RENEWABLE AMMONIA PRODUCTION FOR AGRICULTURE AND SUSTAINABLE ENERGY: PROSPECTS AND CHALLENGES IN GLOBAL FRAMEWORK

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Abstract

In the current study, analysis and observation have been made to generate the current value for renewable ammonia production. It has been observed that renewable ammonia is generated through solar, and wind renewable sources which contribute for cut off environmental hazards. Even the operation is linked with 2050 Net zero carbon emission as a load of industrial processing is noticed on the environment. The concept and the sources of production of renewable ammonia are analysed and discussed. The uses of renewable ammonia for agriculture and sustainable energy field has been analysed to identify potential opportunities and challenges. Data analysis has been performed in global framework for renewable ammonia production and their development has been reviewed. Regional and country-specific data has been included to understand the impact for the upcoming future. The observation-specific future scope has been specified in the study.

Keywords: Renewable ammonia, Sustainable energy, Agriculture, Ammonia production.

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1. Introduction

In the current study,a discussion has been developed about the flow of renewable ammonia production ina worldwide aspect. Identifying value for market growth is 17 million in 2021 which is just get enhanced with the upcoming 2030. The predicted value for the upcoming renewable ammonia market is USD 5,415 million (Mukelabi et al. 2022). Growth of CAGR is expected at 90.2%. Developing discussion has been about what actual renewable ammonia is and the potential deliverable advantages and challenges for the specific sustainable energy and agriculture sector. Selecting two specific sectors makes the scope of managing the discussion for a specific aspect basis. Understanding the scope of this development future scope of generating stability and performance stimulation is recognised and discussed.

2. Problem Statement

Examining the area that can produce the eventual border for renewable ammonia production is very basic whichthe initial cost for investment is. Evaluating the value per ton ammonia production is near about USD 1300-2000 (Cesaro et al. 2021). Comparing the value between natural gas plants and ammonia gas plant is 1.5 times higher. Looking at the reason for causes the higher cost is thatrenewable ammonia production is associated with natural gas which makes 75% responsibility of operation costs increase. Even the cost of electrolysers is also increasing that makes the concern for the operating cost increasing

3. Research Aim and Objectives

Aim:

Current research is aimed at analysing the engineering opportunity of renewable ammonia production in agriculture and sustainable energy production.

Objectives:

- To analyse the worldwide opportunity gaining scope through the increased production of renewable ammonia.
- To analyse the role of renewable ammonia is playing in the field of agriculture for opportunity generation.
- To analyse the impact of renewable ammonia production in the development of sustainable energy production.
- To analyse the existing challenges that are posed for agriculture and sustainable energy from the increasing production of sustainable ammonia.

4. Literature Review

4.1 Overview of Renewable Ammonia

Renewable ammonia is produced through renewable energy sources that include wind, solar and hydro. As per Palys and Daoutidis (2020) it is one of the cleaning processes of renewable ammonia production that works for a different solution like agriculture fertilizer, energy sources and transportation fuel. The use of a sustainable source for ammonia production always makes the chances for generating a better scope of sustainability generation that works for different alternative needs from which the scope of support delivering for the needs of agriculture and sustainable energy is developed. The presence of a lower carbon footprint and reduced emissions makes the future scope for industrial uses.

4.1.1 What is Renewable Ammonia?

Knowing the basic underline fine differences between ammonia and green ammonia it has been evaluated that ammonia is the production of carbon-free and 100% renewable processing. Now knowing the different production processes is there that is continuously making an impact involving the process of electrolysis. Smith and Torrente Murciano (2021) mentioned that if the production process is looking through the applied Haber process it can be observed that the reaction of hydrogen and nitrogen is performed together for which there is the need for higher pressure and temperature presence for making the production maximum. Throughout the process of developing renewable ammonia production, it needs to be understood that there is the production of carbon dioxide needs to be reduced. The target of reaching net zero emissions is plannedfor 2050.

Evaluating the ammonia produced amount of CO_2 production is near about 0.5 gigatonnes and the chemical sectors are continuously releasing 15-20% which makes concern for the future scope of generating ammonia production (He et al. 2019). With the concept of renewable ammonia, it has been noticed that there is developing scope for cutting off the emission rate and a chance for future stability is generated through the use of renewable energy production.

