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[1.] Jihen EL KHALDI, [1.] Omaima BEN AMARA, [1.] Oussama Mansour KHORCHANI,
[2.] Mohamed Fathi KAROUI, [1.] Mohamed Najeh LAKHOUA

# ANALYSIS, SYSTEM MODELING AND SUPERVISION OF A WIND TURBINE

[1] University of Carthage, Carthage School of Engineering, Department of Electrical Engineering, Research Laboratory Smart Electricity & ICT, SEICT, LR18ES44, 45 Entrepreneur Street 2035 Charguia II–Tunis–Carthage, TUNISIA
[2] University of Carthage, Tunisia Polytechnic School, Department of Electrical Engineering, Research Laboratory Smart Electricity & ICT, SEICT, LR18ES44, V8HP+VXW, El Khwarizmi Street, Archaeological Site of Carthage–Tunis–Carthage, TUNISIA

**Abstract:** We must switch to renewable energy sources to meet our growing demand for energy while also doing our part to protect the environment. Subsequently, a straightforward yet effective description for wind turbine system modeling and supervision must be provided. The purpose of this paper is to present the functionality and the behavior of a wind turbine, so we present a model of wind turbine in first phase and supervision of this system in the second phase using the system the modeling language and Siemens software.
**Keywords:** Wind turbine, systemic modeling, SysML, supervision

## INTRODUCTION

These days, a growing reliance on electricity has resulted in an unabated rise in the global energy demand. As this is going on, fossil fuels that are the main source of energy production — use limited, non–renewable resources that will eventually run out. Furthermore, their availability is already declining, driving up costs, or their retrieval is causing increasing environmental harm. We must switch to renewable energy sources in order to protect the environment and meet our growing demand [1]. Discovering that humans have been using natural phenomena like sunlight and wind for the same kind of productivity purpose for centuries may surprise you.

Gathering wind energy is one of the alternate methods of producing electricity [2–3]. But since ancient times, this latter has been utilized to supply mechanical power for tasks like grinding grain or pumping water. However, for more than 1.200 years prior to the Industrial Revolution of the 18th century, the only power generators available were windmills and water–driven mills. Later, Denmark, France, Germany, and the UK carried out step–by–step system evolution and perfection of these technology [4–5].

While wind energy collecting is not a novel concept, modern countries mostly rely on fossil fuels to meet their growing need for electrical energy. However, the sustainability of the energy supply, rising demand, and environmental concerns have captured interest in renewable energy sources like wind turbine systems throughout the last decade years of the 20th century.

In this study, we offer a high–level graphical description based on SysML diagrams to comprehend the entire functioning of the wind turbine system.

This paper's outline is as follows. After un introduction, section 2 provides an overview of wind turbine generating systems. SysML for systems modeling in Section 3. In section 4, we show our model and system supervision through a functional, structural, and behavioral description of a wind turbine using SysML diagrams. Finaly, we concluded and present prospects in section 5.

### Wind Power System

Wind energy has reemerged between the most crucial sustainable energy resources, in part for it is pollution–free, with no greenhouse gas or heat pollution. Furthermore, wind energy is an unpolluted, durable, free, and renewable source that will never run out [6–7–8].

A wind turbine is a device that uses the wind's kinetic energy to generate electricity [9–10]. There are double types of wind turbines: horizontal axis (HAWTs) and vertical axis (VAWTs) [11].

Wind turbines are constructed in a variety of modest and big sizes [12–13]. The smallest turbines are utilized for applications like charging batteries for supplemental power in boats or RVs, as well as powering traffic lights. Slightly larger turbines can be utilized to contribute to a residential power supply while selling excess power back to the utility provider via the electrical grid [14–15].

Smart grids are electrical grids based on decentralized renewable energy generation like wind energy, solar energy, hydroelectric energy, biomass, and traditional thermal energy production as an emergency energy source if the renewable energy production does not meet with the demand [16–17]. this type of grids utilizes modern communication means (Internet of Things, Bluetooth,...) between all components of the grid which make them easy to detect malfunctions and program maintenance before the problem can evolve and helps with the demand expectation and the billing process, the communication part of the grid are presented in what's called smart meters which communicate and transfer all the data needed to the grid supervisor–operator which make this type of grids more convenient compared to traditional grids [18–19].

