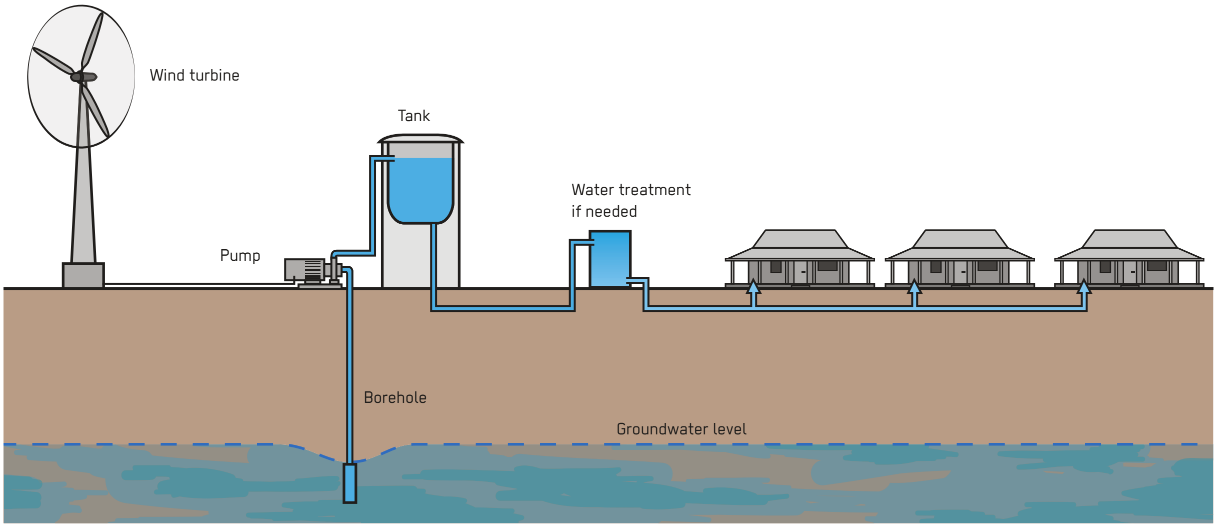
Wind-Powered Energy System

Response Phase Acute Response ⋆⋆ Stabilisation ⋆⋆ Recovery	Application Level ⋆ Household ⋆⋆ Neighbourhood City	Management Level ⋆ Household ⋆⋆ Shared ⋆⋆ Public	Objectives / Key Features Abstraction of water using wind power
Local Availability ⋆⋆ Medium	Technical Complexity ⋆⋆⋆ High	Maturity Level ⋆⋆⋆ High	



Wind-Powered Energy Systems use wind energy either directly (e.g. to mechanically move a pumping mechanism) or indirectly (e.g. to create electricity that can be used or stored). If it is not already present, this system is not well suited to the acute response phase, though may be a suitable option for more sustainable power in the longer term.

Wind energy can reduce the running costs of a water system. In a typical simple system, wind turns a turbine, often mounted on a tower, to lift water. This can consist of only a simple system to lift surface water short distances for irrigation, though it more commonly involves bringing groundwater to the surface via a pumping mechanism.

Design Considerations: Mechanical (direct) windpump systems work by physically connecting a bladed wind turbine directly with a mechanical pumping system (usually a positive displacement pump with pistons, **see A.2, A.4**). However, with this system, the borehole must be in an ideal location to capitalise on the wind speed and it can be difficult to match the power characteristics of the turbine with the type of pump, meaning power is not transferred efficiently at all wind speeds.

Wind-electric (indirect) pump systems that create energy to be stored are more efficient, using either direct current (DC) pumps or standard three-phase electric alternating current (AC) centrifugal pumps. AC pumps can be operated directly using power generated through a permanent magnet generator connected directly to the pump motor. Operation is possible as standard pumps can operate at variable speeds if the powering voltage and frequency also vary, which is the case here. With this system, the more efficient match in power requirements is advantageous (where the turbine and impellers in the pump have similar rates of increase in rotational speed), as is the ability to offset the pump from the turbine. However, an offset pump can suffer from voltage drops along longer lengths of electric cabling, though if the turbine receives higher wind speeds at the offset position, the extra power can compensate for cable losses for an overall favourable energy balance.