4.1.2 Sources of Renewable Ammonia

One of the sources for the production of renewable ammonia is the hydrogen that is processed through water electrolysis in which power generation is done by alternative energy sources. Jiao and Xu (2019) stated that from the existing process that is used for renewable ammonia production, it has been noticed that 1-tonne hydrogen and water of tonnes are combined to produce 33.6 million ammonia is produced. The ratio of water and hydrogen stimulates the rate of production of the required amount of ammonia. The hydrogen production process is sometimes for making renewable ammonia production at the maximum rate. Identified variety of sources like wind, water, and sun are considered as the source of renewable ammonia production.

4.2 Uses of Renewable Ammonia in Agriculture

Reduction of environmental hazards through the activity and cultivation of agricultural firms by renewable ammonia is noticed. It has been noticed that repeated emissions of CO_2 and other substances make the stimulation for the affecting surroundings and bring impact climate change. Costs and the need of replacing the importation for making agriculture production well-structured use of renewable ammonia are useful for the agriculture field (Lim et al. 2021). The importance of renewable ammonia makes the impact supporting the growth of plants that can be usedinthe agriculture field. Minimum need makes the benefits for reducing the cost structure growth for agricultural field use.

4.2.1. Benefits of Renewable Ammonia for Agriculture

Examining the scope of using renewable energy production it has been noticed that different aspects are there for incorporation in agriculture and sustainable energy. It needs to understand that cultivation pressure is enhancing due to the need of importing fertilizer. It can be resolved with the use of renewable ammonia production that can make the influences for the required fertilization applied. As per Palys et al. 2021) even the cost gets cut off when the ability of production stimulation is possible for the industry. Replacing the need for N-fertilizers chances of developing the application of renewable ammonia is possible.

Reduction of the impact of the environmental footprint from the agriculture field has been observed and there is a need fordecarbonization. The process of leading to this aspect of reducing the pressure or threat of climate change can be resolved with the help of renewable ammonia production. It needs to be understood that larger emission control for greenhouse gas is possible asan alternative to the application of fertilizer for agriculture. Before the concept of leading the ability of CO_2 production cut off it has been noticed that 1.8% of emission is responsible for agriculture field. The use of renewable ammonia can make a significant impact on environmental contribution.

4.2.2 Potential Challenges

Costing repeatedly causes concern for integrating issue facing. It has been recognized that compared with solar and wind resources are lower pricing than renewable ammonia. Even the pricing structure is the notice for $900/t (Sagel et al. 2022). The energy conversion rate and the integration cost both seem to be a conman for the plan of integrating an agriculture firm.

Table 1: Different Market Outlook (Rouwenhorst et al. 2019, pp.301)

Involved types of equipment	Capacity	Capex ($M)
Wind plant	17Mw	20,000
Solar plant	10MW	9,500
Air separation unit	6.5 $MtNH_3$	1,200
Water desalination plant	12.6Mt	8
Electrolyser	14.2GW	14,700
Ammonia plant	6.6 Mt	1,400

4.3 Uses of Renewable Ammonia in Sustainable Energy

From the perspective of considering it as a source of energy generation, it has been observed that there is a ratio upward direction. Con tribute market share from this production of renewal ammonia is approximately 13%

higher from 2021 (Rouwenhorst et al. 2019). The most vital factor for which the need of continuing the production is arranged is to deliver carbon-free ammonia production that provides the base for preparing sustainable energy production and the scope of power generating rate increasing is possible through the use of renewable ammonia sources. The use of alkaline water electrolysis for the expected production development is noticed.

4.3.1Benefits of Renewable Ammonia for Sustainable Energy

As per Rahman and Wahid (2021) evaluating the responsibility of the shipping industry for the production of environmentally hazardous emissions it has been recognised that 3% GHG is released. Even the condition of higher diesel consumption and the fuel used in shipping makes the need for altering the usage. Most shipping uses practices of crude oil and heavy fuel oil. 2050 target of reaching the maximum goal of adopting safety and higher production can be achieved by using alternative ammonia sources. With this perspective, renewable ammonia makes the way of improving the chances of 25% higher efficiency build-up in maritime fuel by using this alternative source.

4.3.2 Potential Challenges

The main concern for integrating these potential benefits of renewable ammonia is because of the limited available knowledge for uses. Technical challenges arise through the associated process that is involved in the production of renewable ammonia including electrochemical and photochemical synthesis. Without having the proper knowledge and capability to handle technical processes the chances of wasting the scope and minimizing the chances of better production of renewable ammonia are raised. It needs to be understood that investment security is developed only when proper technical skill and knowledge of handling the process is there for the use of renewable ammonia.

