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Effectiveness of small wind turbines in urban and suburban areas

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1 Introduction

The small wind power market features heterogeneous technologies, which promise solutions for different purposes like the supply of off-grid areas or converting buildings to electricity generators. Experience shows that especially the urban use of small wind turbines (SWT) needs to be assessed carefully. Even though the turbines are already on the market, the following determining question often stays unaddressed: Is the wind turbine able to meet its intended outcome of environmental friendly, renewable energy production? Furthermore, as a precursory requirement: Considering its whole life cycle, is the turbine producing more energy than it consumes?

Although these requirements seem fundamental, international studies [1] show that there are turbines on the market, which do not fulfil these requirements. There are none Life Cycle Assessments (LCA) published considering the turbines sold on the middle European market. Therefore, in face of the LCA results of international SWT studies, the question arises whether the use of SWT in middle European urban and suburban sites is energy effective and, thus, whether SWT can contribute to a sustainable energy transition.

2 Method

Life Cycle Assessments of two SWT were conducted. The LCA were structured according to ISO 414040 covering goal and scope definition, inventory assessment, impact assessment and interpretation. The software open LCA and the Ecoinvent database were used. Within the Impact Assessment the categories total energy demand and global warming potential (GWP100) were used. Further, the energy payback time was calculated. A cradle to cradle approach was used, hence the end of life treatment as well as the transport are included.

A horizontal axis SWT with 5 kW nominal capacity as well as a horizontal axis SWT with 500 Watt nominal capacity were examined including the turbine itself, the tower and the electrical system. The 5 kW turbine is mainly made of steel and glass-fibre composites and is using a neodymium magnet generator. The 500 Watt turbine is composed of a steel tower, wooden blades and a generator consisting of ferrite magnets and copper bobbins cast in epoxy resin.

Performance data are collected at suburban and urban sites. The 500 Watt turbine is installed on a suburban site close to Vienna and data of power production and wind speed are collected. At an urban site in Vienna, wind data are collected and will be used to calculate a fictive power production.

Using the inventory data of the two SWT and the production data of the two sites, energy payback and global warming potential is calculated.

3 Results and Discussion

Both turbines show to produce more energy than they consume when installed at suburban sites with good wind conditions (average annual wind speed of 3.92 m/s). The payback time showed to be between 3 and 10 years and is heavily depending on the wind conditions of the site. Other studies show similar results [2, 3]. Literature underlines the variation of payback times related to the turbines as well as the wind class the SWT are installed at. Even though, energy effectiveness is feasible within the life span of a SWT, which is assumed to be 15 to 20 years, the payback times are high compared to other renewable energy technologies like big wind turbines or photovoltaics [4, 5]. Some SWT show to not even reach energy effectiveness [1].

In urban areas in contrast, the wind conditions are unsteady and often show very low wind speeds. Therefore, considering the measured average wind speed of 2.35 m/s at an urban rooftop site, the question arises whether a rooftop SWT can be energy effective at all.

The impact assessment showed that the use of steel (especially for the tower) as well as the transport of the turbines are the main causes for energy consumption of the SWT as well as the related Greenhouse Gas emissions. The emissions showed to be between 27 and 115 g CO_2 eq. / kWh, which are comparable values to photovoltaics and rather high compared to big wind turbines [6].

In further research, the life cycle results will be integrated in a holistic technology assessment, considering ecological and safety issues as well as economic feasibility. First results show that SWT may be effective at windy sites in suburban areas, but seem to face serious problems in urban use.

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