Seabed Drilling for Marine Energy
BAUER Group

The BAUER Group is an international construction and machinery manufacturing concern based in Schrobenhausen, Bavaria. The stock-market listed holding company BAUER Aktiengesellschaft is the parent of more than 110 subsidiary businesses in the fields of construction, equipment and resources. Bauer is a leader in the execution of complex excavation pits, foundations and vertical seals, as well as in the development and manufacture of related machinery for this dynamic market. The Group also deploys its expertise in the exploration, mining and safe-guarding of valuable natural resources. BAUER Renewables Ltd. is a subsidiary of BAUER Spezialtiefbau GmbH, the construction company and - with regard to the group’s development - the BAUER Group’s parent house. BAUER Spezialtiefbau GmbH concentrates mainly on the execution of complex special foundation works in difficult soil and can present the best references worldwide.

BAUER Renewables Ltd.

BAUER Renewables Ltd. (BRL) was founded in 2010. The offices are in Bishops Stortford, UK, at the same address of the other UK subsidiary BAUER Technologies Ltd. BRL’s business is the installation of drilled foundation piles for offshore wind and tidal energy turbines. The BSD 3000 Seabed Drilling Rig provides BRL the possibility to install monopiles or pin piles into the seabed. There are nearly no environmental limits for the installation work like depth of water, speed of current and hardness of rock. Bauer Renewables provides a full service from structural design to drilling and grouting works on site. The BAUER Group has introduced and applies a Management System for Occupational Health and Safety that complies with the requirements of the Occupational Health- and Risk-Management System OHRIS, fulfills the Guideline on Safety and Occupational Health Management Systems ILO-OSH 2001 and satisfies the requirements of BS OHSAS 18001.
Bauer Seabed Drilling Systems
safe, environmentally friendly and economical

Safety

All drilling work – with the exception of the different lifting processes - is executed remote controlled from a modern operator’s cabin on deck. No work is done from drilling platforms or piling gates over board the vessel; no drill pipes must be handled to increase or shorten the drill string. This is a significant contribution to a safer offshore workplace. Standard risk plans help to further reduce the risk of personal injuries.

Economics

The Bauer Seabed Drilling Systems are economical, because
• they do not depend on expensive jack-up platforms, but can be operated from floating platforms or vessels.
• they are ideal for pre-piling for jacket structures, so that the foundations can be installed independently from the other work steps, eliminating the risk of negative influence between each other.
• they can work in very difficult environmental conditions like strong currents, deep water or bad weather.
• depending on drilling depth and soil/rock conditions, the installation time for pin piles for one jacket or tripod foundation structure can be within one and five days. Please ask us for a proposal!

Underwater Noise

All of Bauer’s Seabed Drilling Systems do not cause any noise which could be detrimental to marine mammals or fish! Our drilling equipment does not produce more noise than the thruster of a standard construction vessel. Within approximately 300 m the generated noise drops below the background noise in the water. It has been shown that noise levels above 160 dB are harmful to marine life; the Bauer Seabed Drilling Systems are far below that limit.
References

EMEC Monopile for Tidal Turbine, Orkney, UK
In the summer of 2011 Bauer Renewables was principal contractor for the monopile foundation for a tidal turbine from Voith Hydro. At a water depth of 37 m a 23 m long monopile of 2 m diameter was installed in an 11 m deep rock socket and fixed with high-strength mortar. The drilling equipment was designed and built by Bauer Maschinen.

Nouvelle Autoroute A 30, Montreal, Quebec, Canada
In the area of the Beauharnois canal, 138 piles of 1,850/2,000 mm diameter were executed both on land and in the water for the A30 Montreal bypass highway. The piles had to socket as much as 4 m into the rock.

Yasat Ali Island Lighthouse, Abu Dhabi, UAE
Off the coast of Abu Dhabi 25 piles with 750 mm diameter had to be drilled to a depth of 24 m into the seabed for the Yasat Ali Island lighthouse. The work was carried out using a BG 22 working from a jack up barge. The piles were provided with a 16 m long steel sleeve to protect the free pile length in the salt water.

Barrow Offshore Windpark, UK
The monopile foundations for the 90 MW windpark in the East Irish Sea were installed by the Drive-Drill-Drive technique. Bauer Maschinen did the relief drilling using its Flydrill BFD 5500 to reduce frictional resistance of the 4.75 m diameter foundation pieces in the hard soil layers. Main contractor MPI Ltd. used its state-of-the-art installation vessel “MPI Resolution” for the work.