5. Methodology

The current research study has been developed in descriptive form as there are questions that need to be resolved by further data gathering. Research objectives specific data gathering has been done through secondary data collection. Renewable ammonia production has been analysed to collect and evaluated global data and specific representation has been made through accurate graphs and tables. Quantitative data analysis techniques have been used to ensure the data gathering for the knowledge gathering regarding the use of renewable ammonia for agriculture and energy field.

6. Data Analysis

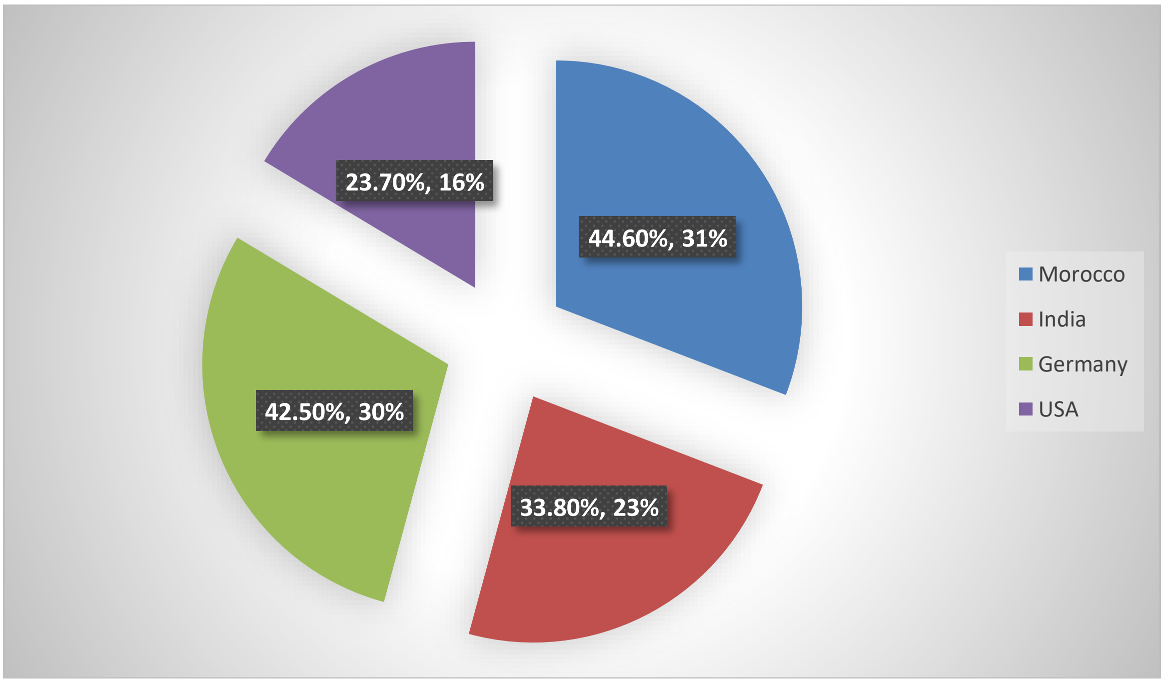

Figure 1: Investment Comparing Renewable Ammonia Production (Rouwenhorst et al. 2019, p.301)

From the existing paper review, it has been already established that renewable ammonia production is increasing. Now the need of looking for country-wise different contributions is considered to reflect the influences of giving importance to renewable ammonia production. It has been noticed that Morocco is already investing 44.60% compared to the highest for these four considering countries (Brown 2019). For Germany, it has been noticed that there is only 42.50% investment which is comparatively high but the USA is still now in under developing stage and recognises investing value as 23.70%.

Table 2: Comparing the Differences in Renewable Ammonia production (Macfarlane et al. 2020, p.291)

Country name	2018 Renewable ammonia production (tonnes)	2020 Renewable ammonia production (tonnes)
Germany	1700	2,800
China	37,290	45,000
India	3,000	14,000
Canada	1,200	4,000
Egypt	1,000	3,300

From the above figure, it has been observed that in 2018 and 2020 the production rates are reflecting the awareness and the growing practices for the use of these alternative energy sources. As per Macfarlane et al. (2020), it has been observed that working withnewer opportunities of using renewable ammonia 1700 tonnes is produced by German that convert into 2,800. It shows that growth optimization is done through the use of processing renewable ammonia production. 1,100 more production is happening in Germany just because of the developing target for 2050 net carbon zero emissions. Next is China that which are producing 37,290 in 2018 which increased up to 7.7% within 1 year. Reached value of China's renewable ammonia production is near about 45,000. For India that increased production is recognised for 11% which makes the knowledge that increasing awareness for ammonia production alteration and the potential opportunities makes this leading path of energy production. In Canada, their production value increased up to 4,000 tonnes from 1200 it creating value for enhancing integration.

