Systemigrams for PESTEL Analysis of an Offshore Windfarm System

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***Abstract*—As energy transition is ongoing, many companies are looking for new opportunities in new markets. Offshore windfarm systems, especially those with large-scale hydrogen storage functions, have become an important part of the global energy transition. Companies often use PESTEL (Political, Economic, Social, Technological, Environmental and Legal) Analysis to get a macro picture of an industry environment when deciding whether to join an opportunity. However, the PESTEL Analysis analyzes each aspect one by one, often missing their interdependencies. This makes it more difficult to discover all relevant factors; moreover, the results of the PESTEL perspectives may not be well integrated. In this paper, the authors use Systemigrams as a tool to integrate the individual perspective from PESTEL aspects into a holistic understanding of an offshore windfarm system for Faroe Islands. Using this tool, management can gain a comprehensive understanding of a renewable energy system for the Faroe Islands that will inform their decision on whether to bid for the project.**

Keywords-system thinking; PESTEL Analysis; Systemigrams; offshore windfarm; Faroe Islands.

I. INTRODUCTION

This section includes three parts: first, the background of the case project; second, explaining what the PESTEL Analysis is; thirdly, the case system introduction.

A. Background

The Faroe Islands is one of the world's leading producers of renewable electrical power, with 50% of its electricity is derived from renewable energy sources. The other 50% comes from fossil fuels. Denmark aims to become 100% independent of fossil fuels by 2030 [1]. Fig. 1 shows that the Faroe Islands are located in the North East Atlantic Ocean, where the average wind speed is above 11 m/s from October to April [2]. This is ideal for producing clean renewable wind power. However, in June and July, the wind speed drops below 8 m/s, which means that a hybrid system is needed to balance the low wind season.

An offshore windfarm system is being developed to help the Danish government to achieve the goal by 2030. A project team has been developing the concept, and the next phase is convincing the company`s management that it is the ideal solution and using the concept to bid the project. During the project, the team focuses on a holistic approach that includes the Political, Economic, Social, Technological, Environmental and Legal aspects of the system of interest.

Figure 1. Location of Faroe Islands [3]

B. PESTEL Analysis

A PESTEL Analysis is an analysis of the external macro environment (big picture) in which a business operates. These are often factors which are beyond the control or influences of a business, however, are important to be aware of when doing product development, business or strategy planning [4]. It is important to understand that all external factors of the environment need to be checked and identified before making a decision. PESTEL Analysis allows to determine and analyze the key factors of change in business environment [5]. The PESTEL aspects are shown in Fig. 2.

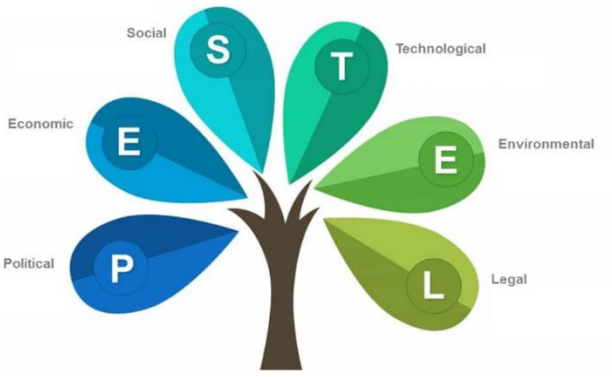

Figure 2. PESTEL aspects [6]

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- Political aspects refer to the influences from the government. They include all the policies, laws and restrictions.
- Economical aspects have a major influence on how organizations run business and how profitable they are [5]. they include the taxes, duties, exchange rates, cost of living and Gross Domestic Product (GDP), etc.
- Social aspects refer to the size and growth rate of the population, immigration rates, lifestyles, education levels, and attitudes regarding investing, etc.
- Technological factors have become a huge influence for organizations in assessing and listing issues that could have a potential impact on its operations and that could be critical to its long-term future [5].
- Environmental factors relate to the influence of the surrounding environment and the impact of ecological aspects [5]. They include the weather, environmental policies, climate and support for renewable energy, etc.
- Legal aspects include, for example, employment laws, health and safety laws, taxation, etc.

