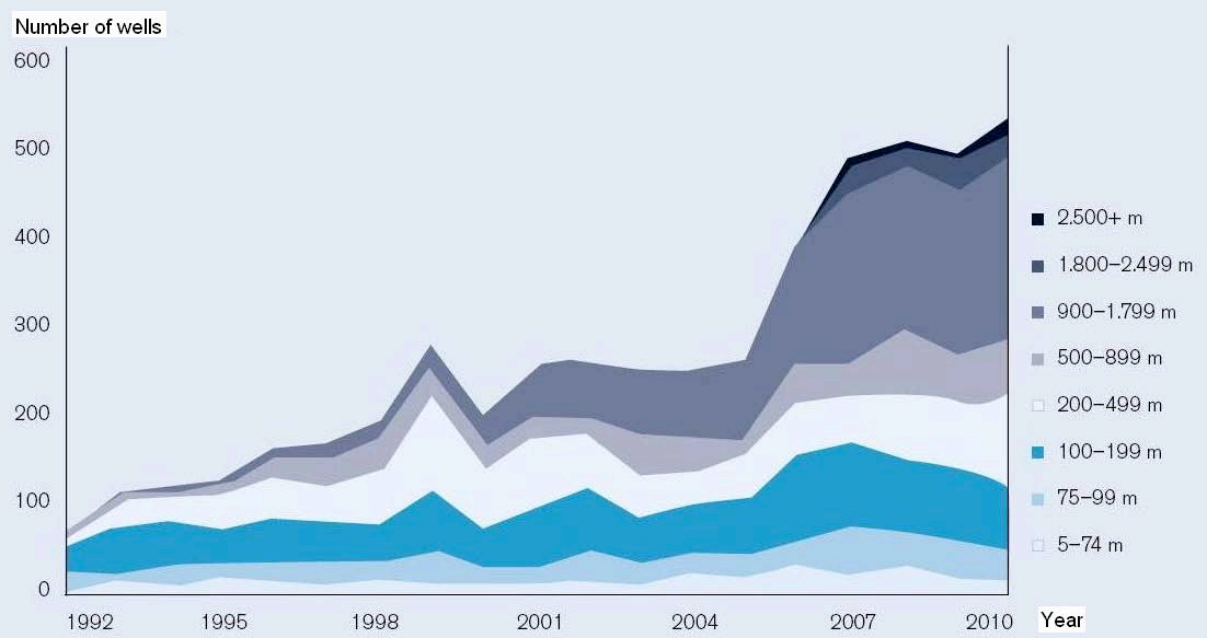
A 500 Tons AHT Winch with ECO-Pull Drive Technology

The demand for large Anchor Handling, Towing and Supply vessels (AHTS) did increase significantly in the last years. Large in this respect does not only consider the pure size of the vessel but refers to a bollard pull of more than 300 tons and in coincidence with this winches with line pulls of up to 500 tons and huge rope and wire capacities.
In the following a summary is given about the challenges in applying the latest technologies of variable frequency drives (VFD) for large AHT winches.

Investments in offshore oil and gas production have been more than doubled in the four years from 2003 to 2007. Subsea production in water depths up to 2500 m gained a share of 15% of total production in 2010, coming from only 5 % in 2005. The number of wells counts to over 500 in 2010. About 20% are in water depths up to 200 m and thus classified as “shallow water”. “Deepwater” wells doubled in five years from 2005 until now to more than 400.