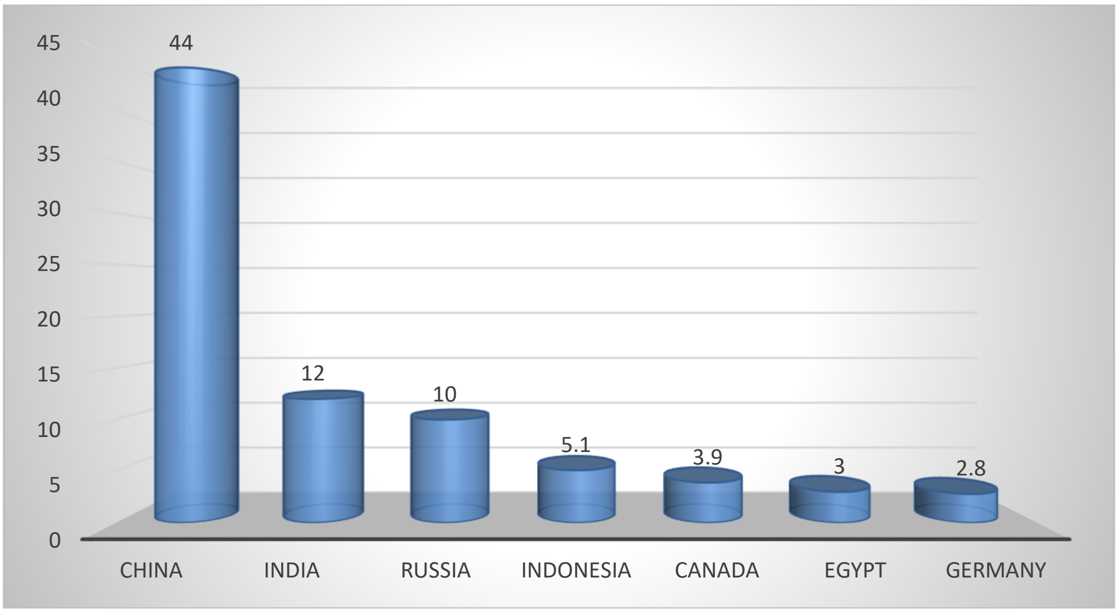

Figure 2: Production According to Position for Worldwide Renewable Ammonia Production (Daiyan et al. 2020, p.201)

The developing figure is reflecting the worldwide production according to position. Among all of the existing countries, it has been observed that 44% of production is done through China where it becomes 12% for India, and the whole figure that according tothe position is defining (Daiyan et al. 2020). It has been recognized that where the topmost production is noticed for China than on opposite end lowest production in Germany. It depends on the existing situation and the favourable scope for the development which ultimately makes the way for developing standard renewable ammonia production.