It is very important to understand the offshore windfarm project from the PESTEL aspects` perspective. However, the results of the PESTEL perspectives may not be well integrated. In this context, it is necessary to apply a system thinking approach to integrate these perspectives into a comprehensive view of the offshore windfarm system.

C. Offshore windfarm system for Faroe Islands

The offshore windfarm system is a sustainable renewable energy system that uses offshore wind energy to generate electricity and extract green hydrogen from seawater. The system will supply electricity to the Faroe Islands without interruption year-round, making the Faroe Islands 100% fossil fuel free by 2030.

The system includes a wind turbine system, an electrolysis system, a hydrogen storage system, a fuel cell system, and a seawater treatment system. When the wind is active, the power from the wind turbines is fed directly to the grid. During periods of excess electricity available, electricity will be used to split water into hydrogen, which will be stored in storage tanks onshore, with a portion of the hydrogen distributed to transport fuel and another portion of the hydrogen converted into electricity again when there is no or low wind. An overview of the system is shown in Fig. 3 [7].

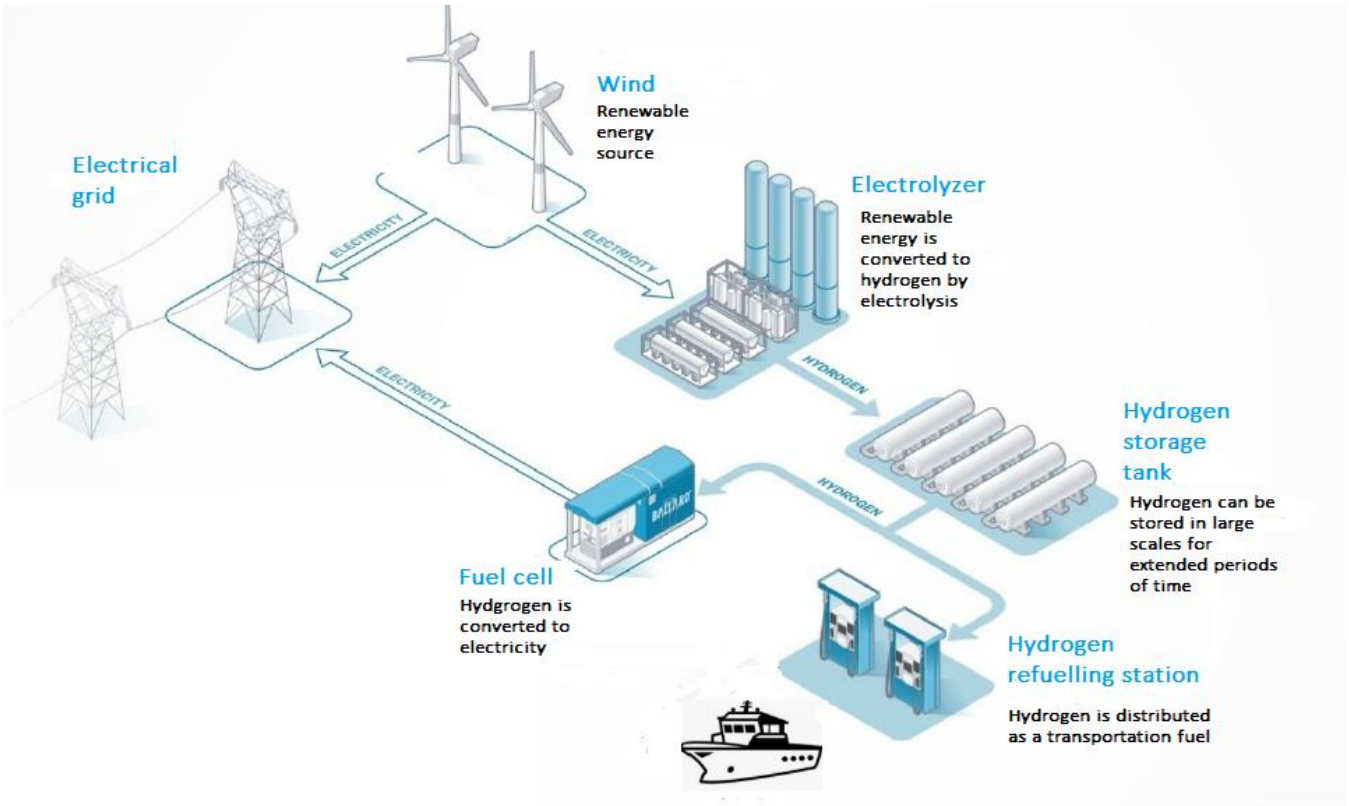

Figure 3. Offshore windfarm system overview

II. SYSTEM THINKING APPROACH

In this section, the purpose of using Systemigrams is explained. Then, we describe how Systemigrams are used to integrate the PESTEL aspects of the Faroe Islands offshore windfarm system, and thereby address project challenges and opportunities.

A. Systemigrams

