

# Software Technology for Autonomous Energy Systems

## Background

Currently, the need for clean energy has increased as a result of the Danish Energy Agreement aiming for 55% renewable energy in 2030 and the Paris Agreement aiming for a net-zero-emission in 2050. These objectives result in less use of fossil fuels, however, also increases the strain on the power infrastructure. This is the result of the increasing use of electric vehicles, heat pumps, energy cartridges and solar power cells [6]. Digitizing the energy grid is important as it will greatly benefit the utilization of the current energy grid, however, is also necessary due to future needs. Currently, it is estimated that the grid cannot withstand the new needs from the consumers and the production of renewable energy as it will overload the grid[2]. Intelligent use of energy could minimize the strain on the grid by implementing demand-side flexibility where smart charging (bidirectional) or district heating is a possibility[4]. Upholding the availability is critical when digitalizing the energy grid. Currently, the energy grid has an uptime of 99.99%, which in software would be defined as a high availability system. A digitized optimization and actuation of the grid would have to uphold the same uptime in order to provide power for critical institutions in Denmark[2].

## Aim

The multi objective multi issue optimization framework Controleum will be refined into a high-performance, high availability cloud solution, capable of supporting a wide variety of multi objective problems in various domains. The refined version of Controleum will be used for an application to optimize the distribution of power via objectives such as: providing enough power, distribute the power fairly in peak hours and not overburden the grid in the process. The system will have to integrate with the existing power grid and receive inputs from multiple grid entities. The final application will contribute towards the digitalization of the danish energy grid.

## Objectives

- ▶ A refined version of the Controleum framework functioning in a cloud setting
- ▶ An application utilizing the Controleum framework to optimize energy distribution
- ▶ Monitoring and management tools for analysis of the running Controleum services
- ▶ Investigation of mechanisms to ensure high availability, security and performance for Controleum

## Methodology

The refinement of Controleum will be meticulous in order to secure the highest quality of software. The result will be evaluated by an extensive collection of metrics inspired by the ISO 25000 standard[5] and metrics presented by Visser J.[7].

The project will employ a literature review to gain insights into the problems faced when operating within the domain of energy infrastructure. This will provide insights into the key software qualities and requirements for the optimizing application utilizing Controleum. This application should be able to optimize the distribution by integrating grid entities through a digital representation of producers and consumers, including demand side flexibility[3].

Experimentation will be used to identify the algorithm best suited to optimize within the energy domain. The experiments focus on availability, security and performance in order to accommodate the cloud nature of the system[1].

## Project Period

Start date: 1 September 2020  
End date: 31 August 2024

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