The invention relates to a windmill, comprising a generator house (12) with a generator and a plurality of rotor blades (13) at an upper part of an upright shaft (11) characterized by said shaft (11) comprising at least one telescopic joint for altering the height of said windmill, and further comprising a pivotal connection (14) of the blades (13) between a substantially vertical and a substantially horizontal position. The invention also relates to a method of installation, intervention or decommissioning of said windmill. The invention can be applied to fixed, bottom mounted offshore windmills or onshore windmills.
Windmill and method of installation, intervention or decommissioning

The present invention relates to a windmill and method of installation, intervention or decommissioning of said windmill, according to the preamble of claims 1 and 12, respectively.

At present the costs of installation, intervention and decommissioning of onshore wind mill concepts as well as fixed bottom founded offshore wind concepts are unreasonably high when using state of the art conventional technology, such as large mobile cranes for onshore operations and jackups or offshore crane vessels for offshore operations. There is thus a need for new thinking to develop safe but less costly technology and procedures for said operations.

For onshore wind mill concepts state of the art is to use large mobile cranes for said operations while for fixed bottom mounted offshore wind concepts state of the art is to use jackups or possibly crane vessels for said operations, however, this might not be attractive in view of the costs of employing sufficiently sized equipment that can operate under most weather conditions, in particular there is a concern regarding limited access to offshore wind mills in situations with waves.

The prior art design of fixed bottom founded windmills for shallow waters requires the use of larger cranes for installation of generator house/turbine as well as the blades of the windmill. The investment costs of the windmills are thus larger than necessary and heavy maintenance is particularly difficult.

Similarly, the prior art design of onshore windmills requires the use of large mobile cranes for installation of generator house/turbine and blades as well as for heavy maintenance of said equipment.

The present invention aims at solving or at least mitigating the above or other drawbacks or deficiencies by providing a windmill with telescopic shaft and method of installation, intervention or decommissioning of said windmill, according to the characterizing clause of claims 1 and 12, respectively.

Advantageous embodiments of the invention are set forth in the dependent claims.
In view of the above, the inventors of the present invention have developed new technology for installation, intervention and decommissioning of wind concepts. The inventors will in particular suggest the use of a telescopic windmill shaft in combination with a pivotal connection of the blades between a substantially vertical and a substantially horizontal position and further combined with use of offshore service vessels to perform said operations offshore safely or the use of smaller lightweight mobile cranes onshore that can work in any wind conditions hereby ensuring that the operational downtime be kept to a minimum.

DE 4029932 A1 discloses a windmill with a telescopic shaft, but without any pivotal connection between the nacelle or the rotor blades and said telescopic shaft.

In the case of offshore deployment, the technology development suggested includes new modules that can be handled by work procedures used by the offshore service industry. In particular, this involves for the following phases:

- Installation: Tow to field of the base wind energy concept combined with new technology components that can be handled offshore with the use of service vessels. With the present invention, installation costs of generator house/wind turbines as well as the blades of the windmill should be substantially reduced.

- Interventions: The telescopic shaft is lowered and maintenance can be carried out directly from service vessels.

- Decommissioning: Reverse installation.

Throughout these operations procedures for telescopic lifting of large structures as developed for the offshore lifting industry will become central elements.

In the case of onshore windmills, this involves:

- Installation: The generator house/ turbine are installed much closer to the ground than in the case of traditional onshore windmills. The blades are then lifted onto the top of the generator house/ turbine into a horizontal position. The telescopic shaft lifts the generator house/ turbine and blades to required position whereafter the blades are turned to the normal vertical position.
• Interventions: The blades are rotated from vertical to horizontal position, the telescopic shaft is lowered and maintenance can be carried out directly from smaller mobile cranes.

• Decommissioning: Reverse installation.

In the following, non-limiting embodiments of the present invention are described in more detail with reference to the accompanying drawings, wherein:

Figure 1 is a side view of a first embodiment of a fixed mounted offshore windmill according to the present invention, having free hanging counterweights, during normal operation.

Figure 2 is a partial view of the windmill of Fig. 1, in an installation position,

Figure 3 is a partial view of a second embodiment of a windmill according to the invention, having integrated counterweights, during normal operation,

Figure 4 is a partial view of the embodiment shown in Fig. 3, in a first installation position, and

Fig. 5 is partial view of the embodiment shown in Fig. 3 in a second, lowered installation position.

