Technical Description

Dismantlement and Disposal

ENERCON Wind Energy Converters

ENERCON
ENERGY FOR THE WORLD

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1 General information

At ENERCON, we will always strive to reuse our wind energy converters and their components. All reusable components require appropriate approval from our QA department, and load-bearing parts require a static inspection. If individual components cannot be reused, they will undergo a recycling or disposal process.

Given that dismantling work has to be carried out by trained specialist staff with sufficient experience, a wind energy converter must only be dismantled by employees of ENERCON or by specialist personnel authorised by ENERCON.

Before work can begin, it must be ensured that, in addition to the occupational health and safety requirements, the appropriate access facilities, crane platforms, storage facilities and aids are available. If necessary, the existing crane platforms must be upgraded. The machines required for dismantlement and the crane must also be sufficiently earthed.

The electrical connections and cable pass-through holes on the wind energy converter must be in a condition permissible for dismantlement. The wind energy converter to be dismantled must be disconnected from the power grid.

All safety measures such as securing of bodies of water, protective scaffolding for overhead power lines and upgrading of crossings above gas and water lines must be carried out and approved.

At sites in the immediate vicinity of bodies of water, lakes and canals, safety plans must be drawn up in order to avoid breaches of slopes or hydraulic soil failures.

For locations where high water levels are to be expected, a sufficiently dimensioned, closed or open water drainage system must be planned.

Fig. 1: Dismantling a wind energy converter

The section below contains a brief description of the principle of dismantling a wind energy converter and mentions the reuse or disposal of components. The document does not claim to be exhaustive and is not intended as an instruction for safe dismantlement of a wind energy converter. There follows an estimation of the required effort for dismantlement using the example of the E-82 wind energy converter with a hybrid tower.

2 Integrated components

2.1 Cables

If the wind energy converter is to be reused, the cables are generally removed from the tower and the nacelle. Pulling hoses, which are fastened to winches, are attached to the tower cables. The clamps of the respective cable to be lowered are then loosened at the cable holding rails in the tower, and the cables are let down carefully. The cables removed from the tower are collected in containers. The cables between the levels of the E-module are removed and stored.

If the wind energy converter is not to be reused, WEC components can also be removed without first removing the cables. For this purpose, if necessary, the cables are cut and removed together with the attachments.

Cables and cable clamps might be suitable for reuse for the same purpose, or can be disassembled into their individual parts, cleaned, melted down and recycled for a new use.

2.2 Service hoist

Before the wind energy converter is disconnected from the power supply, the drive cable for the service hoist has to be fully extended from the winch. If the hoist cage is at the lowermost level, the guide ropes/cables are released and let down. The hoist cage can be removed.

If a grid-connection hoist is required for further dismantling work, this can be installed instead of the service hoist.

After removal, the service hoist is packaged and transported away. If necessary, it is then dismantled into its component parts, and these parts are either disposed of or recycled.

2.3 Fixtures

Fixtures such as ventilation hoses, guardrails, grab handles, grids, side plates and brackets, nets, net retainers, hose supports, cable supports, steel-cable guides and the frame of the service hoist are removed. All vessels that contain liquid are sealed or emptied. The liquid is either used or disposed of, depending on its type.

Other fixtures are further dismantled as far as possible on the ground. All fixtures are put into intermediate storage in sealable containers to then be transported away. Fixtures might be suitable for reuse. If this is not possible, they can be dismantled into their individual component parts and recycled or disposed of.

3 Rotor blades

If the rotor blades of the wind energy converter can be removed together with the rotor head, the rotor head is attached to a crane, removed and lowered with the rotor blades in place.

The rotor head is stored in a stable position on the ground; the individual rotor blades are secured and removed.

Fig. 2: Lowering the rotor head with rotor blades

If the rotor blades of a wind energy converter cannot be removed and lowered together with the rotor head, as is the case with smaller types of wind energy converter, the rotor blades have to be removed from the wind energy converter individually. For this, the rotor is locked, the respective rotor blade is turned to the 3 o’clock or 9 o’clock position and attached at the respective lifting points for lifting. Once the first rotor blade has been dismantled, the rotor head can be turned with an additional ballast arm or via a rotor blade attached in the appropriate position. The rotor blade to be dismantled is then detached from the connection point on the rotor head, lowered and set down in a stable position on the ground. During lowering, the rotor blade is secured by guide ropes/cables to keep it from swinging.