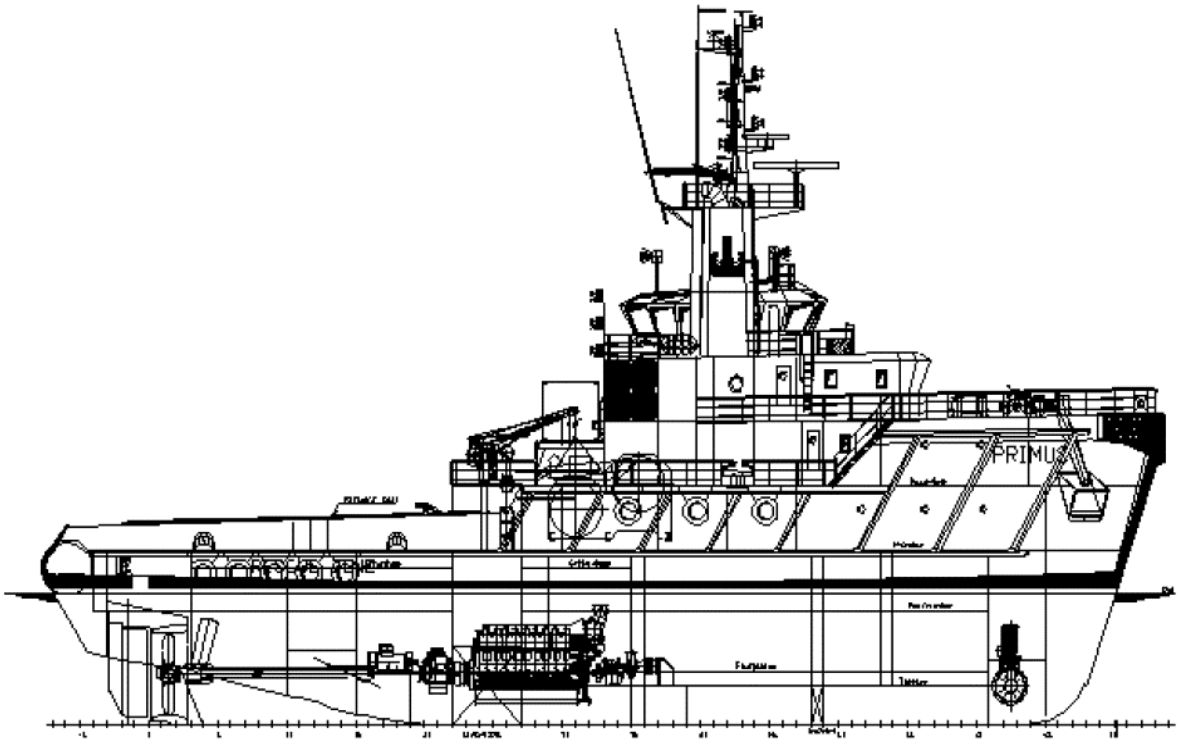


The growth of subsea production (Source: www.dasinvestment.com **)**

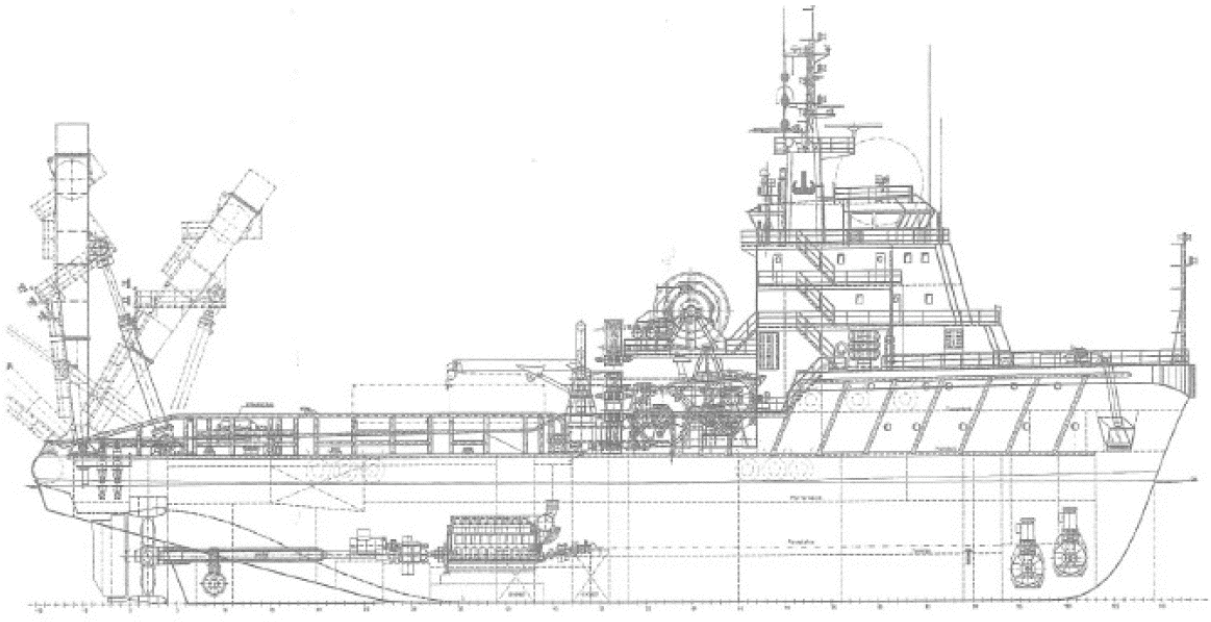
Deepwater exploration and production requires floating facilities that are either anchored to the ground or dynamically positioned. The installation and maintenance of subsea modules such as blow out preventers, pumps- and stimulation units is done by installation vessels and cranes also making use of dynamic positioning (DP).