In order to better comprehend and analyze the complex structure of wind turbine systems, we will introduce one of the tools for modeling complex systems, SysML, in the following sections. We will then use it to provide a model of a wind turbine system, and finally we will present its supervision.

## SYSTEM MODELING LANGUAGE SysML

Many languages already include the Structured Analysis Design Technique (SADT), standard fundamental analysis tools (APTE, FAST, and GRAFCET) [20–21].

SysML diagrams can be classified into three categories [22–23]:

- Diagrams representing requirements of the system (requirements diagram) and physical restrictions (parametric diagram).
- System structure diagrams, including internal block and block definition diagrams.
- System behavior diagrams (use case, sequence, activity, and state machine diagrams).

There are also many others modeling methods like:

- Petri Nets: is a method of system modeling and presentation which is based on states and transitions, there is many derivatives of this method like the Coloured Petri Nets.
- OOPP: Oriented Object Project Planning is a method of system modeling which mainly used to analysis complex projects.
- Bond Graph: a type of graphical model of a physical and dynamic system which we trying to design or represent.

After providing an overview of SysML, this language is used in section 4 to acquire a high–level graphical representation of the operation of a wind turbine system. These descriptions describe the interactions and flow of data and control between system components, which is required to understand the overall operation of the wind turbine and then to provide a supervisory application [24–25].

## RESULTS

### RESULTS OF WIND TURBINE MODELING

In this section, SysML is used to offer a basic yet effective description for modeling wind turbine systems. In fact, we give a functional model with a use case diagram (See figure 1). The requirements diagram follows as a complement to functional modeling (See figure 2).

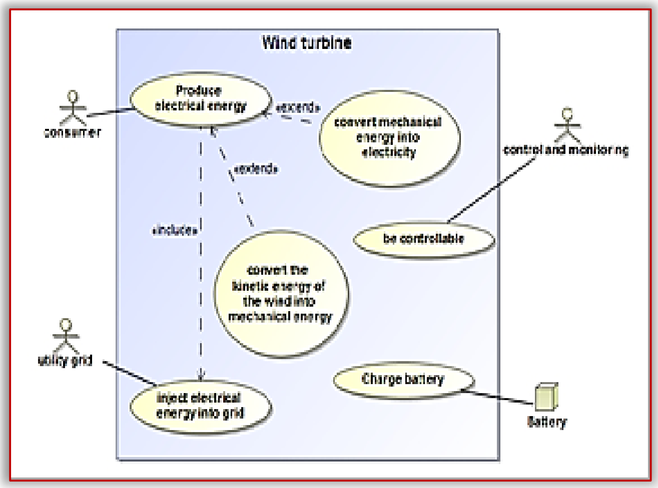


Figure 1. Use case diagram.

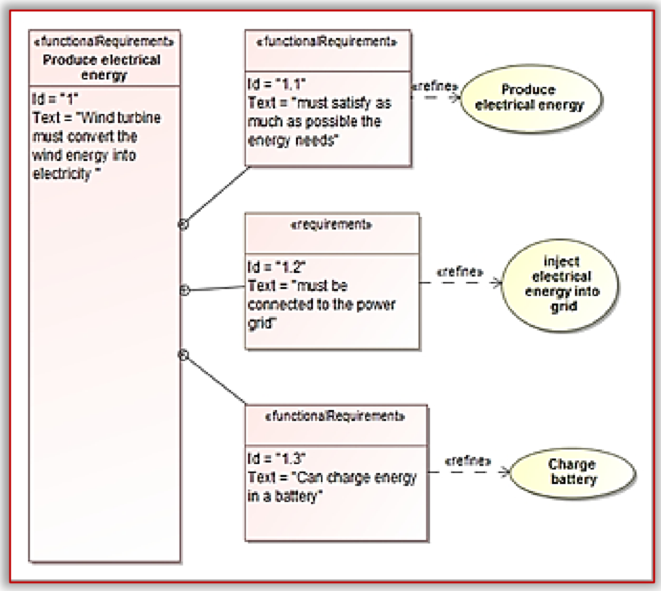


Figure 2. Functional requirement diagram.

