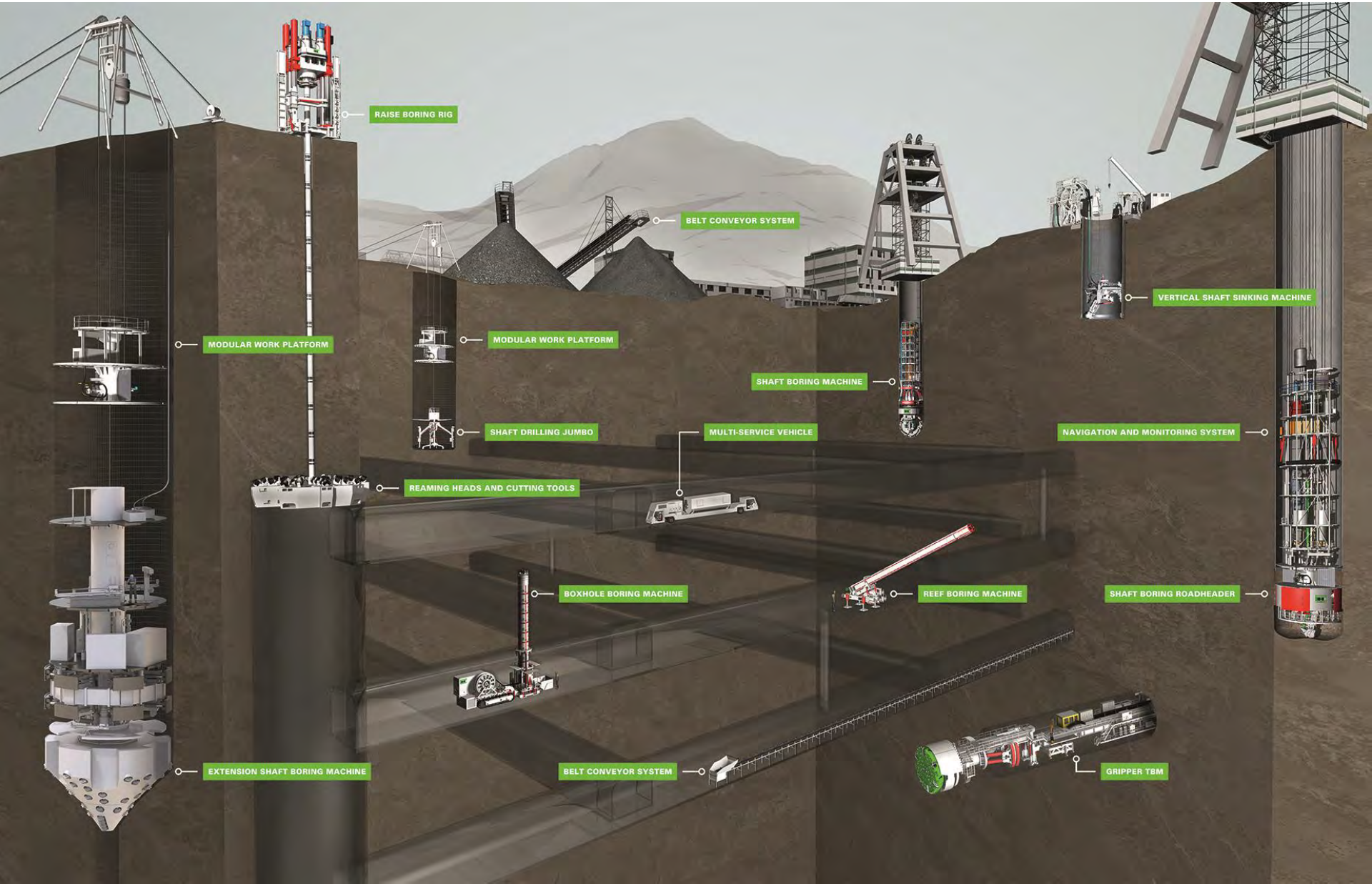
End customer Shell.

Terra Invader rig „made in Germany“ for project in China.