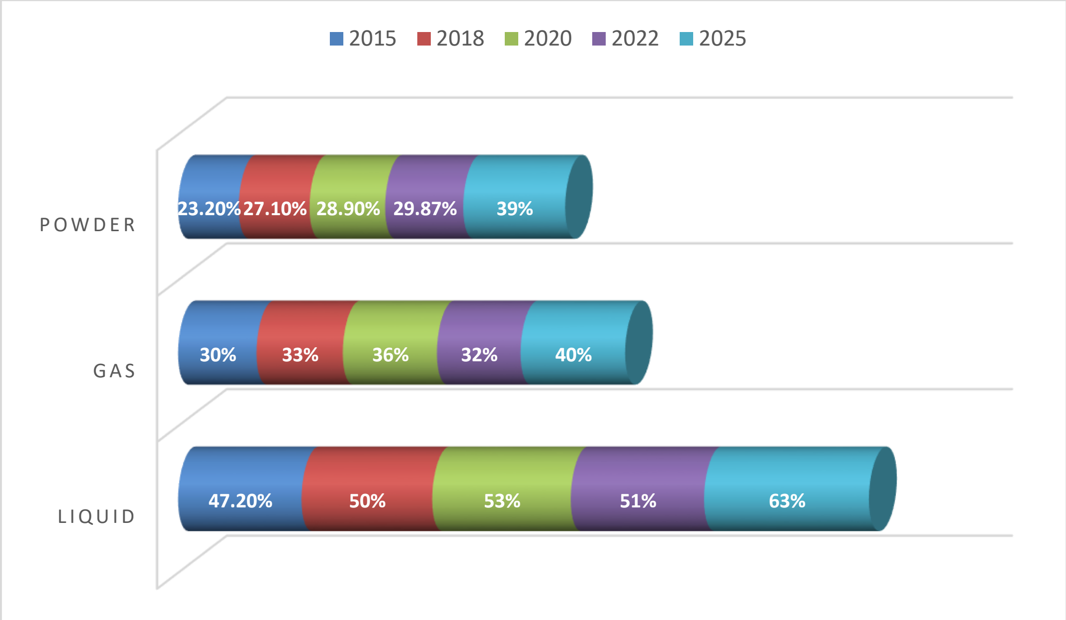

Figure 3: US Market for Ammonia production (Daiyan et al. 2020, p.328)

From the above figure, a comparison of ammonia production in a different state has been considered. It has been observed that the 2015 to 2025 production rate of the Ammonia market in the US is passing through ups and downs. As per Rouwenhorst et al. (2021), looking at the 2015 market production it has been noticed that there is 47.20% liquid production whereas for gas production rate was 30%. It needs to understand that different yearsof production may be different but the direction in the upwards or backward direction that matters most.

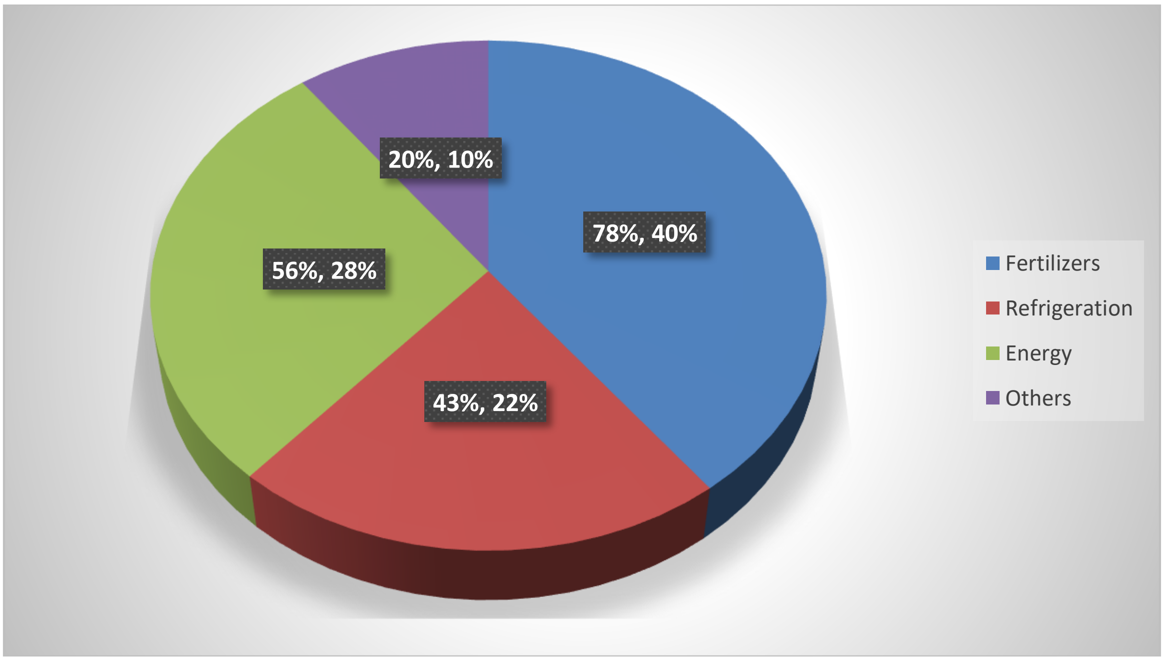

Figure 4: Different Applicable Benefits from Renewable Ammonia Integration (Daiyan et al. 2020, p.391)

The current research discussion has been developed for identifying the opportunity and benefits can industrial processes get through renewable ammonia production. It has been observed that for fertilizing purposes used rate of renewable ammonia is near about 78% which is comparatively high for the others aspect of the application. It has been observed that 43% of uses are there for use in the refrigeration process and energy production uses ammonia 56% (Mansoori et al. 2021). It is understood through this above figure uses are generating the potential opportunities are developing in real-life practices.