## RESULTS OF WIND TURBINE SUPERVISION

The supervision of the wind turbine is assured using the Siemens 2700 controller, this controller is presented in the figure 3.

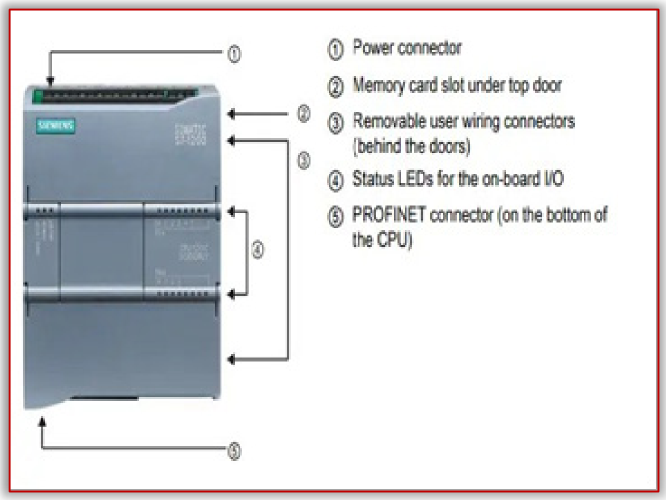


Figure 3. S7–1200 controller

This controller has a microprocessor, integrated power system, integrated inputs, and outputs, an integrated PROFINET, high speed data acquisition and delivery through the outputs and inputs and analogic inputs integrated on this controller.

First, the figure 4 present the detection of wind direction.

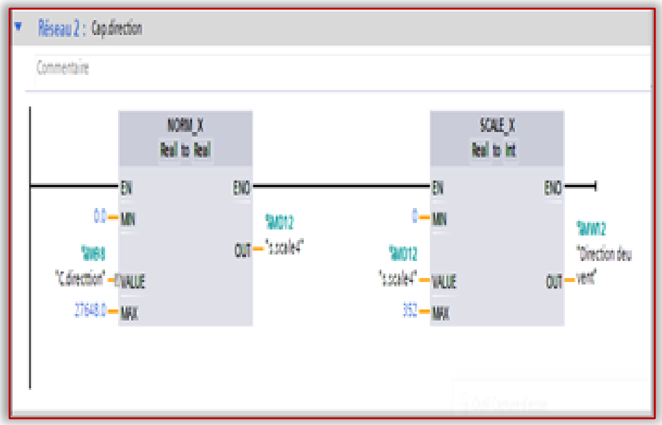


Figure 4. Wind direction data detection

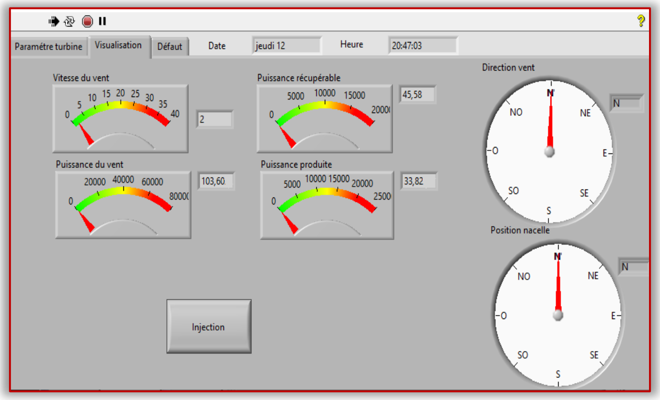

Figure 5. Man Machine interface

After the detection of the wind direction the wind turbine must change direction to the most suitable in order to get the maximum energy generation from the wind and here there are multiple engines which help with the turning the turbine to the desired direction.

Figure 5 depicts the man–machine interface of the wind turbine system.

## CONCLUSION

In this work, we introduced the graphical modeling language SysML for systems engineering, then we used it for modeling the functionality of a wind turbine system. These descriptions depict the interactions, flow of data, and control amongst system components that are required to comprehend the wind turbine's overall performance and ensure system supervision.

Starting with this case study of wind turbine analysis, modeling and supervision on the base of the systems modeling language SysML and Siemens software presented in this paper, work is underway to establish wind system simulations.

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