COMMUNICATION SKILLS
Master of Science in Computational Mechanics
Master Métodos Numéricos en Ingeniería

CONTRIBUTION OF COMPUTATION TECHNIQUES ON COST REDUCTION OF WIND ENERGY PLANTS

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Abstract. This document provides information and instructions for preparing an extended abstract for the course *communication skills*

1 INTRODUCTION

As modern machinery industry seeks greater challenges while keeping costs low and weight light, complex simulations are more often included in their design methods. At the same time computation techniques have seen important improves during the last decades. However, latest reports of wind energy costs show that development and engineering costs remain around 2% of the total capital cost.

2 BACKGROUND

Wind turbines are an example of that due to their big, slender structures and complex topologies that require remarkable engineering efforts including accurate loads' computation multibody tools coupled with specific loads' models and controllers.

However, recent reviews [1] show that capital costs of such devices are dominated by manufacturing and installation costs, whereas engineering and development take just around 2% of the capital cost for land-based wind turbines and around 3% for offshore wind turbines. Figure 2 shows the distribution of capital costs for a land-based offshore wind turbine and Table 2 shows a comparison of the Levelized Cost of Energy (LCOE) for two reference land-based and offshore wind turbines. Some bibliography exist that also reports higher operation costs due to frequent and expensive failures with long down times [2].

The low development and engineering costs turn into a limited use of computation methods and technology by development departments of wind turbine manufacturers. Although during the last decade, perhaps alongside the technological leap associated

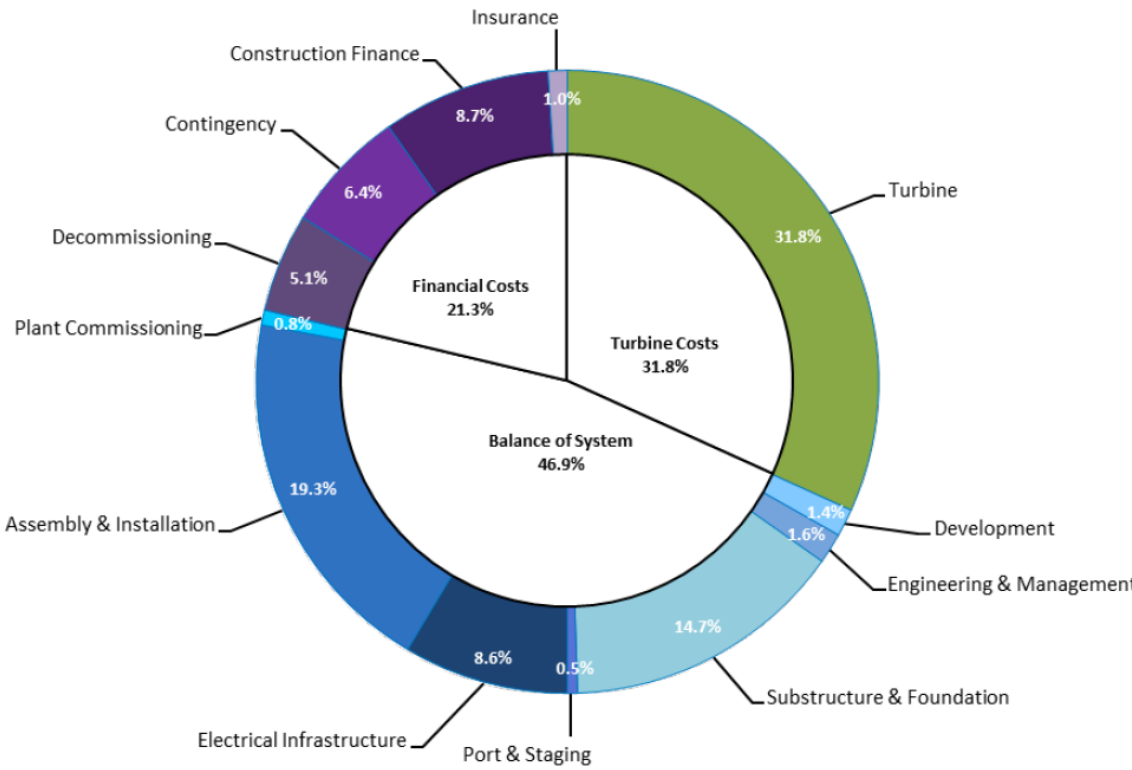

Figure 1: Capital expenditures for fixed-bottom offshore reference wind plant project. Source: NREL

Table 1: Summary of land-based and fixed-bottom offshore reference project

	Land-based WT (reference 2.0 MW) ($/kW)	Offshore WT (reference 4.14 MW) ($/kW)
Turbine capital cost	1209	1466
Total capital expenditures	1690	4615
Operational expenditures	51	179
Total LCOE ($/MWh)	61	181

to the first offshore plants, some important contributions have been incorporated from other disciplines and industries, the state of the art of computation techniques in wind energy still lags behind other more mature industries like helicopters, railway or oil and gas. For instance, loads computation models are far more simple than those used in aerospace industry, optimisation is almost absent from development departments and key code development is often seen as outsourceable matter.

3 A NEW APPROACH

However, a number of computation techniques that lay beyond the industrial state of the art, are currently ready and available. Most of these technologies are developed by the academia and many are seldom incorporated by the industry. Big inertia of research and the particular tempos of the industry favour the lag between the two worlds. That is the case of, new computation, optimisation and statistical techniques and other artificial intelligence methods.

Loads computation is a paradigmatic case of this technological delay. Loads computation teams of wind turbine manufacturing companies face a huge amount of computation effort as the number of load cases required by certification firms increase year by year. The higher complexity of modern wind turbines and their more slender structures require a better computation of loads that ultimately contribute to a smarter use of materials and other resources, therefore laying in the core of the cost reduction strategies. The state of the art of numerical models used are simplified, linearized models of structures subjected to complex and refined unsteady aerodynamic loads' models. It is unrealistic to try estimate how many wind turbine failures, most of them in the drive train, are caused by a poor loads estimation but it is also evident that the many ways to avoid them need to start with an accurate computation of loads.

On the other side, an alternative, more accurate flexible multibody approach, first formulated by Cardona [3], includes a non-linear Beam element that naturally takes on account mechanical phenomena such as gyroscopic effect, rigid stiffening and others that have an important contribution to loads on structures. This approach is more computationally expensive but was early embraced by helicopter industry whereas it is only recently and slowly being introduced in wind energy.

In addition, the amount of computation power accumulated in companies and in the cloud that may be used in parallel computation schemes suggest that a technological leap is now ready for the industry. Currently wind energy companies have engineering departments with around 1000 engineers and their cost are only the 2% of the capital cost.

Taking a look to evolution of the cost of energy of wind energy plants it is easy to identify the innovation impact of breakthroughs such as pitch control, individual pitch, increase of rotor size, etc. A new approach in complex machinery design, increasing the development budget with an aim to reduce overall cost of energy, seems after all a reasonable objective for the following decade and may have a leading role in the future breakthroughs in this industry.

4 CONCLUSION

The relatively small development and engineering costs in the wind industry, together with the technological delay with respect to other industries and the poor use of advanced technologies developed by the academia suggest that increasing the development budget my lead to an overall reduction of LCOE both in the capital costs and operational costs.

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