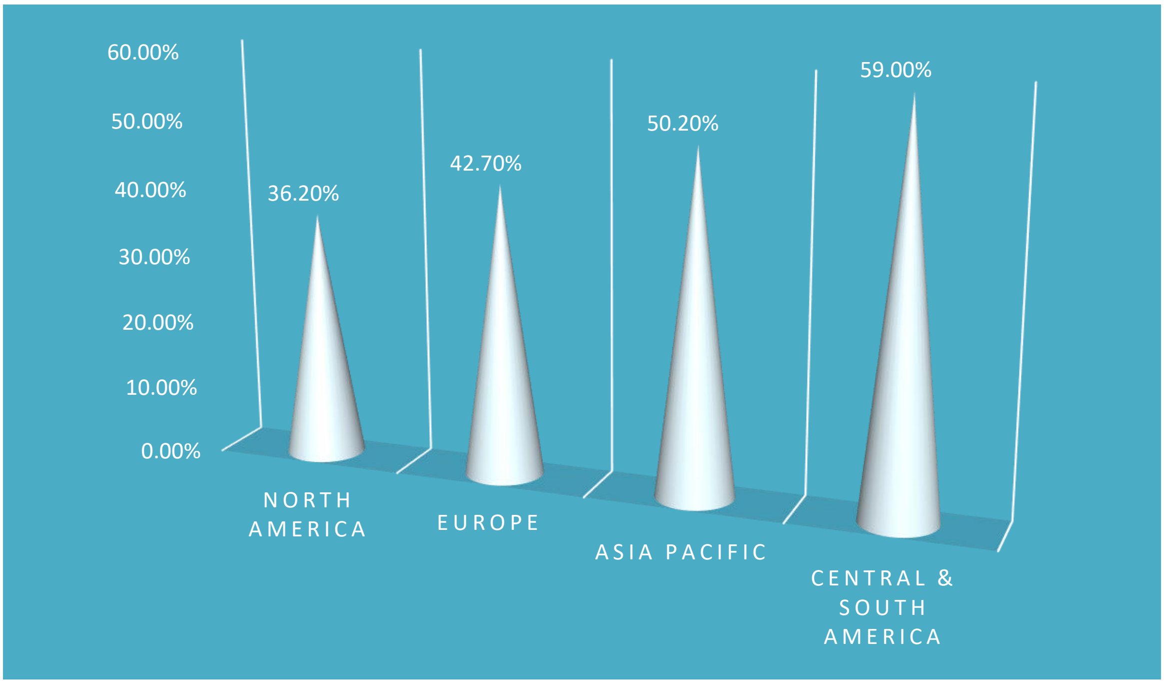

Figure 5: Regional Market of Renewable Ammonia production (Gulati 2022, p.431)

From the purpose reflectionon the purpose of generating a market for regional countries, it has been noticed that different country has a variety of market-generating values. It has been recognised that for North America generating value for the renewable ammonia market is 36.20% whereas for Europe it is 42.70% (Gulati 2022). It needs to understand market demand and knowledge both make the impact for generating stimulation for market values. 50.20% values for Asia pacific region and for central and South Africa recognise the value of the market is 59.00%.

Table 3: Ammonia Energy Association (Gulati 2022, p.901)

Company name	Location	Business	Contribution
Yara	US	Production of fertilizer	34%
Proton Ventures	Netherlands	Engineering	41%
Nel Hydrogen	Norway	Production of hydrogen and system	56%

Knowledge and analysis observation has been made for the existing ammonia energy association and their role of developing scope and generating business is discussed. It has been observed that their location-based company has been selected to understand their contribution. Yara a company in fertiliser production plays the contributory role of 34% of ammonia production and their business location is in the US. On the other hand,the selected company proton venture is releasing the role of engineering for the 41% production that is developing in the Netherlands location. Here in this table, specific information has been selected to reflect their role and contribution tothe upcoming market.