A fixed, bottom mounted windmill for shallow waters, e.g. offshore, comprises a foundation element or portion 1 that e.g. could be fixed to the ground by a plurality of piles 2 or by a suction anchor system to ensure stability and the required motion characteristics of the wind mill. In the present invention, the basic foundation element or portion 1 up to waterline or slightly above are designed according to characteristics developed for optimization of motion and stability of a traditional fixed offshore wind mill. The foundation element or portion 1 and the piles 2 (if required) could be installed by use of smaller lifting barges or service vessels (not shown) during the summer period where waves are small. Alternatively, the foundation could be floated into location in vertical position and ballasted to the seabed. So far there is nothing particular new with the new concept.
During operation of the wind mill, the above-the-water parts of the design consist of the above-the-water shaft 11, the generator house 12 with gearbox and turbines and the blades 13 of the wind mill. During normal operations, the differences between our invention and a traditional floating wind mill may not be visible according to the present description, see Figure 1 for reference.

As described above in the introduction and the prior art description, however, the installation and in particular the maintenance of the generator house and the blades of the wind mill will require use of a large jackup, of which the day-rate for hiring might be very large. Alternatively, large crane vessels could be considered used. However, cranes that behave stable in waves (even in waves that are expected to occur most of the year) might have to be of the semisubmersible design that is particularly costly to hire.

With the present invention, however, said shaft 11 will be of the telescopic type that can be folded together into a relatively short tower that may even be retracted wholly or partly into the foundation structure. Then all lifting of the blades of the wind mill can be performed while the blades are in horizontal position. This will be ensured by mounting a strong hinge 14 between the generator house 12 and the above the water shaft 11. The hinge could in practice be designed such that the generator house is installed vertically on the top of hinge (or together with the hinge) that is located on top of the shaft 11. This installation can be carried out by service vessels or the generator house can be floated over the above the water shaft on one or two barges and transferred to the shaft.

Thereafter the blades are lifted in position and installed horizontally on the top of the generator house by the cranes of a service vessel at a height determined by the reach of the cranes and the height of the telescopic tower of the shaft 11. Figure 4 shows how the installation of the generator house and the blades are carried out. Alternatively, the installation can be carried out by float-over technology where the equipment is placed between barges that are hauled in place over the generator house. The transfer of the blades could thereafter carried out by jacking up a part of the telescopic shaft.

Following the installation of the wind mill blades 13, the wind mill shaft 11 is jacked up or raised up by some other known manner to its basic height such that the blades reach a height where the hinge 14 with the generator house 12 on top can be turned 90 degrees to ensure that the wind mill blades get in the standard traditional vertical position for efficient generation of electricity. Through this operation the generator house will get in the traditional horizontal position. As part of this operation, it could be possible to slide
the generator house back by engaging a rail system mounted on the underside of the generator house 12. Hereby the hinge 14 will act as a counterweight to the wind mill blades 13 and can be engaged to ensure that the generator house 12 be placed in a balanced position on top of the shaft 11. Figure 3 shows the generator house, the hinge 14 and the blades 13 in operational position, and with the arrow indicating one direction of sliding movement of said generator house.

As a less complex alternative, the generator house 12 can be designed with at least one free hanging counterweight 17 hanging outside the shaft 11 of the windmill and below the hinge 14 during installation in order to balance the weight of the generator house 12 and the blades 13. Said counterweight 17 preferably has an aerodynamic shape, e.g. a tail wing shape assisting the positioning of the rotor blades 13 against the wind and as shown in the figures. Alternative designs of the hinge could be considered as well, as designed by a person skilled in the art.

As soon as the hinge is fixed and secured, the wind mill can be ready for use. The hinge could also be designed such that it can rotate e.g. on a joint 18 to ensure that the blades are in optimum position with respect to the wind direction to produce as much electricity as possible.

Details of the hinge are shown in Figure 2. It should be noted that we in principle also could consider a design according to the principles described above whereby the blades 13 rotate in the horizontal plane on top of the generator house 12 and shaft 11, i.e. said blades 13 rotating in the horizontal plane in an operation mode of said windmill.

The installation operations as described can be very efficiently carried out with the use of service vessels under controlled conditions.

For heavy maintenance, the hinge 14 can be activated and the blades 13 can be moved into horizontal position and the wind mill shaft 11 can be folded together by its telescopic joints to required height such that the cranes of (not shown) service vessels can perform operations on the blades 13 and the generator house 12.

The windmill preferably includes a joint 18 at the upper part of the shaft 11, said joint enabling rotation of the generator house 12 about the longitudinal axis the shaft 11. It is thus secured that the blades 13 are in optimum position with respect to the current wind direction.
According to the invention there is thus also disclosed a method of installation, intervention or decommissioning of a windmill as described above, comprising the steps of: telescopically adjusting said windmill to a required height above sea level, arranging the rotor blades 13 in a substantially horizontal position, or parts for connection with the rotor blades 13, e.g. generator, rotor shaft, etc., in a position for substantially horizontal mounting of the rotor blades 13, and conducting or continuing installation, intervention or decommissioning operations.

