Faculty of Engineering

MCG 2101

Introduction to Design of Mechanical Systems

Design project A: Aeolus new wind turbine

Context

Renewable energy sources are increasingly popular not only in Canada but also internationally. In particular, wind power capacity in Canada has experienced a fast increase since 2007 and its trend keeps being positive (see **Figure 1**).

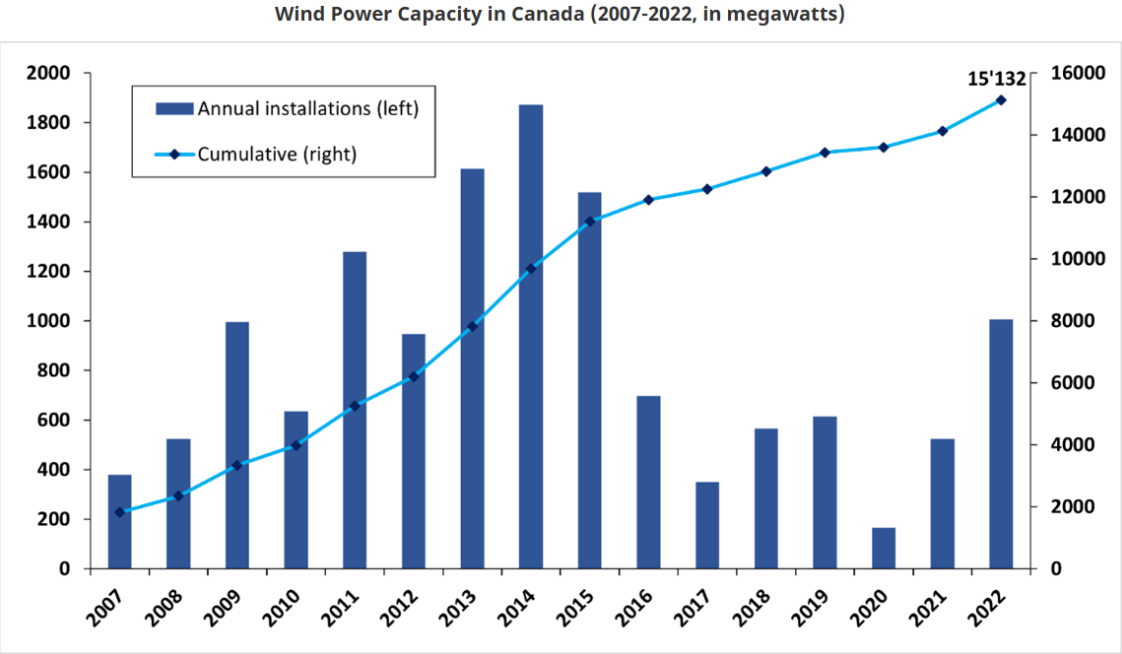

Figure 1: The bar chart displays annual installations of wind power capacity in Canada since 2007, in megawatts. The curve shows the rapid increase in cumulative capacity from 1,846 megawatts in 2007 to 15,132 megawatts in 2022. Source: Natural resources Canada.

In this project, you will play the role of a consultant company specialized in the design of mechanical systems. Your client is the company Aeolus, a Canadian manufacturer of small-scale wind turbines. This is a relatively new company in Canada (6 years in the market) with some experience in extremely small wind turbines with power below 10 kW. They are interested in the development of a new product with larger power and hired you to help them with the design of some particular components to be described below. In the following section you will find

additional details of the request made by this company. Take the following section as a direct communication from Aeolus CEO.

Aeolus request

We are interested in the development of a new product consisting of a small-scale wind turbine (nominal power between 10 kW to 100 kW) intended for residential or farm applications for Ontario clients. We believe that multiple clients may be interested in investing in independent energy conversion systems to profit from the net metering system available in Ontario or in remote areas where extending the electric grid may be too expensive. Although other products exist in the international market, we think that they are not well adapted to the Ontario market which is what we intend to do with this new product. These are the minimum requirements we need you to consider for your design:

1. We would like to develop a robust product that can work efficiently under the **variable wind velocity conditions** found in Ontario and capable of dealing with the challenging **weather conditions** of this province.
2. Since we are aiming at both farm and residential clients, we are concerned about keeping the **noise** of the wind turbine and all its components at minimum. Please note that we do not mean a wind farm but an agricultural farm as our potential customer.
3. It is also important to make this product with **minimum energy losses** and thus maximize electricity generation.
4. It would be ideal to make this product using **materials available in Ontario (or Canada)** so we can use this property for marketing purposes in the future.