Some design considerations apply to both mechanical and electrical systems. Water is used as an energy store where more water is pumped on windier days, which can then be released into the system by gravity on days when the wind drops and pumping is less productive. For this to work, a storage tank should have the capacity to hold at least three days demand. As a standby option for low wind days, wells can also be fitted with a handpump **(see S.8)**. The maximum flow during peak wind conditions should be compatible with borehole design, where velocity across the screens should not exceed 0.03 m/s and where groundwater drawdown is still sustainable **(see I.8)**. As wind speeds increase with height above the ground surface, turbines are installed on towers. The exact height and site of the tower should ensure that the turbine is not obstructed, which means placing it so that the rotor is at least ten metres above and 100 metres from any surrounding trees and buildings. To prevent damage from over-rotation in winds over 13 m/s, turbines should be equipped with an automatic mechanism that furls the blades (turns them away from the wind) through various active or passive design measures. A manual override should also be included.

In addition to pumping water, wind energy can be used to generate electricity for other processes (e.g. certain water treatment systems) or that is fed to the grid. Energy can be stored using batteries (e.g. in hybrid systems that also use solar energy), though due to the cost, short lifespan and inherent energy losses that occur during battery storage, it is generally better to avoid batteries through a well-designed pumping system together with adequate storage.

Materials: Materials needed include the turbine, a supporting tower, pumping mechanism (which can vary), sufficient water storage to cope with wind fluctuations and, where they cannot be avoided, batteries.

Applicability: For wind to be a viable energy source, the location needs to have enough wind. A wind assessment is therefore needed, but care should be taken with interpreting local data, which can often be underestimated, particularly if meteorological stations are poorly maintained, as is often the case. Pumping type and wind conditions should be carefully matched. For mechanical pumps that are optimised for low wind speeds and that provide water on most days, the minimum average wind speed required is 2.5 m/s, while electric centrifugal pumps **(see A.8)** require an average of at least 4 m/s. Given this variability and the need for careful design, wind energy is not well suited to the acute response phase unless existing windpumps are functional. Wind energy is generally more suited to the medium- to long-term stabilisation and recovery phases.

Operation and Maintenance: Wind turbines can operate for long periods with little maintenance if the initial set-up ensures good lubrication of the gears and driving mechanisms and if the vanes and blades are protected against corrosion. Turbine blades and bearings should be checked and replaced at the latest every 10 years, which should outlast most emergencies. The pump usually requires more intensive O & M; the mechanical linkage between the turbine and pump, in particular, is responsible for around 40 % of all maintenance requirements. In addition, piston seals in the pump should be replaced every one or two years.

Health and Safety: Health and safety issues concern the safe design and construction of the tower structure. If battery systems are used, they should be in a place with restricted access to avoid electrocution risks.

Costs: On one hand, the capital costs of mechanical Wind-Powered pump systems are high, usually varying between 35,000 and 60,000 USD and up to 120,000 USD for a larger, community-level wind electric system (including storage and distribution). On the other hand, maintenance costs for mechanical wind systems are moderate (around 0.8–1.5 USD per person per year), which are comparable to other electric-powered systems. With this offset, wind electric systems can be a least-cost approach, such as where "m^4" (daily volume required in m^3 multiplied by pumping head in meters) ranges from 200–10,000, where the average annual wind speed at 10 meters is above 4 m/s, where other fuel-based pumping systems have proved problematic and where the electricity grid is more than 2 km away. Apart from financial costs, choosing a renewable source of energy has a much lower ongoing environmental cost, and like solar power, it should be a key (if not over-riding) design consideration.

Social and Environmental Considerations: Wind is a relatively untested resource, but ought to be uncontroversial – particularly as environmental awareness increases. In environmental terms, wind is a renewable energy source that reduces the need for energy derived from fossil fuels, thus reducing the system's carbon footprint and improving air quality. However, turbines may have an impact on migratory birds, depending on the size of the rotors, the height of the tower and the location of the windmill. In terms of social acceptance, turbines might be viewed as unsightly, and the noise from whirling turbines can be viewed as a nuisance for those living too close by, which however, may be less relevant in emergency settings.

Strengths and Weaknesses:

⊕ Uses renewable energy, a low-carbon energy option
⊕ Is relatively low maintenance

⊖ Requires larger storage requirements to compensate for intermittent power supply
⊖ Has relatively expensive initial hardware costs

→ **References and further reading material for this technology can be found on page 213**