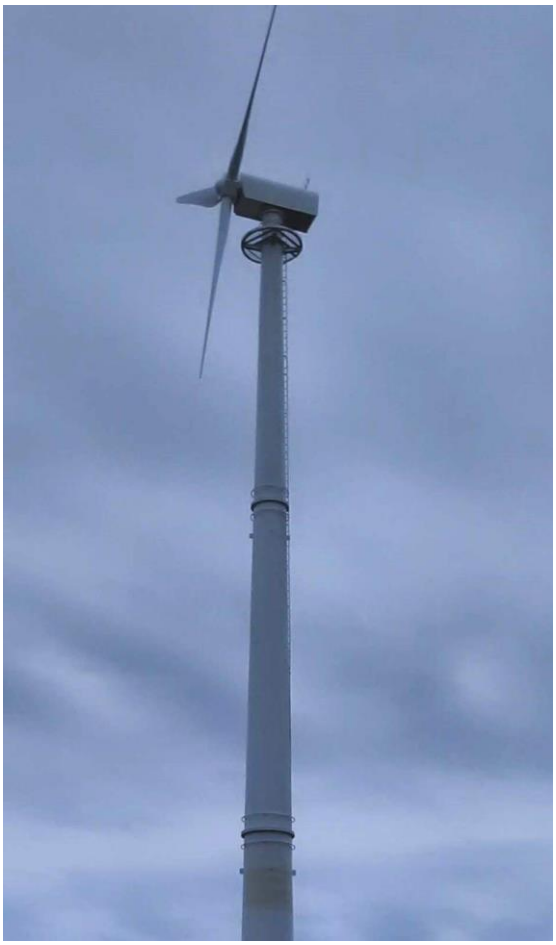
# TUGE60
## Small wind turbine technical specification

This document is for potential project developers that plan to include TUGE60 small wind turbine in scope of their project. This document contains more detailed description of turbine components and functions, as well as additional information that can be useful for project planning.



Rev.1.0

| Date (dd.mm.yyyy) | Version | Description |
|---|---|---|
| 01.02.2022 | 1.0 | Document created |
| 13.02.2024 | 1.1 | Document created |

# Contents

# 1. TUGE60 general specification

| TUGE60 | |
|---|---|
| Rotor axis direction | Horizontal |
| IEC SWT Class | II ($V_{ref}$=42,5 m/s, $V_{ave}$=8,5 m/s) |
| Rated power | 55 kW |
| Max power | 60 kW |
| Rated wind speed | 14 m/s |
| Cut-out wind speed | 25 m/s |
| Rated rotation speed | 56 rpm |
| Rotor diameter / area | 16 m / 199 $m^2$ |
| Blades | 3, fixed angle, upwind, stall control and tip-brake |
| Ambient temperature | -25…+40°C |
| Generator type | asynchronous |
| Grid connection | Direct with reactive power compensation |
| Grid parameters | EN50549 |
| Tower height | 36 m |
| Tower type | Steel, tubular tower with maintenance platform |
| Designed lifetime and maintenance interval | 20 years / 2 years |
| Data connection | GPRS or Ethernet (OrbiScada) |
| Brakes | Stall, electro mechanic failsafe rotor brake, tip-brakes |

Assumed Average Energy Production (AEP, Rev10)

| Yearly average wind speed m/s | Energy MWh |
|---|---|
| 3,5 | 24,6 |
| 4,0 | 40,1 |
| 4,5 | 58,2 |
| 5,0 | 78,3 |
| 5,5 | 99,6 |
| 6,0 | 121 |
| 6,5 | 143 |
| 7,0 | 165 |
| 7,5 | 185 |
| 8,0 | 205 |
| 8,5 | 223 |
| 9,0 | 241 |
| 9,5 | 256 |
| 10,0 | 271 |

The main parts of the wind turbine are foundation, tower and nacelle with rotor, electric panels and cables necessary for energy transfer and turbine control. Electrical yaw gear is used for turbine nacelle rotation. In addition, a mechanical brake of nacelle rotation is used to avoid excessive mechanical forces to the gear. The turbine rotation speed is constant, blade tip-brakes activate automatically when rotor

speed exceeds 15% of nominal speed and disengage when rotor speed drops to normal. Mechanical rotor brake is activated by control system or automatically with grid failure. All these methods allow for safe operation and control of the turbine.

# 2. Faulty operation

During any faults two things can happen according to the specific scenario:

Hard stop – generator is disconnected from the grid simultaneously with applying shaft brake to the rotor shaft.