Fig. 3: Rotor blade attached to the crane

Further dismantling work such as separating multi-part rotor blades, disassembly of the spoiler or disassembly of the blade heating system might then need to be performed immediately afterwards. Once the rotor blade has been reduced to a size that makes it suitable for transportation, it is loaded and transported away.

Depending on whether or not the rotor blade is to be reused, it might need to be overhauled and reinstalled, or dismantled further and disposed of properly.

The rotor blades are mostly composed of glass-fibre-reinforced plastic. Wooden inlays are inserted in certain positions. The blade tips are made of aluminium. The rotor blades on certain types of wind energy converter contain carbon.

When disposing of the rotor blades, the components are separated and re-used as far as possible. Current technologies for full re-use of compound materials are taken into consideration in the process. If re-use of the material is not feasible, thermal recycling in incinerators for energy production is another option.

4 Nacelle

4.1 Rotor head

If it has not been lowered together with the rotor blades, the rotor head is attached at the designated lifting points, connected to the crane and guided with ropes/cables. It might be necessary to remove the casing sections and install lifting tackle to do so.

On EP1-platform wind energy converters, the rotor head is released and lowered together with the generator. For other types of wind energy converters, the rotor head is detached from the generator and lowered. The rotor head is stored in a stable position on the ground and further dismantled. All the parts are then packaged and transported away.

Fig. 4: Rotor head fastened

The rotor head can be reused as a rotor head or disposed of. Aluminium casing sections can be cleaned and melted down. If possible, casing sections made of glass-fibre-reinforced plastic are materially utilised as far as possible. If this is not feasible, thermal recycling is another option. Cast parts and steel components can be melted down and recycled for reuse.

4.2 Generator

Depending on the type of wind energy converter, the size of the generator and the crane technology available, the generator can be dismantled and lowered in its entirety or in parts (only the generator rotor or generator rotor with rotor bearing unit and generator stator).

Any liquids are drained off. The liquids are either used or disposed of according to their type. Liquid connection points are disconnected, and the openings of the connection points are closed. The generator is attached in its entirety or in parts by means of lifting tackle and guided with ropes/cables.

The generator is then disconnected from the machine house and lowered.

The generator is set down in a stable position on the ground. Further dismantling work, such as separating generators that are made up of multiple parts, might need to be carried out immediately afterwards. The generator is then packaged and transported away.

The generator can be overhauled and used as a generator again. If this is not possible, it is dismantled. The components are recycled or disposed of properly. Steel and copper components can be melted down and recycled for reuse.

4.3 Machine house

The machine house is attached to the crane used for dismantlement at the designated lifting points. It might be necessary to remove the casing sections to do so. The machine house is then released at the joint and lowered from the uppermost tower section.

The machine house is set down in a stable position on frames on the ground. Further dismantlement, some of which is extensive, is performed immediately afterwards. Once the machine house has been dismantled into parts that can be transported, these are packaged, loaded and transported away. If the components are not reused for their original purpose, they are dismantled and reused.