7. Discussion and Findings

From the above-presenting analysis, it has been noticed that year-wise changes have been developed for the more developing prospect for the integration of renewable ammonia sources. Different country and their year-wise change have been presented through statistical data. Application area of renewable ammonia and their generating growth or the standard of integration has been presented Jeerh et al. 2021). It has been identified that working with proper knowledge and favourable surroundings of growth makes the way more generating scope for the business market. Ammonia energy association and the different regional aspect has been covered through the current analysis.

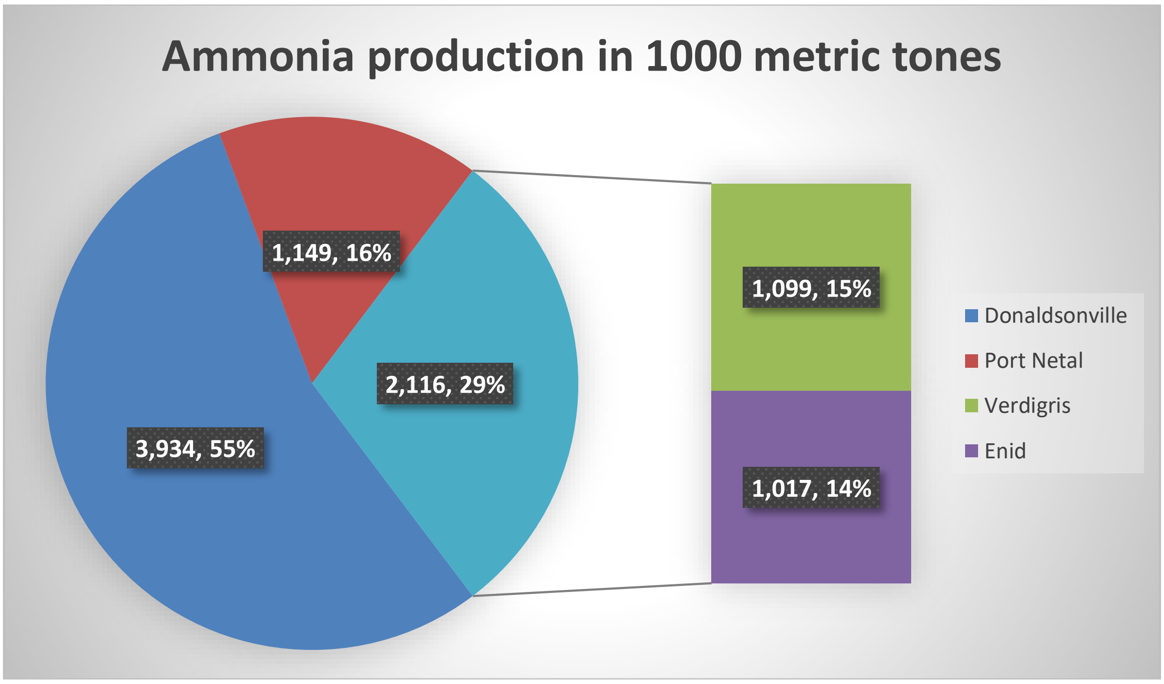

Figure 6: Ammonia Plant produces Ammonia Production in 1000 tonnes (Gulati 2022, p.849)

From the above figure, it has been noticed that the US-developed ammonia plants make a major contribution to production. It has been noticed that Donaldsonville can produce around 9334 tonnes whereas the production rate for Enid is very poor near about 1,017. It needs to be understood that different ammonia plant has different operating conditions and level of different limitations. It has been observed that Verdigris can produce approximately 1,099.

Renewable ammonia is a form of ammonia (NH3) made from renewable energy sources such as solar, wind, or hydropower (Salmon et al. 2021).. It is an increasingly attractive alternative to the traditional ammonia produced from fossil fuels, as it has a much lower carbon footprint and can be used for a variety of applications in both energy and agriculture. As per Song et al. (2021) renewable ammonia has the potential to be an important part of the global effort to reduce emissions and combat climate change. Renewable ammonia is a form of fuel derived from renewable resources that can be used as an energy source as well as for agricultural purposes. Renewable ammonia is created by combining atmospheric nitrogen with hydrogen derived from renewable sources such as solar, wind, and hydropower. This energy source has the potential to reduce emissions of carbon dioxide, sulphur dioxide, and other pollutants while providing a sustainable energy source. Additionally, renewable ammonia can be used in agricultural applications such as fertilizer production and can be used to produce hydrogen for fuel cells.