The move into deeper waters causes new design parameters for the supporting vessels.
The winches need to offer much more storage capacity for ropes and wires and higher line pulls are required, especially if anchor handling shall be done in deeper water.
Due to the specific weight of high tension steel wires the pay load decreases

constantly with the paid out wire. Therefore the power output of the winch needs to be very high.
A countermeasure to reduce the decline of pay load can be the use of synthetic ropes with a much lower specific weight than steel wires. Due to larger diameters of these ropes the size of winch drums increases significantly.
The increase of weight of the main deck machinery for an AHT designed for deepwater operation compared to an AHT for shallow water can be shown by comparing two vessels. The deepwater equipment is about ten times heavier!

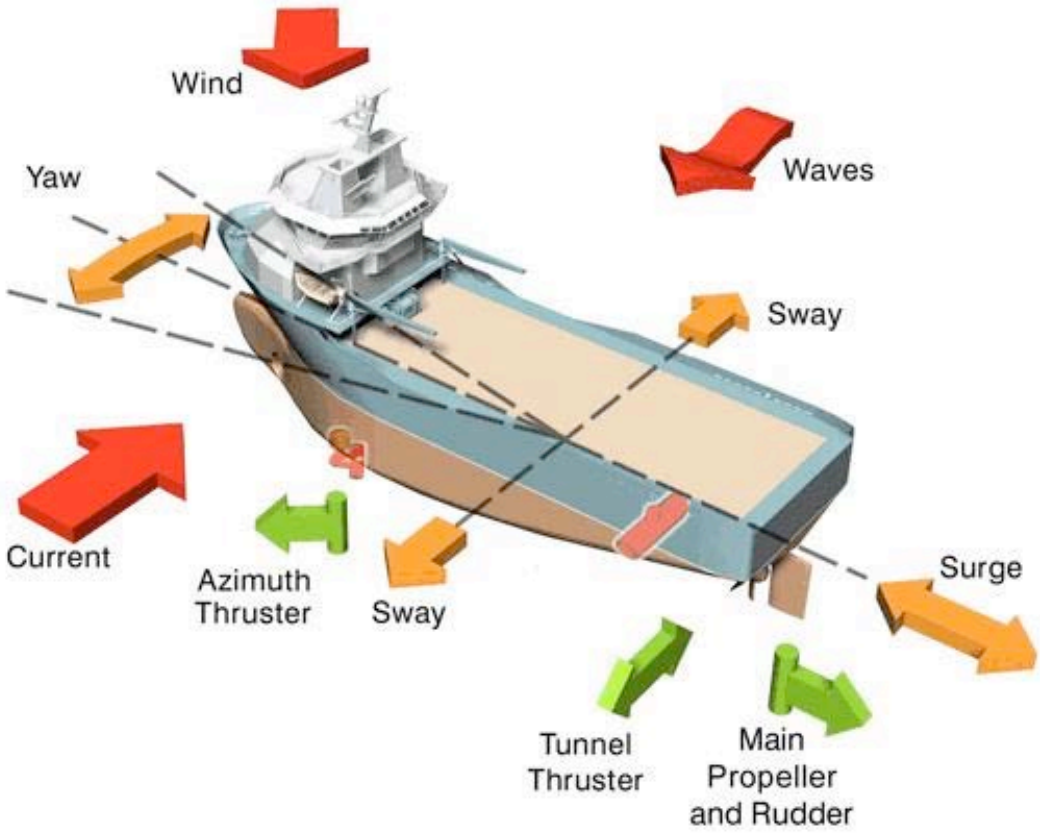


Shallow water AHT: 100 tons electric 2-drum winch; equipment weight: 57.000kg



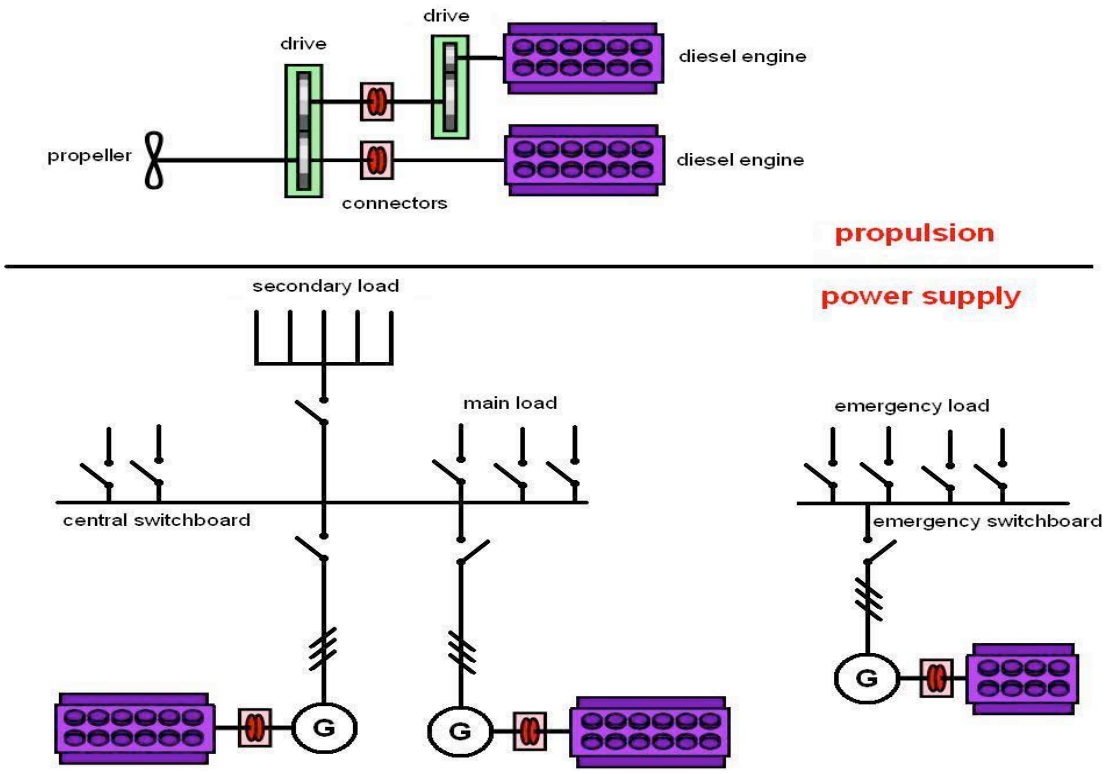
Deep water AHT: 500 tons electric 3-drum waterfall winch, 2 130 tons secondary winches, A-frame; equipment weight: 530.600 kg

As the vessels assist during work in deeper water the dynamic positioning becomes more and more important. For DP only a small part of the installed driving power of an AHT is used. Additionally the generated power must be distributed to various consumers (propulsion, steering gear and thrusters) which can be easiest done electrically.



Dynamic positioning: external forces, movements and equipment

Traditionally the power generation on board of ships is divided between propulsion and power supply for the consumers.



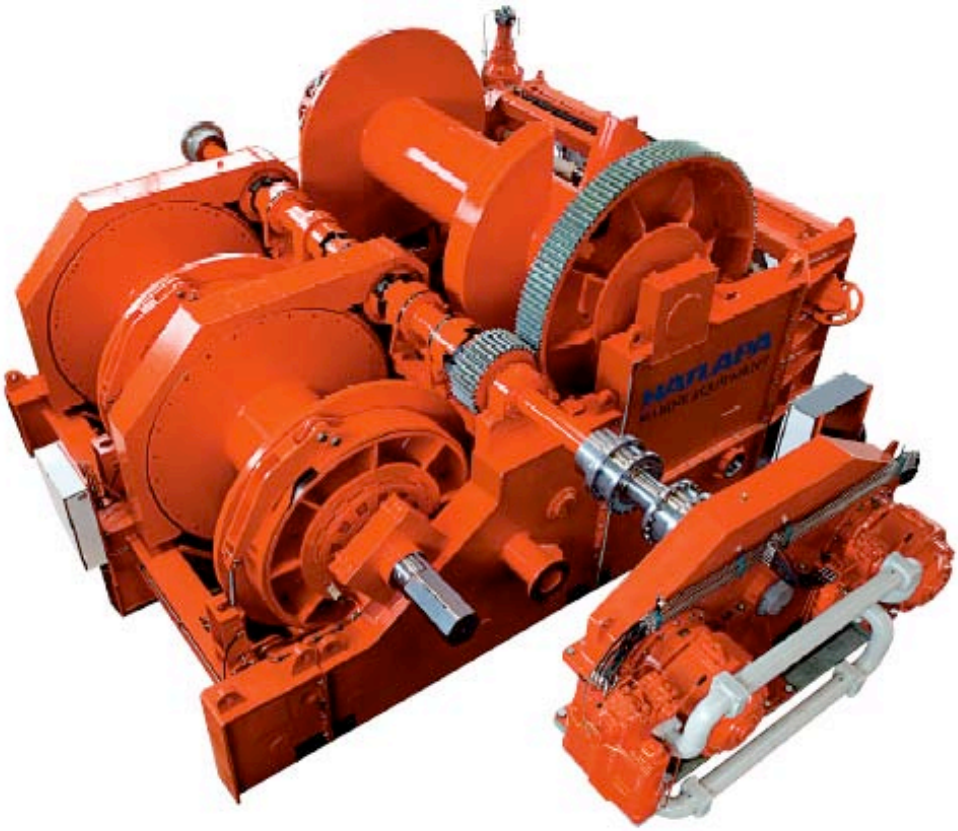
Convential power generation on board of ships