Systemigrams provide a powerful tool for the analysis of systems first described in written form. Using Systemigrams to integrate the PESTEL, especially considering the interdependencies between sub-aspects, is very useful for a project to establish a holistic view of the system. Because PESTEL Analysis analyzes all aspects one by one, a Systemigram can provide a verification platform that helps analysts ensure that all relevant PESTEL aspects have been discovered. All individual aspects can be integrated through a Systemigram. This can provide a common basis for group discussions [8] and presentation to the management.

Fig. 4 shows the Systemigram of the offshore windfarm system in terms of PESTEL. From top left to bottom right is the mainstay, which is the purpose of the system. This renewable energy system will be able to produce electricity and hydrogen for consumers year-round. This will make the Faroe Islands 100% independent of fossil fuel. Furthermore, the PESTEL aspects are developed around the mainstay and are categorized by different colors.

- Blue represents political aspects. The political situation in Denmark and the Paris Agreement will both be considered. For example, the Danish government`s goal of having green energy supply all electricity in the Faroe Islands by 2030 shows the Danish government`s support for the Paris Agreement. In addition, tax laws such as the CO2 tax are DKK (Danish Krones) 173 per ton of CO2 [9]. From this, we can conclude that this system will help to save huge CO2 taxes compared to fossil fuel systems.
- Economic aspects are shown in light green. The most important economic parameters of the system are CAPEX (Capital Expenditure), OPEX (Operating Expenses), and Consumables [6] that make up the energy cost. The cost is high, however,

