Comparison of Small Building-Mounted Wind Turbines and Photovoltaic Panels

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Research information

Keywords

Small wind turbines, photovoltaic panels, rooftop retrofitting, cities.

Introduction / Context

Rooftops in cities are mostly underused. They are the last remaining bit of free space, and thus have a high potential for sustainable retrofitting. In this context, photovoltaic (PV) panels have proven to be a good solution to produce renewable energy. Meanwhile, the market of small wind turbines is increasing and several building owners are starting to install wind turbines on their rooftops. Some countries have begun to develop a specific legal framework for the installation of Small Building-Mounted Wind Turbines (SBMWT).

Question / Goal

That leads to the question of why owners would prefer SBMWT to PV panels. Moreover, in which rooftop scenario would SBMWT be more profitable than PV panels? To answer this question, we developed a program to study the Annual Energy Production (AEP) and the Levelised Cost Of Energy (LCOE) of PV panels and SBMWT installed on a rectangular and flat rooftop. Through several graphs, this poster summarises the comparison of AEP and LCOE for both systems. These results take part of a bigger research. We want to develop a tool which determines the best rooftop retrofit solution. This solution may also combine several rooftop installations.

Hypothesis / Methodology

The AEP is evaluated for both systems for an increasing rooftop surface (Figure 1). In these simulations, we considered both systems to be of high quality in order to compare them on the same level playing field. The chosen wind speeds are common on rooftops of high-rises in Brussels. The AEP of the wind turbines has been calculated according to the norm IEC-61400-12-1[1]. The AEP of PV panels is determined considering a high performance ratio (PR) and a good efficiency[2].

$$AEP_{PV} = G_T \times A_{PV} \times \eta_{PV} \times PR$$

Where G_T is the annual solar irradiation [kWh/m^2], A_{PV} the surface of PV panels [m^2] and η_{PV} the efficiency of the solar panel [%].
The LCOE is also evaluated for both systems for an increasing rooftop surface (Figure 2)[3].

$$\text{LCOE} = \frac{I_O + a \times A_{OM}}{a \times M_{t,el}}$$

Where I_O is the investment cost, a the annuity factor, A_{OM} the annual cost for operation and maintenance and $M_{t,el}$ is the annual produced quantity of electricity.

Results

A setback distance between turbines has been adopted to avoid any wind disturbances. This explains why the energy production of the turbines is constant until a new turbine can be installed on the roof.
The reduction in LCOE for increasing roof surfaces is due only to economies of scale. This causes the drops of LCOE for the turbines.

Conclusion

We have shown that, for several rooftop surfaces and/or wind speeds, SBMWT can have a higher AEP and a lower LCOE than PV panels. As a consequence, PV panels should not always take priority over SBMWT when one considers to produce renewable energy on rooftops. In fact, combining both may lead to even better results and will therefore be the focus of future work.

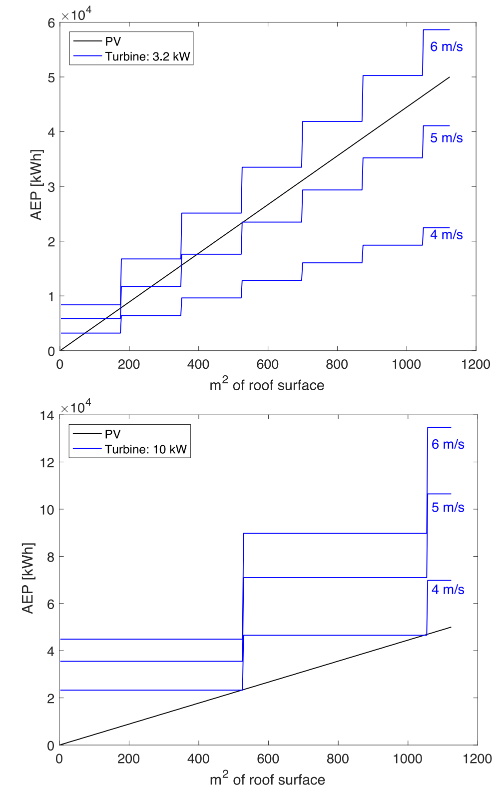

Fig. 1: AEP comparison between photovoltaic panels and small building-mounted wind turbines. The blue lines represent the AEP of the wind turbines at several wind speeds and the black line represents the AEP of the PV panels. Top: We observe that rooftop having high wind speeds could be more suitable for SBMWT. Bottom: The 10 kW wind turbine, even at lower wind speed, performs better than the PV panels. In general, one can say that a wind turbine is a good option when the surface of the roof is limited.

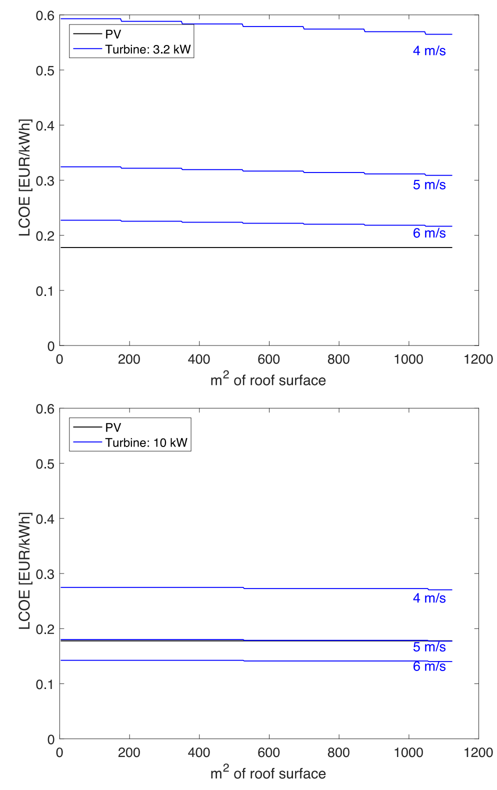

Fig. 2: LCOE comparison between photovoltaic panels and small building-mounted wind turbines. The blue lines represent the LCOE of the wind turbines at several wind speeds and the black line represents the LCOE of the PV panels. Top: at every wind speed, the 3.2 kW turbine is less profitable than the PV. Bottom: Above 5 m/s, the 10 kW WT is more profitable than PV panels.

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