Chiapas Bridge, Mexico
The Chiapas Bridge is a crucial part of the highway connection from the Atlantic Ocean to the Chiapas Region in Central Mexico. The foundation piles for the seven jacket piers were drilled with the Top Drill BA 2500 and a Casing Oscillator from Bauer Maschinen. Maximum water depth was 93 m and the maximum drilling depth into the claystone was 62 m. The full face roller bit was equipped with under reaming rollers to allow casing penetration into rock.
Interaction of the gravitational forces of the sun and the moon causes water levels of the oceans to rise and fall. In places with favorable geomorphologic conditions like natural canals or narrows the changes in the water levels result in rather substantial currents which can be used to create energy. Tidal currents and therefore the energy produced from tidal currents can be predicted with precision, as opposed to energy produced from wind and waves. This makes it very valuable for utility companies.

Tidal energy is one of the greenest energy available:

- There are no emissions from pollutants and negligible noise emissions.
- Tidal energy farms have no significant negative impact on marine life, water quality and water levels.
- Submerged tidal turbines are not visible from shore or vessels.

The installation of drilled foundation piles for tidal turbines is one of the most challenging tasks in offshore construction. The environmental conditions with very strong currents and rocky seabed are unique; working on such a site is extremely difficult. Bauer developed its seabed drilling technology specifically for the safe, fast and economic installation of monopiles and pin piles in deep water, working from a floating platform like an offshore construction vessel.

Future offshore wind turbines in deep water with more than 5 MW will most likely be founded on jacket structures. The jackets are fixed to the seabed with pin piles. Bauer offers seabed drilling solutions for pin piles installed from either floating or fixed offshore vessels.

The Bauer seabed drilling techniques offer many advantages:

- Applicable in all soil and rock types.
- Operated from vessels – no jack-up barges necessary.
- System works in water depth of more than 60 m.
- Noise emissions are negligible.
- Fast and economic installation process.
- Makes pile driving redundant.
The BSD 3000 is a reverse circulation drill with a full face roller-bit with weights. The drill spoil is transported to the top by the air-lift technique - the air-lifting pipe ends shortly above the drill rig. All the main functions can be monitored through cameras. The drill rig and the umbilicals withstand all forces caused by currents and waves. The umbilical handling system has to compensate for the unavoidable movements of the vessel up to approximately 20 m in all directions and it must also ensure that in case of a complete loss of position the umbilicals can be detached safely and all hoses will be closed shut. All critical parts of the drill rig are designed, constructed and tested by Bauer in Schrobenhausen, Germany.

The actual drill rig consists of three main components:

1. The drill template with legs including leveling system and weight plates and the centerpiece with casing clamp and oscillator.
2. The conductor pipe with drilling shoe and internal brackets and plates to support the drill unit.
3. The actual drill unit with a rotary drive, the climbing mechanism, drill pipe, heavyweights and full face roller bit.

The following additional components were also utilized for operating the drill rig:

4. The umbilicals for supplying the template, drilling unit and monopile with hydraulics, air, grout, electricity and electrical signals.
5. The umbilical handling system with quick release mechanism and mooring winches.
6. The operator’s cabin with hydraulic power unit and compressors.
7. The deck storage frame for conductor pipe and drill unit.
Due to the high current forces the seabed at tidal energy sites consists of bedrock. For both types of drilled foundations – monopile and tripod – the Bauer Seabed Drilling Technique is the ideal solution.

A **monopile** foundation structure can be installed in one drilling and grouting operation; this saves time and eliminates risk. Monopiles are chosen whenever design loads (especially fatigue loads) make it possible. Dimensions go from 2.00 m to 3.00/3.50 m in diameter and 10.00 m to 15.00 m in drilling depth. The monopile is grouted into the rock socket using a high-strength offshore grout.

Higher design loads make a **tripod** foundation structure necessary, which is fixed to the seabed by three pin piles. The pin piles will be installed using the Bauer modular template with separate center and satellite pieces for an easy and flexible operation. Normal dimensions are 1.00 m to 1.80 m in diameter and 5.00 m to 10.00 m in drilling depth. The pin piles are pre-installed and grouted into the rock socket; then, in a secondary grouting step the tripod structure is fixed to the pin piles.

Bauer uses a specifically designed low-viscosity high strength grout with a 28-days-strength of 100 MPa.
Many future offshore wind sites have a difficult geology with a certain amount of loose, granular or cohesive soil overlying bedrock. The jacket foundation structures are fixed to the seabed with pre-installed pin piles. Because of the high loads the piles must extend into the bedrock. The BSD 3000 can be easily adapted for those conditions – the conductor casing can be drilled into the overburden soils in order to provide support for those unstable layers and normal rock drilling with an uncased borehole can proceed from top of rock downwards.