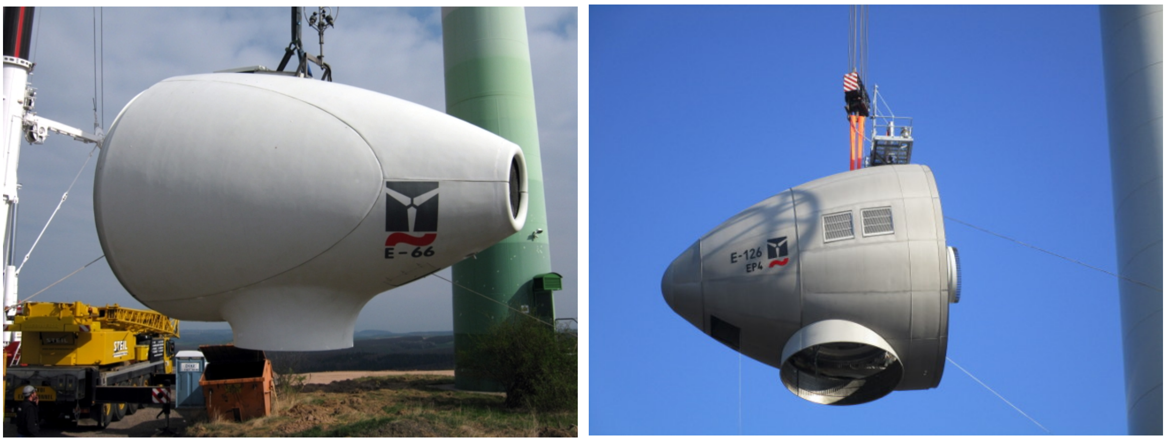

Fig. 5: Machine houses from various types of wind energy converter attached to the crane

5 E-module

Fig. 6: E-module underneath an attached steel section

The E-module is generally situated in the tower base. It consists of different levels, some of which are bolted or plugged together. Before the E-module can be dismantled, all the cables have to be traced back to the E-module level.

In hybrid towers, once the tower has been dismantled down to the lowest segments, the E-module can be attached to a crane and lifted out of the tower base.

On steel towers, all the steel sections are removed first. Then the E-module is attached to the crane.

If there is no E-module, as is the case with converter types E-44, E-48 and E-53, the cabling to the components in the tower base is disconnected. The components, such as the power cabinets or the transformer, are attached to the crane and removed individually.

Components that can be reused are packaged in splash-proof film and transported away. It might be possible to recondition the E-module and reuse it or disassemble it into its component parts, dispose of it or recycle it for a new use.

6 Tower

6.1 Hybrid tower

Hybrid towers consist mostly of concrete segments. In the lower part of the hybrid tower, the concrete segments are made up of partial segments. The upper segments are full-ring segments. Depending on the tower version, there can be up to 4 steel sections of different sizes placed on top of the uppermost concrete segment. The lowermost steel section is tensioned and anchored with the uppermost concrete segment; the other steel sections are bolted together.

Vertical connection of partial segments

The partial segments in the lower part of the tower are bolted together vertically during installation. Pre-fabricated bolting boxes are used for this. After the tower has been dismantled, the bolt connections of the partial segments are loosened to separate them.

Horizontal connection of segments

The joined partial and full-ring segments are horizontally glued or dry-stacked (system joint). The individual tower segments are also tensioned vertically using steel cables (prestressing tendons).

The prestressing tendons run either inside the concrete segments in cast sheathing pipes, or on the inside of the tower.

Fig. 7: Horizontal joint levelled (left); prestressing tendons on the inside of the tower (right)

When dismantling the tower, the tower segments that have a glued horizontal joint and/or grouted prestressing tendons have to be mechanically separated.

If the horizontal connection of the tower segments is designed as a system joint and the prestressing tendons run freely along the inner wall of the tower, mechanical separation can be dispensed with during dismantlement.

6.1.1 Dismantling individual segments of the tower using saw cuts

Before dismantlement, all embedments inside the tower are removed. For safety reasons, the lightning-protection devices and safety-ladder segments are only detached with the segment to be separated.

A working platform is installed on the tower, which can be inside or outside.

Fig. 8: External work platform

A concrete-wall or wire saw is placed in the area of the horizontal cut joints. The cuts are made in the existing joints. During separation, the cut joints are secured with steel or wooden wedges.

Fig. 9: Guide rail for the concrete-wall saw bolted to the tower segment (left); concrete wall saw (right)

Once approximately 2/3 of a segment has been cut, it is attached to the crane. If necessary, the lifting points on the segment must be exposed. For this, the segment adhesive must be removed from the threaded bushes and, if necessary, the thread in the bush must be re-cut. The section between the concrete segments is then completely separated. The concrete segment is lifted by crane and set down onto a storage surface near the tower. Vertical connections between the partial segments are disconnected on the ground.

Fig. 10: Re-cutting damaged threads (left); lifting down individual segments (right)

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.2 Dismantling individual segments of the tower without saw cuts

If the tower segments have exposed prestressing tendons and a system joint (unglued), this simplifies the dismantling work. Due to the prestressing tendons on the inner wall of the tower, mechanical separation of the joints is no longer necessary. The prestressing tendons are released in the tensioning basement or in the area of the tower base and pulled upwards and wound up. This requires the use of an internal working platform.

