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Defining the key requirements for an energy storage selection decision support tool for homeland defence installations

Background

Global decarbonisation and the pledge to achieve zero carbon dioxide emissions by the year 2050 in the European Union is a problematic target to meet. To meet this goal, the burning of fossil fuels as an energy source will cease. Thus, the renewable energy generation market is transforming and rapidly growing as the demand rises for clean energy.

Renewable energy generation is a variable energy source with unpredictable long-range forecasting. Intermittent energy generation from renewable energy sources requires an energy storage system to store energy during times of low demand and release energy at times of high demand with low production. Energy storage systems are vital in enabling successful renewable energy production and building resilience in energy supply networks.

This CF SEDSS research study investigates the key requirements for an energy storage selection decision support tool. The tool should enable the user to select an appropriate energy storage system matched to their application. To define the key requirements, energy generation and storage technologies needed to be reviewed.

Problem Analysis

Energy storage systems will play a critical role in decarbonising and breaking the reliance on fossil fuels. All European countries are reducing their reliance on fossil fuels by boosting renewable-energy outputs, whether this is through wind, solar or some other type of renewable energy sources. The intermittent nature of these renewable energy sources (RES) makes energy storage systems vital to the success of green energy generation. However, during times of low renewable energy generation, previously stored excess energy should be called upon to meet the energy demand.

This study is the initial step in building an energy storage selection tool, which will give the user a clear indication of what energy system would best suit their application and requirements. This study aims to define the key requirements for selecting an energy storage system. Choosing the most appropriate energy storage solution could help reduce carbon emissions and dependence on civilian power grids and increase resilience and business continuity.

There is no singular energy storage system that suits all applications. Applications vary from low-energy applications to energy-intensive applications. Those with higher energy demands which require more energy-dense storage systems may be better suited to hybrid storage.

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Methodology

- Conduct a literature review of academic papers, scientific journals, and published works of creditable data that will provide the source of information.
- Categorise and analyse suitable energy storage systems identified by the literary review.
- Conduct a brief analysis of renewable energy generation systems.
- A questionnaire has been sent to the members of the WG-2 on RES and its results have aided in this study's final direction.
- Categorise the data into qualitative properties; this categorical data will become the building blocks of a decision-making tool.
- Develop a process logic map to include key questions that need to be answered when selecting an energy storage technology.

Solution Implementation

1. **Identify available renewable energy generation systems and storage options.** Energy storage systems have been reviewed under the following technologies:
   - Thermodynamic
   - Mechanical
   - Electro-chemical
   - Electro-magnetic
   - Hydrogen technologies

2. **Identify key requirements for developing a decision support tool.** The key requirements have been developed in a manner that will allow for referencing and correlation from the database of reviewed technologies.

Results

The main objective of this study was to define the key requirements for an energy storage selection decision support tool for homeland defence installations. **In this regard the tool should:**

1. Be Software-based.
   - Fuzzy logic, the Pugh matrix, or the multi-attribute utility theory should be used to select a suitable storage system. This type of reasoning is suited to software.
2. Allow the user to select their preferred type of renewable source input.
3. Be able to pull information from other sources of online information, such as running internet services, Rest APIs, IoT commands, Rest, Post Soap, etc.
4. Be able to reference database information such as Annex A of this report (a Microsoft access sheet).
5. Be able to select from multiple storage systems performing analysis for the best outcome based on the users' input.
6. Present the key attributes of the energy storage system in this report as part of the information contained in its selection for the storage system.
7. Be able to run PDF reports on the findings from the user inputs.

Opportunities

A fully-fledged software tool should be developed to assist the user in identifying suitable energy storage systems. The Pugh matrix or the multi-attribute utility theory should then be used to identify the most suitable storage system from the database or the utilisation of Fuzzy logic. The most likely solution may be utilising a mixture of both.

Consideration should be given to the level of impact protection needed for a storage system that is to be used in harsh environments by the MoD.

Traditional financial evaluation methods for energy and carbon-reducing projects are becoming outdated. Energy and carbon reducing projects are becoming projects of necessity rather than projects that provide a return on investment. Financial evaluation should put more emphasis on the cost, not in monetary but in environmental terms, as well as the cost to humanity.

Energy-intensive applications, such as mobility and transport, require high energy density from their fuel source. Power-to-gas solutions fit well with energy-intensive applications, and hydrogen appears to be the leader of the available systems. There are, however, other gaseous elements like ammonia and methanol gaining significant traction in the alternative fuel source market and should be, equally with hydrogen, investigated as an alternative to diesel for heavy energy-intensive applications.

A collaborated approach to hydrogen storage projects in the areas of application set out by the study is required. A centralised repository of the data collected by the projects will help inform the MoDs for future applications.

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