If a considerable time of operation is done in stand-by or DP mode this is not very efficient as the propulsion system is running at low load far away from a good efficiency.
This circumstance leads to a constantly increasing acceptance of so called Diesel-electric vessels.
Diesel-electric vessels use a number of smaller and often identical engines with generators to supply the needed electrical power into the main switchboard and into an emergency switchboard respectively.

Diesel-electric concept (Source:Stadt Power Technology)

Full use of the advantages can be made if the utmost number of consumers makes use of electric drives.
This approach guided us, when we developed large AHT winches with electric drives.

Most common today are AHT winches with low pressure hydraulic (LPH) drives.



LPH AHT winch with pull 450 t @ 9 m/min (Source: HATLAPA)

Their sturdiness is proven. A lot of space below deck is needed for the hydraulic pump unit with E-motors, pumps, filters, valves and coolers. Due to very high volume flows of oil at comparable low pressures (max. 70 bar) piping diameters are in the range of DN 150. The piping required for low pressure installation needs a lot of space and adds considerable weight to the vessel. During the building process of the vessel many man hours are needed for piping and ship-owners representatives carefully watch over the cleanliness of the installation.

The efficiency of LPH systems is limited as the energy will be transformed from electric to hydraulic and from hydraulic to mechanic, including all the pressure losses in pipes and valves.

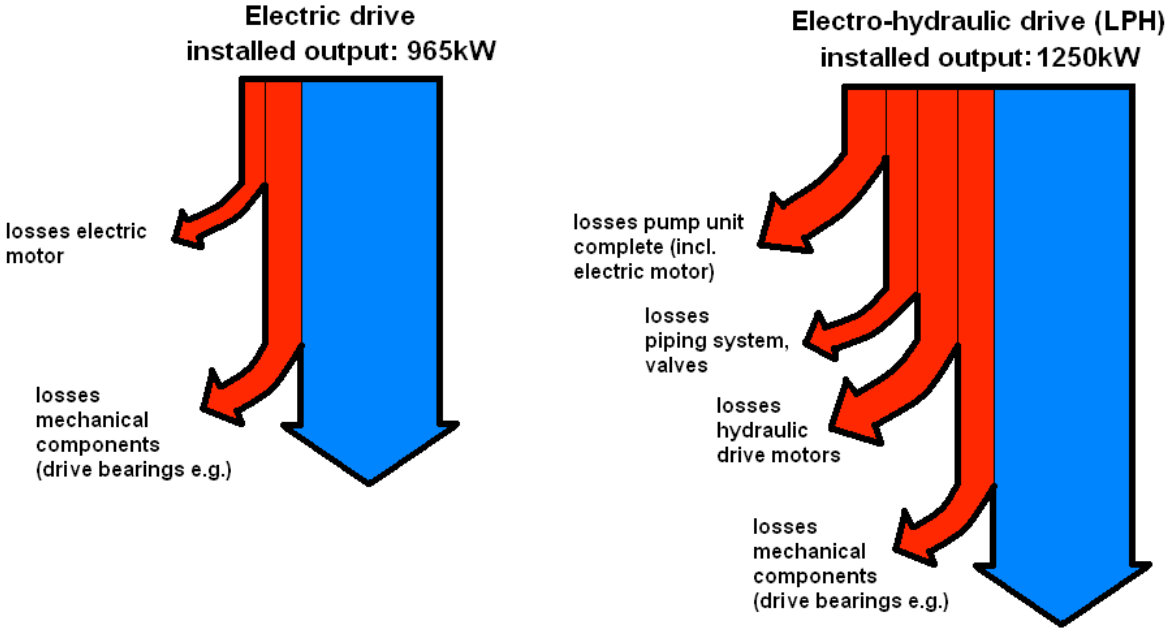
High pressure hydraulic (HPH) systems are also in use. They make use of standard industrial hydraulic components, which are due to much higher pressures (up to 420 bar) significantly smaller than LPH components. The overall efficiency of HPH systems is slightly higher than those of LPH systems.