The concrete segments are attached to the crane at the existing lifting points and lifted down one after the other. Vertical connections are disconnected on the ground.

Fig. 11: Attached concrete segment

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.3 Tower dismantling by demolition excavator

Before dismantlement, all embedments inside the tower are removed. The lightning-protection devices and safety-ladder segments remain in the tower.

Neither a crane nor a work platform is required for this type of tower dismantlement.

The demolition is carried out using an excavator with a telescopic arm and demolition shears, or using a cable excavator.

The excavator with a telescopic arm and demolition shears crushes concrete as well as reinforcement bars and prestressing strands. Concrete, reinforcement bars and prestressing strands are also crushed when demolished using a cable excavator, an excavator with a lattice boom, to which the demolition shears are attached via a snatch block.

However, the cable excavator cannot be controlled as precisely as the excavator with a telescopic arm and demolition shears, which increases the demolition time. The advantage of the cable excavator, however, is the greater demolition height.

The material crushed by the demolition shears falls down from the tower. As such, the area in and around the tower is cordoned off for safety reasons. The size of the cordoned-off area depends on the height of the tower.

Because demolition excavators are limited in their working height, they are deployed in conjunction with other technologies.

Fig. 12: Demolition excavator with telescopic arm and demolition shears (left); cable excavator (right)

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.4 Dismantling a tower by bringing it down in a controlled manner

It is not possible to bring towers down in a controlled manner on every site. In order to assess this, an investigation of the subsoil and the surroundings is conducted beforehand. For each tower to be brought down, appropriate calculations are carried out in advance and a concept developed.

For this method, a fall bed is made before the tower is brought down. To do so, depending on the subsoil, the topsoil is removed and the area drained. Sand ribs are made to attenuate the impact. All embedments are removed from the tower before it is brought down.

The tower base is weakened by cutting wedge-shaped notches in the sides of the tower and removing concrete and reinforcement. Then, only in the topple direction of the tower, explosive charges are placed into drill holes and detonated, so that a defined area is blasted out of the tower base. The tower thus falls in the intended direction.

As part of the work, vibration measurements are carried out in the surrounding area during construction.

This method of dismantlement saves time, but requires preparation time for applications and approvals.

The use of a crane or a work platform and the dismantlement of the individual concrete segments are not necessary.

Fig. 13: Brought-down tower (left); controlled felling of the tower (right)

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.5 Tower dismantlement by means of an impact weight

Before dismantlement, all embedments inside the tower are removed. The lightning-protection devices and safety-ladder segments remain in the tower.

Neither a crane nor a work platform is required for this type of tower dismantlement.

The demolition is carried out with an impact weight suspended from a steel cable on the crane and steered horizontally by means of a second cable. The impact weight is steered at a defined angle and hits the tower. Due to the heavy weight, the concrete is loosened from the reinforcement. Concrete pieces are thus broken out of the tower and pieces of the hybrid tower approx. 8 to 10 m in length are toppled.

The area in and around the tower is cordoned off for safety reasons. The size of the cordoned-off area depends on the height of the tower.

Since the crane is limited in its working height by the impact weight, it is deployed in conjunction with other technologies. This method is effective and cost-effective, and can be used for towers up to 90 m in height.

Fig. 14: Demolition by means of an impact weight

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.6 Tower dismantlement using a mounted or spider excavator

Before dismantlement, all embedments inside the tower are removed. The lightning-protection devices and safety-ladder segments remain in the tower.

This type of dismantlement uses a mounted or spider excavator that rests on the tower surface and is equipped with a chisel or demolition shears. The excavator is controlled from a side platform.

Most of the demolition material falls into the tower. The amount of demolition material fills a maximum of 5 to 6 m of the tower base, meaning that the material can be removed from the ground with an excavator after being broken down.

The lowermost 6 to 8 m of the tower can be demolished from the ground using a demolition excavator.