- Designed for efficient shale gas development in the Sichuan province
- Newly developed „X-Y Stepping System“ for fast skidding of the rig thanks to hydraulic cylinder supports
- First well successfully drilled in 2015

- Innovative tunnelling technology for infrastructures in mining

Herrenknecht Mining - product portfolio.



Boxhole Boring Machine BBM.

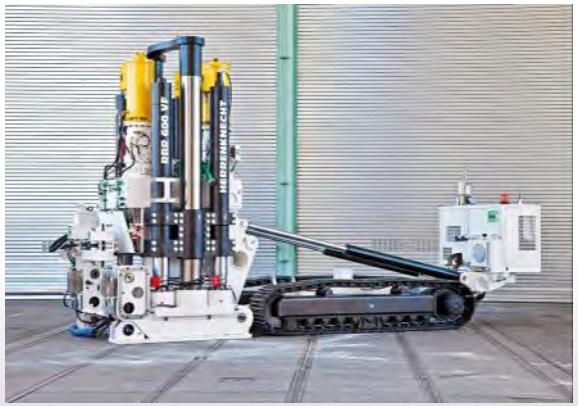
Rapid production of slot holes with small diameters.

- Adaption of the proven pipe jacking technology for the use in mines
- Boring diameter up to 1.5 meters, max. drilling length up to 60 meters
- High advance rates and occupational safety
- Flexibly applicable even with constricted jobsite conditions
- Already successfully used in several projects worldwide

Raise Boring Rig RBR.

Rapid, systematic and secure shaft construction.

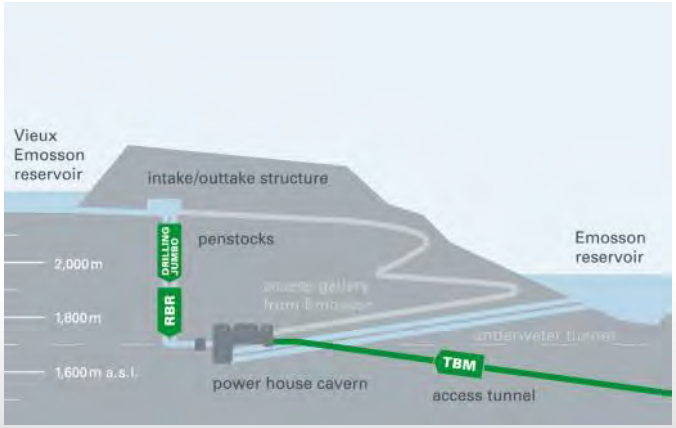
- Precise construction of shafts in rock to 2,000 meters in depth
- High flexibility even under space constraints due to compact design
- Safer, less personnel-intensive and more cost-effective compared to conventional shaft sinking
- Several projects successfully completed

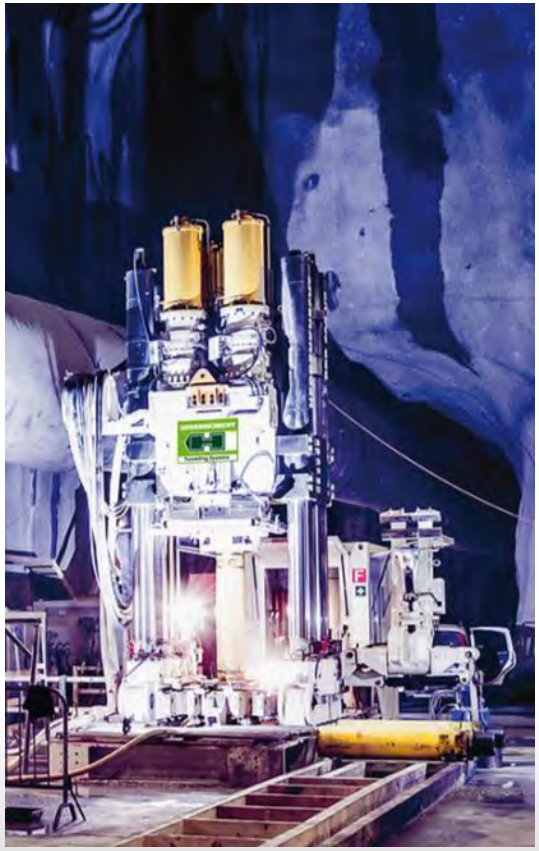


Project Nant de Drance.