The consideration of these factors in your design is essential for us as they will be key elements to strongly position our product in the market and develop a sustainable business. We will also appreciate any further considerations you may have from your end to develop a product of high quality to satisfy the exigent market of Ontario clients.

Here we describe the product that we have in mind and the specific parts where we seek for your help considering your experience with mechanical system design. **Figure 2** shows the basic components of a stand-alone wind turbine as we intend to develop. We note that we have purposely kept the design as simple as possible to give you the freedom to use your imagination and propose any modifications you estimate convenient. The main components are: a mounting tower (1), a rotor consisting of blades with aerodynamic surfaces (2), a velocity matching system (3) that matches the rotor speed with that of the generator/alternator (4), an enclosure or nacelle (5), and a tailvane or yaw system (6). We are considering a height of the tower holding the wind turbine to be between 24 and 37 m high. We have experience in the development of similar wind turbines with power below 10 kW which do not require a velocity matching system. Here we are interested in the development of a horizontal axis wind turbine with power between 10 kW and 100 kW. Therefore, we request your help to the design of the gearbox that will allow us to develop this new product considering all the aspects mentioned above. We have not decided on the specific generator/alternator yet as we expected you could recommend one based on your design of the gearbox. We hope that with your innovative design of the such velocity matching system, its enclosure (nacelle), and the recommended generator/alternator we can directly

connect to the rest of components including the rotor with blades, tower, and tailvane.

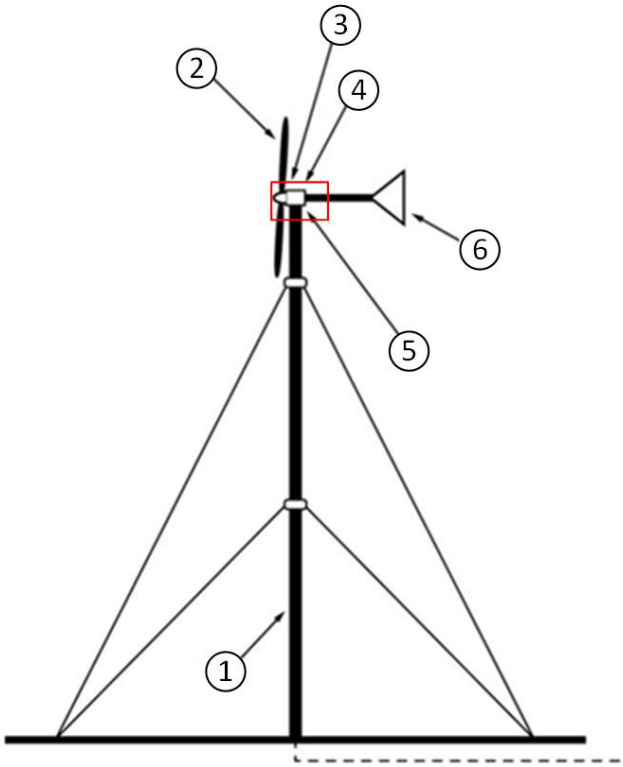

Figure 2: Components of a stand-alone wind energy system, including the electronic portion. Source: Stand-Alone Wind Energy Systems, Natural Resources Canada.

Important considerations

This project will be carried out step by step all along the winter term. By the end, you will submit a complete and detailed design including the requested velocity matching system and its nacelle. Please note that you do not need to design the generator/alternator but the design of your nacelle should include the right amount of space to incorporate such an element. Also note that you **do not need to design additional components of the wind turbine** including its rotor, blades, tailvane and tower. However, your design must certainly take them into account to be ensembled together.

By the end of this project, you will **submit a report** and make an **oral presentation** where you will explain how your design addresses all the concerns of the Aeolus company.