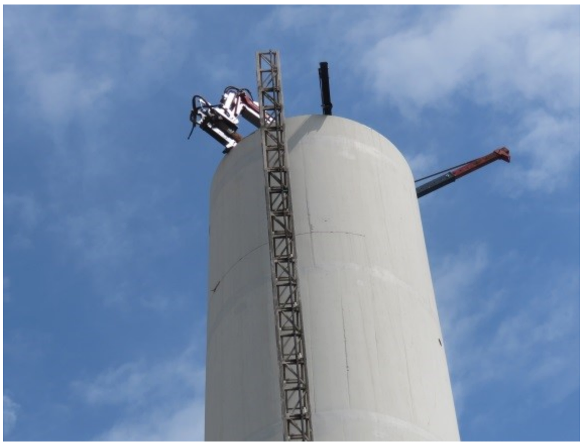

Fig. 15: Fig.: Mounted excavator with chisel (left); mounted excavator atop the tower (right)

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.1.7 Tower dismantlement through removal of segments

When removing segments, the segment joints are separated using oxygen lances and a splitting tool or a high-pressure water jet.

Before dismantlement, all embedments inside the tower are removed. The lightning-protection devices and safety-ladder segments remain in the tower for safety reasons. A side work platform is required for the dismantlement work.

Joint separation using oxygen lances and a splitting tool

Here, the prestressing strands are cut through using oxygen lances. Several holes drilled in a row allow the segments to be separated by perforation. The material becomes brittle in the edge areas of the drill holes, weakening the joint. The remaining cross-section is forced apart using a hydraulic splitting tool.

Once approx. 2/3 of the segment has been cut through, it is attached to a crane. If necessary, the lifting points of the segment must be exposed or replaced. The segments are then completely separated; the detached segment is lifted down and set down safely near the tower. Further dismantlement work is carried out on the ground.

Joint separation using a high-pressure water-jet cutter

Horizontal joints are separated using a high-pressure water-jet cutter. Water to which an abrasive agent has been admixed is accelerated by means of a high-pressure pump and guided through special blasting nozzles. This is directed at the surface to be cut through. Pressures of up to 4000 bar are reached in the process. The high impact energy causes the material to be removed at the surface of the segment. The detached material drains off together with the abrasive agent.

Once approx. 2/3 of the segment has been cut through, it is attached to a crane. If necessary, the lifting points of the segment must be exposed or replaced. The segments are then completely separated; the detached segment is lifted down and set down safely near the tower. Further dismantlement work is carried out on the ground.

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. The reinforcement steel can be recycled.

6.2 Steel tower

When dismantling a steel tower, the tools and lifting equipment for fastening the steel section are moved to the height for removal. The appropriate lifting equipment is connected to the flange of the steel section and fastened to the crane. In the positions in which the fastened steel section is removed the safety ladder sections and any cables and fixtures which are still in place are disconnected. Once the dismantlement crane has taken the weight of the steel section, all but 2 of the bolt connections on the steel section are unfastened. The crane lifts the steel section until a gap appears. The last bolt connections are then unfastened. The steel section is lowered, moved from the vertical position into the horizontal position and set down using an additional auxiliary crane.

Fig. 16: Steel section when being set down (left), removed steel sections (right)

Transport frames are then attached to the steel section. The section is loaded and transported away. The bolts that are still in the tower flange are secured. The dismantling process is repeated on the next steel section.

Fig. 17: Separating and lifting the lowermost steel section on a tower with a foundation basket

The last steel section on steel towers with a foundation basket is released, attached to a crane and lifted using an excavator-mounted concrete chipper.

On steel towers with a foundation section it has to be exposed from the foundation.

The steel sections, if they are not be reused for the same purpose, are scrapped or re-cycled for a new use.

7 Foundation

The following description relates to serial foundations. If the site is to be rebuilt with an identical wind energy converter, the foundation can possibly be reused. In this case, the foundation surface is cleaned using a high-pressure water jet.

In the case of hybrid towers that have a foundation cover, this can remain on the foundation. On hybrid tower foundations with grouted prestressing tendons, the bond between the prestressing tendons and the foundation is broken by means of core boring. The prestressing tendons are then pulled out of the foundation. Prestressing tendons and concrete residue are disposed of, and the sheathing pipes in the foundation are cleaned.