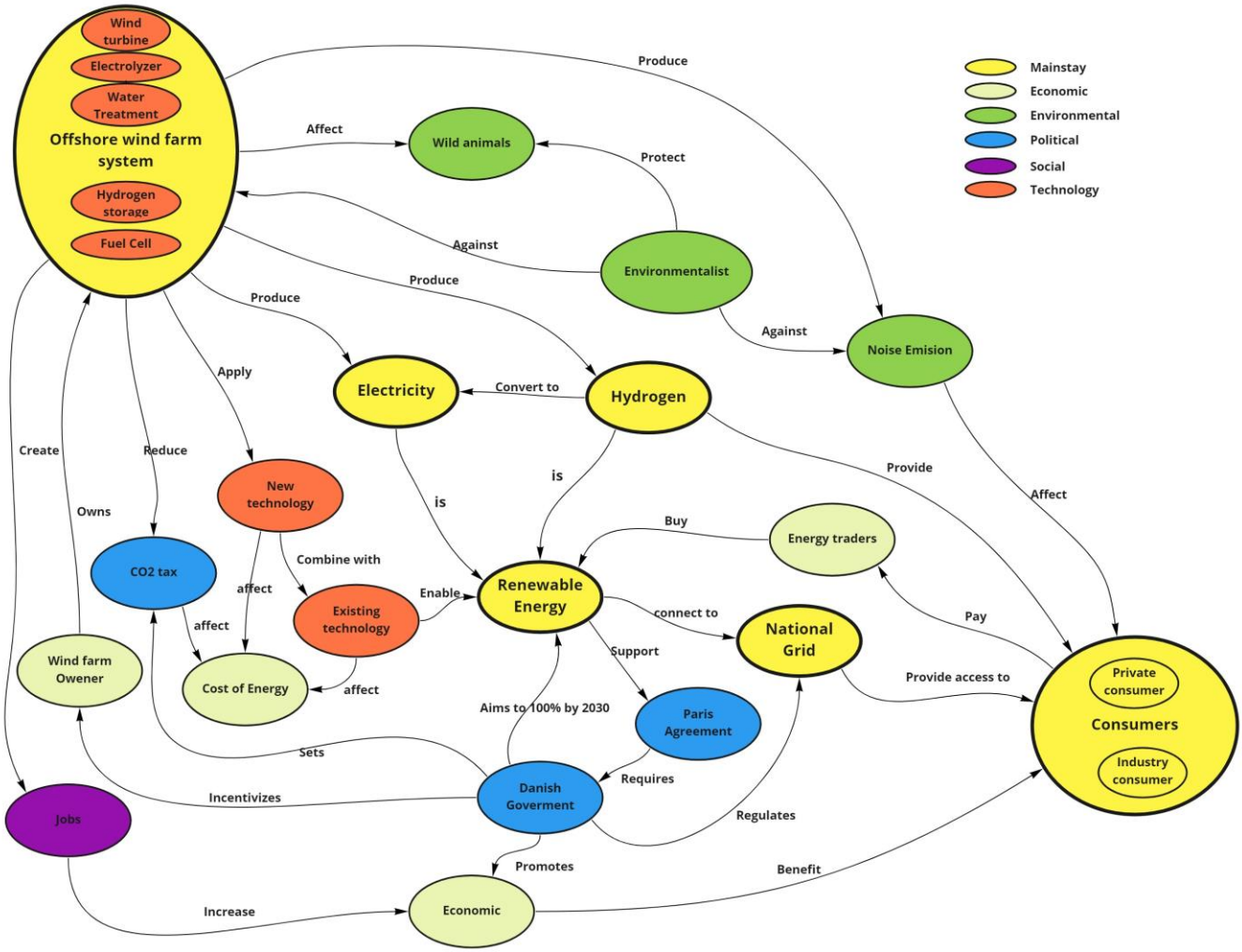

Figure 4. Systemigram of offshore windfarm

the Danish government will incentivize the renewable energy project, which will lower the project`s costs. At the same time, the CO2 tax impacts the cost significantly.

- The system will combine the existing technology with the new technology. Offshore windfarm is expected to be existing technology, as several large-scale offshore wind farms have already been deployed in the UK. However, due to the explosive nature of hydrogen, hydrogen storage presents significant risks. This requires new technology to improve it. Furthermore, since the location is new, some new knowledge input may be required during installation. These will affect the cost of energy. Despite that, using new technologies will increase the efficiency of the system, thereby increasing the output of energy. On the other hand, new technologies will make the system safer and have less impact on the environment.
- The project will create job opportunities for the local community, thereby increasing the local economy. This will benefit the residents who are consumers of the system.
- Environmentalists are normally against the windfarm project because wind turbines take up the space where the wildlife lives. However, there is clear evidence that this energy source is much safer than other methods. In addition, weather conditions will be considered as an important aspect of the environment. As mentioned earlier, wind speeds in the Faroe Islands are ideal for wind turbines all year round except in summer.
- All operations and activities follow Danish regulations.

B. Challenges and opportunities

The current challenge for the project is that the initial cost of the system is higher than traditional energy sources, and new technologies can lead to overruns. Meanwhile, there are still some impacts on local wildlife. But it is also full of opportunities, for example, this project will provide the Faroe Islands with a stable supply of renewable energy. The hydrogen will be able to balance electricity consumption throughout the year, in addition to fueling ships. Because of this project, Faroe Islands to be seen as a pioneer in clean energy. The company also will become a pioneer of the offshore windfarm system with large scale hydrogen storage and has a great opportunity to get more projects.

III. CONCLUSION

In this paper, a system thinking approach as a Systemigram has been applied to an offshore windfarm project to integrate individual PESTEL aspects into a holistic view of the system. At the same time, the opportunities and challenges have also been addressed. These will make the presentation to management more convincing.

Further application of Systemigrams in every aspect will be more in-depth. A Causal Loop Diagram will be created for the system of interest and the balance of dynamic forces will be examined.

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