A modular template assures the correct location of the pin piles; and with Bauer’s flexible template satellite system drilling can commence on two or even more pile locations simultaneously, saving valuable operation time. The modular template makes it possible to leave the location for example when a storm is coming, and to come back and finish the work. All relevant drilling parameters are visualized on the screen in the operator’s cabin to provide full control over the whole drilling process. Special pile top adaptors can be employed to ensure the necessary installation accuracy of the pin piles.
Seabed Drilling for Marine Energy

Pile driving for offshore wind foundations causes underwater noise, which can be dangerous for the health of marine mammals. But until now no economical alternative existed. Expensive noise mitigation measures with questionable success were employed. Government agencies are concerned about the negative effect on marine life and are hesitant to issue licenses. The answer is the MIDOS-Pile - Mixed Drilled Offshore Steel Pile (see next page).

The MIDOS-Pile can be installed fast and reliably at similar cost as driven piles. A seabed drilling technique is used, which can be operated from a floating vessel – another big advantage, because for projects in deeper waters jack-up barges are rare and expensive. The MIDOS-Pile is a pre-installed pin pile, the installation of it is independent from the jacket installation; the best suitable marine equipment for each step of the work can be chosen.

Bauer has extensive experience with different kind of soil mixing techniques for foundation projects. The quality of the soil-cement-mixture is controlled automatically. Special attention has been given to the homogeneous flow of the grout around the pile in order to provide good bonding for load transfer. The unavoidable backflow can be used for scour protection or can be pumped into a spoil barge for disposal on shore. Field tests have proven the reliability and integrity of the MIDOS-Pile.

An electronic monitoring and control system - B-Tronic - can be installed in the operator’s cabin. This data acquisition system monitors and controls construction parameters as well as general rig functions.

Production data as listed below are continuously acquired, visualised and stored.

- Depth
- Volume
- Slurry pressure in hoses
- Slurry-soil pressure in trench
- Pumped volume vs. time
- Pumped volume vs. depth
- Inclination (in two directions)
- Speed of mixing tool
- General rig parameters
Bauer's newest development for seabed drilling is the MIDOS-Pile - Mixed Drilled Offshore Steel Pile. This piling system combines the experience and know-how of Bauer for seabed drilling and soil mixing techniques. The MIDOS-Pile is the long awaited piling solution for offshore wind, offering reliable foundation piles for jacket structures with negligible noise emissions at competitive costs. Wherever you do not need rock drilling techniques you can use the MIDOS-Pile.

The structural element of the MIDOS-Pile is a steel casing; the dimensions are determined by design calculations, usually 2.00 m to 2.50 m in diameter and 30.00 m to 45.00 m long. The casing is positioned in the satellites of the Bauer modular template. At the tip of the casing a starter piece is mounted with a diameter 0.30 m to 0.40 m larger than the casing diameter. At the top of the casing inside one or several rotary drives are clamped into the casing. This rotary drive turns a shaft, which has at the bottom end several mixing tools fitting into the starter pieces of the casing.

Specially designed cement slurry exits the mixing tool, so that the loosened soil is immediately mixed with this slurry to a soil-cement-mixture. When reaching the final depth, the rotary drives with the shaft and the mixing tool is extracted, the casing and the starter piece remain in place. The soil-cement-mixture hardens to a 28-days-strength of approximately 5 MPa. Depending on the properties of the surrounding soil the MIDOS-Pile can reach a bearing capacity in compression and tension beyond 20 MN.
In cases when pile driving does not cause too much noise or when a piling vibrator is used, Bauer has available a system for quick and economical relief drilling for the foundation of jacket structures – the Dive Drill. Often the soil conditions are such, that the foundation piles do not reach the necessary embedment depth because of excessive buildup of friction. In this case the piling hammer or vibrator can be withdrawn and the Dive Drill is inserted into the casing. It clamps itself into the casing and drills out all soil and rock material inside of the casing.

The Dive Drill is mounted on a special outfitted crawler crane which contains all controls, power and umbilical winches to operate the Dive Drill safely and efficiently. A specially designed drilling tool loosens the soil/rock and then mixes it with the seawater in order to be pumped up to the vessel. The drilling operation works in one continuous sequence where the Dive Drill moves down inside of the casing until it has reached the desired depth. Normal drilling diameter is between 2.00 m and 3.50 m.

The Dive Drill offers distinct advantages in relation to conventional top drills:

- It can be installed directly into the casing when hitting refusal, regardless whether the top of the casing is above or below the water table.
- The switch from pile driving or vibrating to relief drilling can be accomplished within a very short time period.
- The drilling tool can be equipped with teeth (or rollers) which fit ideally to the soil/rock to be excavated. Therefore drilling progress is much faster than with conventional full face roller bit reverse circulation drilling.