The system that you will design must be purely mechanical – you can use pneumatic/hydraulic switches if needed, but everything else must be enacted by mechanical components only. Similarly, you cannot simply propose a commercially available design as it will not meet the requirements of the Aeolus company.

Although there are some design considerations not mentioned by Aeolus, that are expected from professional engineers which is the role you play in this project. This includes health and safety as well as environmental considerations. Of course, making a realistic design that could be

manufactured by machine shops in Ontario and that Aeolus can use to obtain profit from selling the new product is essential.

Development of your concept must be based on the methodology steps discussed in class. The concept must reflect the work that you will do then, and the conclusions that you will reach, working in teams, going through these steps.

You must present an assembly drawing featuring enough orthogonal projections ('2D views'). The assembly drawing hardcopy must be produced on a large sheet (minimally A1 for example) or in pdf format if you worked with a CAD software. On the assembly drawing, your main parts must be identified with numbers that also appear in a list of parts on the drawing. Your assembly drawing must be presented on a single sheet. Use of color is not advised; 2D views must be drawn in black only. Use different line types for axes, hatching (when needed), etc. following rules discussed in class. You may use isometric projections ('3D views') showing all or part of the assembly in the report – along with renderings – to discuss your design and its operation. However, limit the number of isometric projections and avoid renderings in your assembly drawing.

YOUR ASSEMBLY DRAWING MUST ENABLE COMPLETE & QUICK UNDERSTANDING OF THE CONFIGURATION AND OPERATION OF YOUR CONCEPT, USING ONLY REASONABLE EFFORT AND NO GUESSING. THE DRAWING MUST MAKE PERFECTLY CLEAR HOW THE CONCEPT IS BUILT, AND HOW IT WORKS.

As discussed in class, the number of views required is left to your good judgment but must enable good understanding of the concept, its operation and its construction. You can, if you wish, add A LIMITED NUMBER OF FEW 3D views. However, the drawing must be complete. It is expected that you will do most of the design working in teams, out of class hours.

A SolidWorks file is optional and appreciated – however, submitting the drawing is mandatory as it is the drawing only that will be marked. SUBMITTING ONLY SOLIDWORKS CAD FILES WITHOUT A PDF ASSEMBLY DRAWING AS DESCRIBED HERE = A MARK OF ZERO FOR THE PROJECT, WITH NO EXCEPTIONS.

Online resources

Below is a list of online resources that may have important information to consider for your design. By all means, you are expected to do your own research.

American Wind Energy Association (AWEA) www.awea.org
Bergey Windpower www.bergey.com
Canadian Wind Energy Association www.canwea.ca
Canadian Wind Energy Atlas (CWEA) www.windatlas.ca
CANMET, Natural Resources Canada www.nrcan.gc.ca
Distributed Wind Energy Association www.distributedwind.org
Electrical Safety Authority (ESA) www.esasafe.com
Independent Electricity System Operator (IESO) www.ieso.ca
Intertek www.intertek.com

National Renewable Energy Laboratory www.nrel.gov/wind
Ontario Ministry of the Environment and Climate Change, Renewable energy approvals www.ontario.ca/page/renewable-energy-approvalsOntario
Wind Smith www.ontariowindsmith.com
Ontario's Renewable Energy Atlas www.gisapplication.lrc.gov.on.ca/REA/Renewable.html?site=REA&viewer=REA&locale= en-US
RETScreen International www.retscreen.net
Small Wind Certification Council www.smallwindcertification.org
Small Wind Electric Systems — A U.S. Consumer's Guide www.nrel.gov/docs/fy07osti/42005.pdf
Small Wind World Report www.wwindea.org
Stand-Alone Wind Energy Systems, Natural Resources Canada, www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/canmetenergy/files/pubs/WindEnergy_buyersguide_ENG.pdf.
U.K. Microgeneration Certification Scheme, www.microgenerationcertification.org
Wind Energy Institute of Canada www.weican.ca
Wind Market Report www.energy.gov/eere/wind/downloads/2014distributed-wind-market-report
Wind Works www.wind-works.org