The electrically (EL) driven winch transfers electric energy directly into mechanical energy and has thus a far better over-all efficiency than the hydraulic systems.

The following table gives an overview about the over-all efficiencies for the different drive systems and shows the electrical power that needs to be installed for a winch with a maximum pull of 4500 kN at a typical speed of 9 m/min.

Drive concept	over-all efficiency η	installed Power P_{inst} for Pull 4500kN @ 9m/min
LPH	0.54	1250 kW
HPH	0.65	1040 kW
EL	0.7	956 kW

Using the so called Sankey diagram the advantages of EL drives can be shown very clearly.



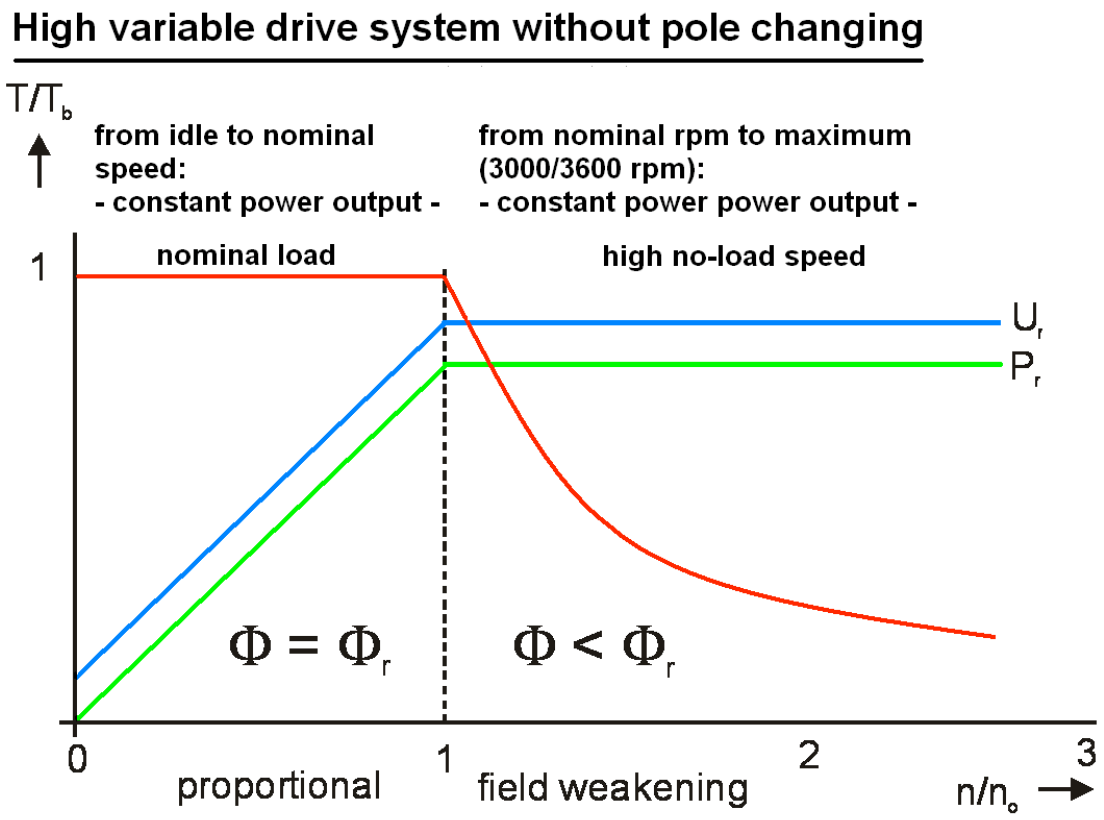
output of the drum:

P = 4500kN • 9m/min = 675kW (both concepts!)

The biggest disadvantage of EL drives with three-phase asynchronous motors was in the past that their speed and torque could not be controlled stepless. If different speeds were required, pole changing motor concepts had to be used as a main drive system.
Smooth control of the winch during operation with high loads and in difficult environmental conditions is a crucial feature for AHT winches.

Applying the latest technologies of variable frequency drives made it possible to develop an electrical drive unit for large winches with fully controllable pull and speed.
The inverter technology makes it possible to control the rotational speed of standard three-phase asynchronous motors with constant number of poles by varying the frequency of the electric power supplied to the motor.

