

# A PERSPECTIVE ON COSTS AND COST ESTIMATION TECHNIQUES FOR ORGANIC RANKINE CYCLE SYSTEMS

Sanne Lemmens<sup>1\*</sup>

<sup>1</sup>University of Antwerp, Department Engineering Management,  
Antwerp, Belgium  
sanne.lemmens@uantwerpen.be

\* Corresponding Author

## ABSTRACT

The potential of organic Rankine cycle (ORC) systems is acknowledged by both the considerable amount of ongoing research efforts and the increased occurrence of its applications in practice. A large share of research in this field strives to improve ORC systems by analyzing the performance of various cycle architectures and numerous working fluids. These technical feasibility and optimization studies are at the core of ORC development. Yet, when it comes down to considering practical instalments the economic feasibility of the project is often decisive. Complementary to research efforts on these technical issues this paper approaches the matter from an economic point of view. The costs-dimension of ORC systems is discussed from various perspectives. First of all, this paper provides a brief review of literature knowledge on ORC investment costs. Technical publications on ORC development increasingly include estimates of the costs associated with the system design, but knowledge on actual ORC module and project costs remains scarce. Secondly, this paper takes a closer investigation into the methods used to estimate ORC project costs from the bottom up and the expected accuracies associated with these estimates. Finally, these insights are used to estimate the costs of a known ORC system applied for waste heat recovery. The comparison of the estimated and the actual specific investment costs confirms the existence of a wide accuracy range. The purchased equipment costs obtained with the bottom-up estimate diverge from the actual costs by almost 44% and the deviation leads to differing interpretations on the share of equipment items in the total purchased equipment costs. The results of this analysis are not generalizable since only one real-life study is used for comparison. The main conclusion of the paper is to be cautious when interpreting estimated ORC plant costs.

## 1. INTRODUCTION

The interest for organic Rankine cycle (ORC) systems is growing increasingly. The concept of using an organic fluid instead of water dates back from right after the invention of the Rankine cycle in 1859, yet it was not until the 1960s and 1970s that ORC technology got more prominent research attention. By today, ORC systems constitute a flourishing research field and its practical possibilities have been proven. The reasons for this success are manifold. Rankine cycles operate with organic fluids, which allows conversion of energy sources in much lower temperature ranges than suitable for conventional steam cycles. ORCs can generate electricity from energy sources such as geothermal wells, biomass, solar and oceanic sources and industrial waste heat. Hence, ORC systems have potential to generate electricity from renewable energy sources as well as to enhance industrial energy efficiency. Both are essential in the transition of energy sectors to more streamlined, efficient, secure and climate-friendly systems. Research on ORC systems is very technical in nature and includes i.a. architecture design and optimization (e.g. Chen, Goswami, and Stefanakos (2010); Lecompte, Huisseune, van den Broek, Vanslambrouck, and De Paepe (2015)), the quest for suitable working fluids (e.g. Hung (2001); Lakew and Bolland (2010)) and the design of new expander types (e.g.