If the foundation can no longer be used, it must be demolished completely or, depending on local regulations, down to a certain depth. Some applications for planning permission require the foundation to be removed from a depth of 1.5 m to ground level. The type of demolition that is possible and practical in a particular case has to be determined for each specific project.

The prerequisite for demolition is that the foundation is exposed externally and the foundation cover, if any, has been removed. The foundation can be crushed using a demolition excavator or an excavator-mounted concrete chipper, or through loosening blasting.

7.1 Demolition by means of a demolition excavator

With this type of demolition, the foundation is exposed all around the circumference. Using an excavator-mounted concrete chipper or a demolition excavator, the concrete is loosened and separated from the reinforcement – and potentially also from the foundation basket. The procedure is time-consuming, and it must also be ensured that the excavator can drive around the foundation on a paved or slabbed surface.

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Existing material from the lightning-protection system is extracted and transported away. If compressible inserts (soft layers) are present, they are removed and transported away.

Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. After a suitability test, the crushed, recycled concrete material can also be used to create a crane platform. The reinforcement steel and steel components such as pre-stressed anchors, sheathing pipes and earthing strips are scrapped. Non-recyclable materials such as ducts and the like are disposed of.

7.2 Demolition by loosening blasting

In this type of demolition, holes are drilled at regular intervals into the exposed surface of the foundation using a drill. The arrangement and size of the drill holes depend on the size of the foundation, the degree of reinforcement and the concrete strength. An explosive is inserted into the drill holes. Finally, the foundation is covered with plastic mats and soil.

After the explosive is ignited, the cover is removed, and the foundation is exposed again. The concrete released from the reinforcement through blasting is removed with an excavator.

The material can then be loaded and transported away or crushed on-site by a demolition excavator.

Reinforcement steel and concrete are separated. Existing material from the lightning-protection system is extracted and transported away. If compressible inserts (soft layers) are present, they are removed and transported away.

Concrete can be crushed to a standardised size by a crushing plant and used in road and path construction. After a suitability test, the crushed, recycled concrete material can also be used to create a crane platform. The reinforcement steel and steel components such as pre-stressed anchors, sheathing pipes and earthing strips are scrapped. Non-recyclable materials such as ducts and the like are disposed of.

8 Estimated effort

Estimation of the time required for dismantlement depends on the technology used.

Below, the estimated effort for dismantlement of an E-82 wind energy converter with a hybrid tower by means of segment separation with saw cuts is described as the first example. The dismantlement time is approximately 6 weeks. Idle times due to weather conditions or similar circumstances are not taken into account.

Week 1

- Installation of the crane, provision of all necessary materials and aids
- Carrying out further preparations, e.g. removal of the cables and fixtures
- Dismantlement of the rotor blades and the rotor head
- Dismantlement of the generator and the machine house
- Dismantlement of the steel sections
- Dismantlement of fixtures, such as power cabinets, transformers, switchgears or E-modules

Weeks 2 to 4

- Installation of the work platform
- Carrying out concrete saw work or any rework on the segments
- Lifting down the segments
- Dismantlement of the crane

Weeks 5 and 6

The foundation is reused.

- Blasting free the foundation
- Performing core boring operations
- Removing the prestressing tendons
- Blasting free the sheathing pipes

The foundation is demolished.

- Removing the foundation cover
- Crushing the foundation

As a second example, the dismantlement of an E-82 wind energy converter with a hybrid tower using a wrecking ball is explained. The dismantlement time is approximately 4 weeks. Idle times due to weather conditions or similar circumstances are not taken into account.

Week 1

- Installation of the crane, provision of all necessary materials and aids
- Carrying out further preparations, e.g. removal of the cables and fixtures
- Dismantlement of the rotor blades and the rotor head
- Dismantlement of the generator and the machine house
- Dismantlement of the steel sections
- Dismantlement of fixtures, such as power cabinets, transformers, switchgears or E-modules

Week 2

- Installation of the crane with wrecking ball
- Execution of demolition work
- Crushing of segment residues
- Removal and disposal of the demolished concrete
- Dismantlement of the crane

Weeks 3 and 4

The foundation is reused.

- Blasting free the foundation
- Performing core-boring operations
- Removing the prestressing tendons
- Blasting free the sheathing pipes

The foundation is demolished.

- Removal of the foundation cover
- Crushing of the foundation