The use of the wording "fixed" windmill in the description and claims should not be construed as only encompassing said windmill in its deployed fixed bottom mounted state, but to encompass the windmill in any state, e.g. stored onshore or onboard a vessel before deployment, or at factory during or after its production.

Further it should be noted that the use of directional terms such as "upright", "horizontal", "vertical", "top", "bottom", etc. relates to the windmill in its operational position deployed at sea.

While the above description relates to a fixed mounted offshore windmill, an onshore windmill according to our invention incorporates similar procedures, however, the offshore equipment be changed out with lighter onshore mobile cranes. The telescopic shaft and the pivotal connection of the blades between a substantially vertical and a substantially horizontal position are similar to the elements of the above described offshore fixed bottom mounted wind mill.

It might be commented that the material costs of the windmill according to our invention might be larger than for present state of art onshore windmills, however the savings are in the use of lighter equipment for installation and maintenance as well as a wider weather window where installation and maintenance can be carried out, whereby the downtime might be substantial reduced.
A windmill, comprising a generator house (12) with a generator and a plurality of rotor blades (13) at an upper part of an upright shaft (11), characterized by said shaft (11) comprising at least one telescopic joint for altering the height of said windmill, and further comprising a pivotal connection (14) of the blades (13) between a substantially vertical and a substantially horizontal position.

The windmill according to claim 1, characterized by being employed as a fixed, bottom mounted offshore windmill, where the telescopic joint(s) are designed to alter the height of said windmill above water level.

The windmill according to claim 1, characterized by being employed as an onshore windmill, where the telescopic joint(s) are designed to alter the height of said windmill above ground level.

The windmill according to claims 1 and 2, characterized by further comprising a foundation element or portion (1), said foundation element or portion, up to waterline or slightly above, being designed according to characteristics developed for optimization of motion and stability.

The windmill according to claim 4, characterized in that said foundation element or portion (1) being fixed to the ground by a plurality of piles (2) or by a suction anchor system.

The windmill according to any of the preceding claims, characterized in that said pivotal connection (14) is a hinge.
7. The windmill according to any of the preceding claims, characterized by at least one counterweight (17) mounted externally to the generator house (12).

8. The windmill according to any of claims 1 to 6, characterized by comprising a rail system connected to the generator house (12) for sliding movement of the generator house (12) relative to a longitudinal axis of the shaft (11).

9. The windmill according to any of the preceding claims, characterized in that said rotor blades (13) rotate in a substantially vertical plane in an operation mode.

10. The windmill according to any of claims 1 to 8, characterized in that said rotor blades (13) rotate in a substantially horizontal plane in an operation mode.

11. The windmill according to any of the preceding claims, characterized by comprising a joint (18) at an upper part of the shaft, said joint enabling rotation of the generator house (12) about the longitudinal axis of the shaft (11).

12. A method of installation, intervention or decommissioning of a windmill according to any of the preceding claims, characterized by comprising the steps of; telescopically adjusting said windmill to a required height, arranging the rotor blades (13) in a substantially horizontal position, or parts for connection with the rotor blades (13) in a position for substantially horizontal mounting of the rotor blades (13), and conducting or continuing installation, intervention or decommissioning operations.

13. The method according to claim 12 for an offshore windmill, characterized by the further step of using one or several cranes of a service vessel or float-over technology in said installation, intervention or decommissioning operations.
14. The method according to claim 12 for an onshore windmill, characterized by the further step of using one or several onshore mobile cranes in said installation, intervention or decommissioning operations.
INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO201 0/000246

A. CLASSIFICATION OF SUBJECT MATTER

F03D 11/04 (2006.01)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F03D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

DK, FI, NO, SE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPOQUE (EPDOC, WPI)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
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<td>DE 4029932 A1 (PRETZSCH SIEGFRIED [DE]) 1992-03-26 <em>Figure 4</em></td>
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<tr>
<td>A</td>
<td>WO 2004070119 A1 (SAIPEM SA [FR]; FARGIER CYRILLE [FR]) 2004-08-19 <em>Whole document</em></td>
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D. Further documents are listed in the continuation of Box C. See patent family annex.

* = Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is considered relevant to patentability only on the date of the later one of the documents mentioned
"O" document referred to in the written description of the invention in an international application
"P" document published prior to the international filing date but later than the priority date claimed

Date of the actual completion of the international search
13/09/2010

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