Recent and future trends of onshore wind turbine foundations

Jesús Armesto Barros, Alexandre Mathern

NCC, Gothenburg, Sweden

Contact: jesus.armesto@ncc.se

Abstract

The decarbonization of the economy and the growing need for electricity are two trends that call for greener energy sources. Wind is a growing renewable energy source, which is expected to become the first source of power in the European Union in the next decade. In particular, onshore wind energy is expected to double by then. Fundamental structural components of wind turbines are their foundations, which are large structures associated with important material consumption and many construction challenges. The dimensions of these foundations are continuously increasing as turbines with taller towers and larger rotor diameters are being built. Designing cost- and material-efficient foundations is crucial to reduce the economic and environmental impact of wind energy. An important factor to successfully address these evolving requirements in the planning and design process is to build on the experience from previous projects. The aim of this work is to investigate the evolution of onshore wind turbines and its consequences on the design and climate impact of gravity foundations by analysing data from Swedish wind farms set in operation between 2013 and 2022. The evolution of turbine size, and foundation dimensions, reinforcement layout, material types and quantities, and embodied carbon are analysed in this paper.

Keywords: Wind energy; wind turbine foundations; reinforced concrete structures; structural design; construction; environmental impact.

1 Introduction

Wind energy is the energy source associated with the lowest greenhouse gas emissions during the life cycle of the facility [1]. It has become one of the cheapest energy sources, with a price ranging between 39 €/MWh and 121 €/MWh, to be compared with prices for energy produced from gas and coal, which range between 78 €/MWh and 290 €/MWh (prices based on German locations as of 2021) [2]. In addition, while wind energy costs are lowering as the technology matures [2][3], costs for energy produced from fossil fuel are expected to increase as CO_2 emission rights get more expensive in the future [2].

Consequently, wind energy is expected to have a key role in the development of renewable energy and electrification for decarbonization of the European Union (EU) in the coming 30 years, growing to produce 50 % of its electricity [3]. In fact, wind is expected to become the first source of power in the EU already during this decade [3].

Sweden's installed capacity represents 5.5 % of EU's capacity. With 10.0 GW it is the fifth country in the EU with most installed capacity (only behind Italy, France, Spain and Germany). Considering all Europe, Sweden ranks sixth (with only the UK having a higher installed capacity besides the previously mentioned countries) [4]. Onshore wind accounts for 98 % of the installed wind power capacity in Sweden, and offshore wind for the remaining 2 % [4].

Sweden produced 27.5 TWh from wind during 2020 [5]. The installed turbines, capacity and