By means of the so called Vector Control the torque of the motor can be directly influenced by controlling the current fed to the machine.
The stator phase currents are measured and converted into a complex vector. Knowing the position of the rotor in the magnetic field by integrating the measured speed, this vector is transformed into a coordinate system fixed to the rotor.
Using a very fast mathematical model the vector can be used to control the stator phase currents in a way that even nominal torque at zero rotation and up to three times nominal speed at reduced load can be adjusted.



High variable drive system with VFD drive

By this operating characteristics for winch drives with VFD can be obtained that are fully comparable with known hydraulic characteristics.

Another topic to deal with is the interference of VFD drives with the power grid on board, known under the expression Total Harmonic Distortion (THD).
The diode rectifier of the VFD takes almost square wave current impulses out of the grid. This leads to harmonic distortions in the power line. As long as the VFD load is small compared with the generator output, the quality of the grid is not noticeable affected. As a rule of thumb it can be said that if the generator output is 3 times larger than VFD output, THD does not create any problems.

A further advantage of VFD drives is seen in respect of the starting current. Compared with usual asynchronous motors the starting current is reduced by 75%.

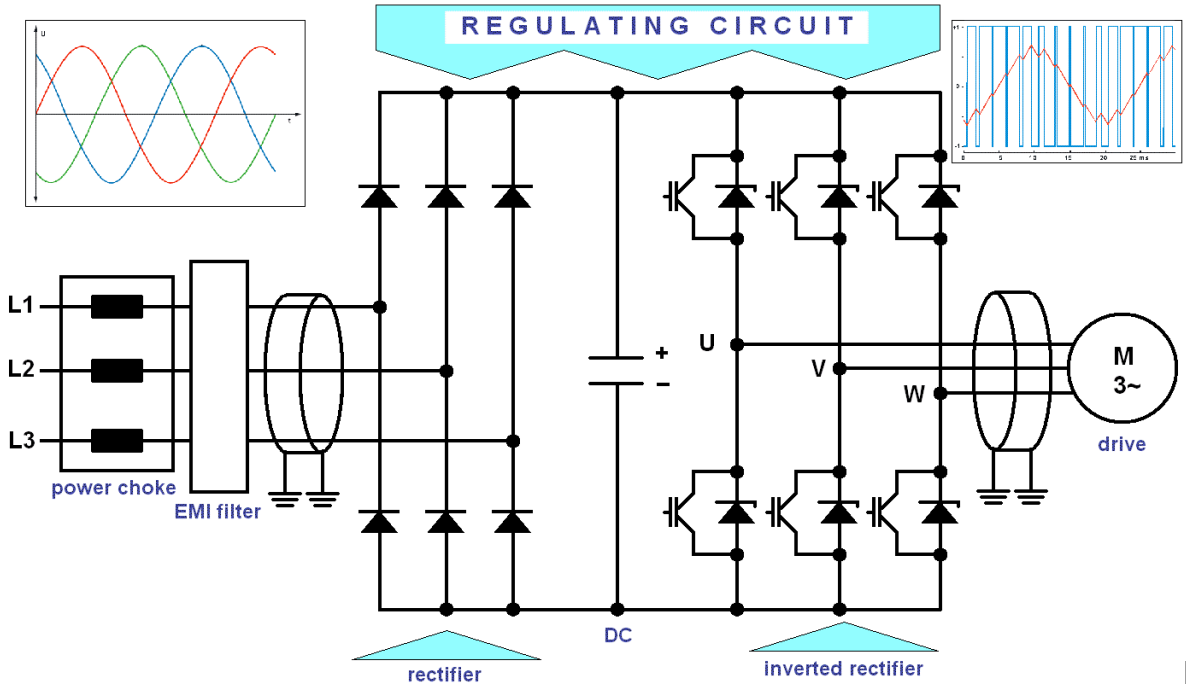
The last challenge to qualify VFD drives for AHT winches is the issue of reverse power during lowering anchors or loads to the ground. Lowering a load and controlling the speed means that the winch needs to absorb mechanical power. Hydraulic winches are using the motor as a brake, thus converting the mechanical

power into hydraulic pressure, then throttling into heat and cooling away in large oil coolers.

Anchor prepared for lowering

To give an idea about the energy that needs to be dissipated:
Lowering of a 15 ton anchor with 150 meters of ground chain and 2000 meters of slack rope with medium speed of 20 meters per minute is resulting in a reverse power of 375 kW.

The reverse power in the VFD drive system can be taken out from the intermediate direct current (DC) circuit.
The voltage within the DC link will rise and will flow through the brake chopper to the external brake resistor where the electric energy will be changed into heat and dissipated. The chopper is switching the pulsed DC link to the resistor.