Successful application of Herrenknecht Mining technology.

- Pumped-storage power plant in Switzerland
- Raise Boring Rig RBR600VF
  - 2 x 424m vertical pressure shaft (penstocks)
  - Shaft diameter 2,440mm
- Gripper TBM for 5.6km of access tunnel
- Shaft Drilling Jumbo for shaft enlargement





Shaft Boring Roadheader SBR.

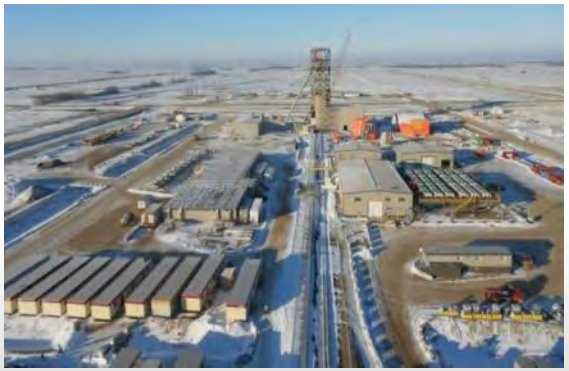
Fast and safe production of blind shafts.

- Shaft depth: up to 2,000m
  (as per requirement & headframe setup)
- Excavation diameter: 7.0m to 12.0m
- Variable diameters in one shaft possible
- Weight (basic set up): ~300t
- Geology: medium hard rock
- SBR suspended by headframe (ropes)
- Installation of inner lining below dust shield possible

Shaft Boring Roadheader SBR.

Fast and safe production of blind shafts.

- First project: potash mine in Canada
- Blind shafts for service and production
- Shaft depth up to 1,000m
- Diameter up to 10.6m
- Geology: medium hard rock & frozen ground
- 2 x SBR in operation



HERRENKNECHT

SHAFT BORING ROADHEADER SBR

Incorporating Rio Tinto
Mine of the Future™ Technology

Responsibility.