Error list:

| Error | Conditions | Reset |
|---|---|---|
| Wind speed instant | 10 second average > 30 m/s | 10 minute average below 20 m/s |
| Wind speed average | 10 minute average > 25 m/s | 10 minute average below 20 m/s |
| Anemometer | Faulty measurement | Manual |
| Yaw | Yawing too long or too slow or no signal | Manual |
| Untwist | Over 3 turns in either direction | Auto |
| No brakes | 30 seconds of braking | Manual |
| Generator temp | Generator temperature > 120 °C | Automatic |
| Cabinet temp | Cabinet temperature > 50 °C | Automatic |
| Over speed | Rotor speed > 65 rpm | Automatic |
| Grid | Grid protection error | Automatic |
| Vibration | Vibration error | Manual |
| Manual stop | Manual input from emergency button | Manual |

# 3. Safety systems

Main danger to the turbine is from over speed events, when rotation speed is out of control. To prevent these, there are three separate systems to prevent that:

1. Special geometry of the blade that creates a stall effect and doesn't let rotor speed to grow over the limit. Special calculations were performed by blade manufacturer Olsen Wings (Denmark), and Denmark University of Technology (DDU).
2. Electromechanical rotor brake applies to rotor shaft and holds the turbine in place during danger. The brake is applied by default and is disengaged by the control system, so the rotor is always stopped during grid failure event.
3. Every blade has a special tip-brake that activates at certain speed (15% over nominal speed) – because of excessive centrifugal force tips of each blade rotate perpendicular to the wind and slow the turbine down. This is unique and time-proven technology of blade manufacturer Olsen Wings (Denmark).

Control system monitors for all other signals in the system (temperatures, position and sensor feedback) and acts accordingly in case of failure.

# 4. Turbine grid connection

60 kW asynchronous generator with 2-stage parallel shaft gearbox from Bonfiglioli.

Generated energy is fed to the grid directly via a thyristor coupling module, system includes two-stage reactive power compensation device. System can be adapted to any grid code using transformers and grid relays.

# 5. Control system

TUGE60 utilizes TMC3 controller from Orbital A/S (Denmark) as its main user interface.


Monitoring submenus:

- Wind speed, power, rotor speed, mode (manual or auto), system status and operation status
- Grid feed state and control status
- Grid voltages (three phase)
- Grid currents (three phase)
- Grid power (three phase)
- Grid frequency (three phase)
- Grid protection state, uptime and software version

- Grid protection fault bit status
- Grid condition bit status
- Grid protection bit status
- Operation mode (manual or auto), brake state and stop type
- Brake shaft output status, input feedback status, brake time and brake time peak
- Yaw vane type, operation state, timer, yaw direction
- Yaw brake output status and input feedback status
- Counters for CW and CCW direction, yaw encoder input status and yaw direction status
- Yaw position encoder counter, position in degrees, turns and on a bar graph
- Energy counter for grid feed
- Turbine error free run hour counter, error hour counter and availability in %
- Power averages for 1, 10, 60 and 600 seconds
- Power peak averages for 1, 10, 60 and 600 seconds
- Wind speed averages for 1, 10, 60 and 600 seconds
- Wind speed peak averages for 1, 10,60 and 600 seconds
- Rotor and generator rpm speed
- Temperatures for generators and ambient
- Temperature for electrical cabinet
- Time and date
- GSM, TCP and overall connection statuses
- Connection status, IP address and service status
- APN and TCP connection counters
- Software versions for main board of the controller, display, counter and thyristor
- Information GSM modem
- Modem transmit and read data
- Controller mainboard software and firmware versions
- Digital inputs
- Digital outputs
- Vibration bands
- Vibration band error status
- Vibration sensor state, status and software version
- Vibration sensor parameter, master and sensor CRC and CAN comm. counter

Control submenus:

- Motor-start, manual stop or reset the turbine
- Toggle main or auto mode, rotate clockwise or counterclockwise

More information and logging can be accessed if the client wishes to connect the turbine to the Internet by installing a SIM card in the built-in modem or providing Ethernet cable to the TMC-3 controller.

Turbine has an optional motor start feature, when turbine can be started as a motor during low winds, which allows bringing the cut-in wind speed down. This feature is available in automatic and manual modes.

Positioning is available due to incremental encoder in the yaw system, which allows avoiding cable twist.

Yaw system is made by IMO especially for wind turbines, consists of two motors and each motor is individually braked during times between yawing.

Temperature of generator, gearbox, ambience and control cabinet are being monitored. Rotation speeds of generator and main shaft are being monitored.

Wind speed is measured by mechanical anemometer (speed is indicative, precise measurement is impossible due to interference of rotating blades) and wind direction is determined with mechanical wind vane (black/white system).

Vibration sensor signal is constantly monitored.

# 6. Maintenance

Yearly – visual check of general condition.

Every 2 years –gearbox oil change and filling of the grease pumps.

# 7. Initial cost

Full set price according to the latest price list in EUR EXW Tallinn, Estonia.

Additional costs:

1. Transport
2. Foundation
3. Installation equipment and machinery
4. Civil and grid works and permissions

Useful resource for wind data assessment:

https://globalwindatlas.info