B
rake transistors / brake resistors

The picture shows an installed brake resistor. It is made of stainless steel; the cooling is achieved by convection and the installed power should be approximately 65 % of the installed power of the winch drive.

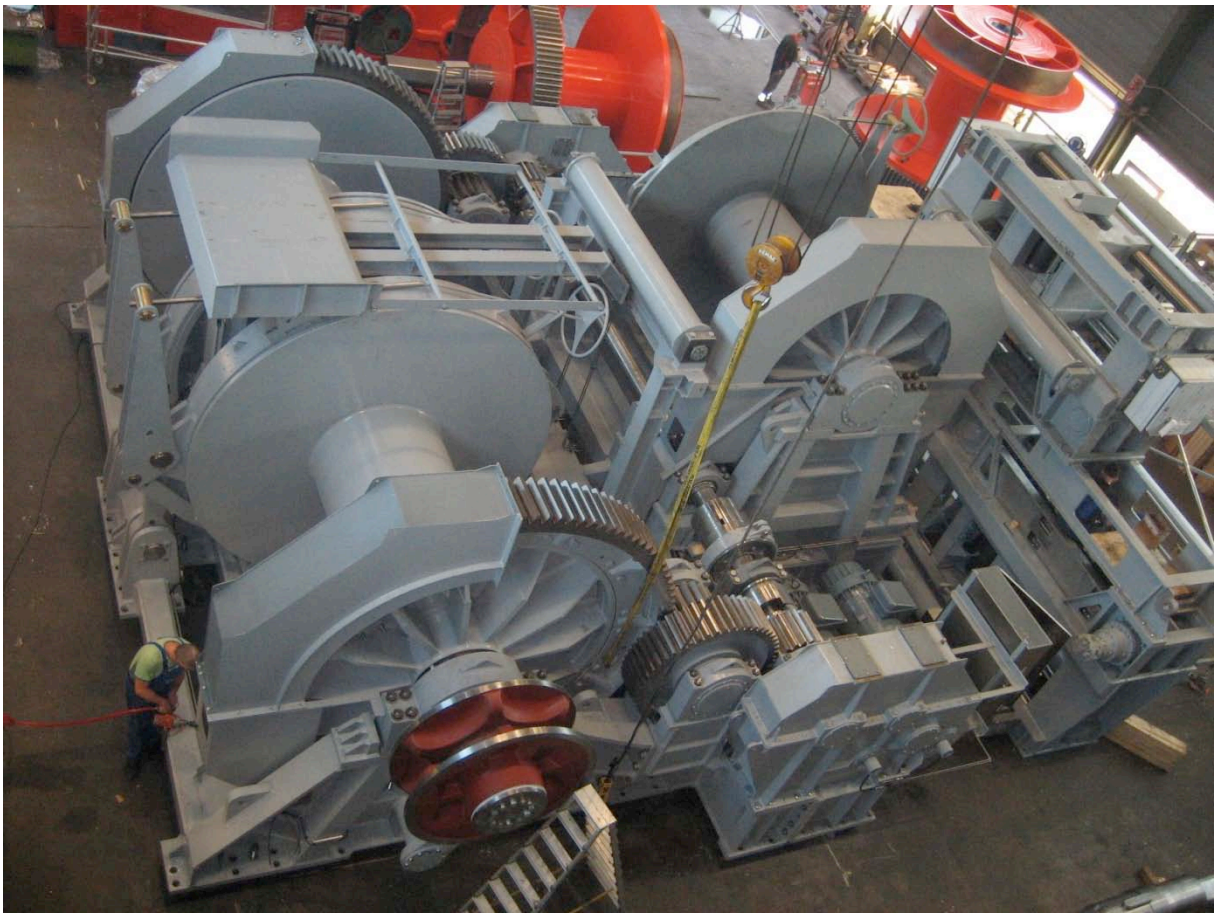
Stainless steel brake resistor

Summary:

Electric drives using advanced VFD technology have been successfully developed and have proven their suitability since almost 5 years in anchor handling and long distance towing.
The core advantages in short are:

- Diesel-electric drive concepts are increasingly accepted
- Efficiency advantages can also provide benefits in the field of auxiliary engines
- Variable frequency drives allow intake of substantial reverse power
- Electric winch drives require up to 30% less installed power, compared to conventional hydraulic drives
- Much less space is required, and installation is less complex (cables instead of pipes)

The VFD drive system with special features for the needs of large AHT winches has been developed by HATLAPA and is named ECO-Pull to find its place in the world wide market.



500 tons ECO-Pull winch during assembly at HATLAPA

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