- Sports

- Christina Obergföll, javelin

- Jennifer Oeser, heptathlon

- David Storl, shot put

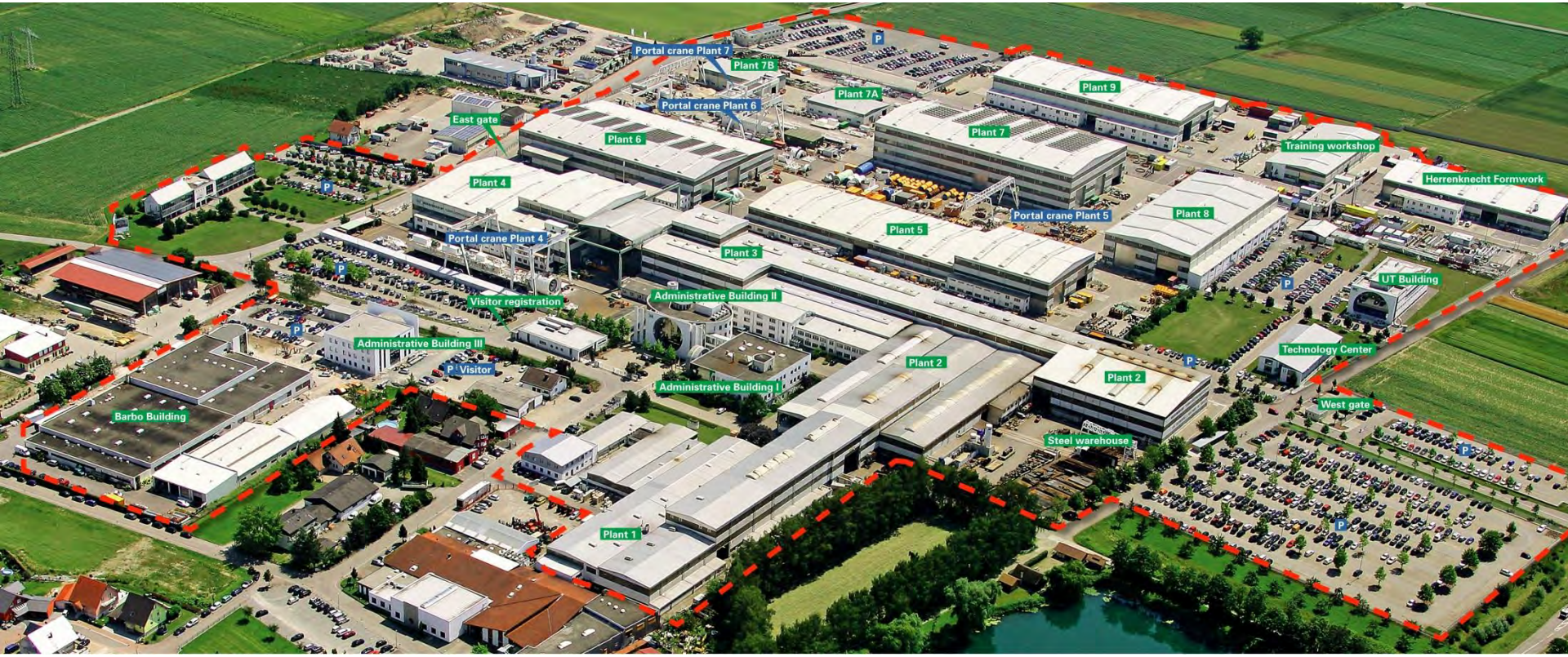
- Carolin Schäfer, heptathlon

Responsibility.

- Education

- Max-Planck-Gymnasium, Lahr
  Support of scientific and technical lessons
- Training of foreign young people (e.g. from Spain)
- Internal further education of trainees (e.g. english courses)
- Support of several academic schools and institutions

Visit.


Portal crane Plant 7
Plant 7B
Plant 7A
Portal crane Plant 6
East gate
Plant 6
Plant 9
Plant 7
Training workshop
Herrenknecht Formwork
Plant 4
Portal crane Plant 5
Plant 8
Plant 5
Portal crane Plant 4
Plant 3
UT Building
Visitor registration
Administrative Building II
Administrative Building III
Technology Center
Plant 2
Visitor
Plant 2
Administrative Building I
West gate
Barbo Building
Steel warehouse
Plant 1

Visit.

HERRENKNECHT AG

SAFETY GUIDELINES FOR VISITORS.

HERRENKNECHT Tunnelling Systems

1. INTRODUCTION.

Welcome

Welcome to Herrenknecht AG. The safety of our visitors and employees is a very high priority of our company. In your own as well as our interests, we would ask you to carefully read and comply with the following health and safety guidelines!

Please wear the visitor badge, issued at the reception desk, in a clearly visible position throughout your visit!

Never leave your group and always stay with your Herrenknecht guide or your visitor group throughout your visit to the plant premises!

2. DIRECTIVES.

2.1 Restricted access

Access to workshops, machinery and equipment is prohibited unless explicitly authorized by your guide!

2.2 Smoking

Please observe the smoking bans, especially in areas where there is a risk of fire.

2.3 Photography

Filming and taking photographs of machinery or plant facilities is not permitted.

2.4 Traffic regulations

The road traffic regulations shall apply on-site. Plant security is responsible for supervising traffic. The maximum permissible speed may not be exceeded. Vehicles may only be parked in designated parking spaces.

2.5 Personal protective equipment

Hard hats must be worn on the Herrenknecht AG plant premises!

Wear sturdy shoes or boots along the marked traffic routes on your visit to the plant premises, and safety shoes away from these routes!

Wear ear protection in designated noise areas!

Use protective eyewear to protect against flying sparks or where indicated (e.g. steel construction).

Occupational Health and Safety, F-5005 Index C

- Please feel free to ask questions or give comments.