The demand for sustainable energy and agriculture is growing rapidly as the world's population is projected to reach 9 billion by 2050. In order to meet the energy and agricultural needs of the world, new technologies and strategies must be developed. One of the most promising technologies is renewable ammonia, which has the potential to be an important energy source. It can be used to power vehicles, produce fertilizer, and store energy from renewable sources such as wind and solar. In addition, renewable ammonia can be used to produce hydrogen, which is an important clean energy source.

7.1 Use of Renewable Ammonia

Renewable ammonia is an energy source that is produced from renewable sources such as wind and solar. It is made by combining hydrogen and nitrogen, which can be produced from renewable sources such as wind and solar (Zheng et al. 2022). The hydrogen and nitrogen can then be combined using a process called nitrogen fixation. This process produces ammonia, which can be used as an energy source.

7.2 Prospects of Renewable Ammonia

The use of renewable ammonia for sustainable energy and agriculture presents many opportunities for system engineering. System engineers can help to design and develop systems to produce, store, and distribute renewable ammonia. They can also develop new technologies to improve the efficiency of the production process, as well as ways to optimize the use of renewable ammonia in energy and agricultural applications. System engineers can also develop strategies for integrating renewable ammonia into existing energy and agricultural systems.

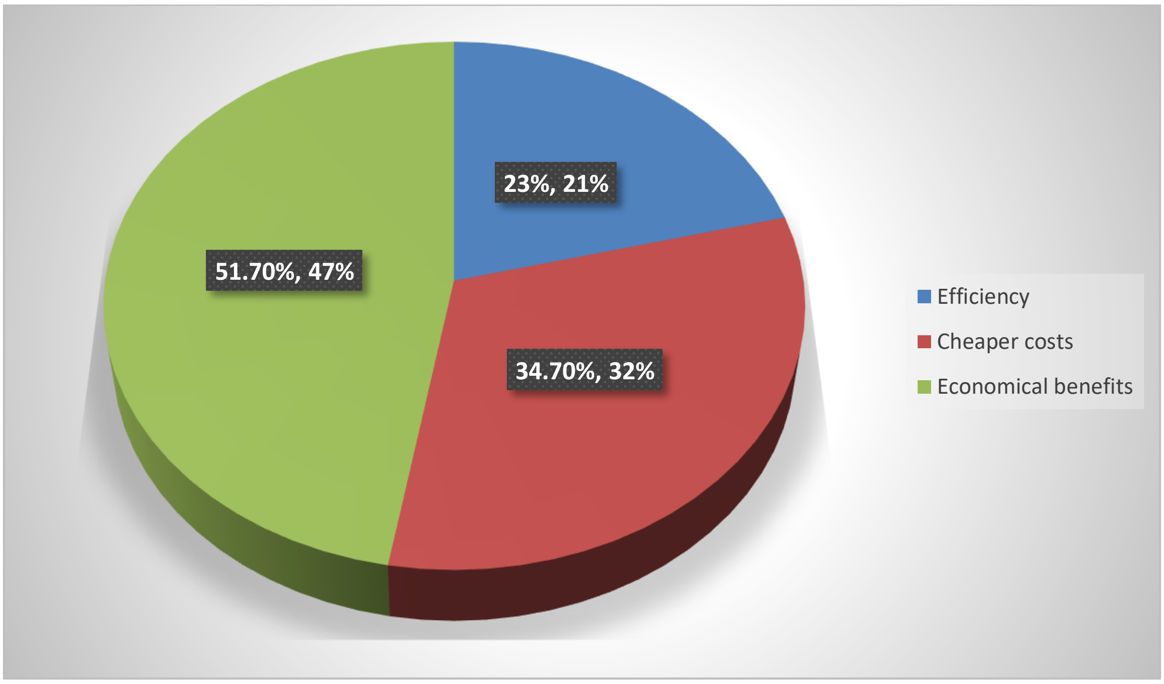

Figure 7: Renewable Ammonia Produced Benefits (Zheng et al. 2022, p.89)

In addition, system engineers can explore the potential of using renewable ammonia for other applications such as fuel cells and industrial processes. They can also develop strategies for transitioning from traditional energy sources to renewable sources. Finally, system engineers can work to improve the safety of renewable ammonia and explore ways to reduce the environmental impact of its production. Renewable ammonia has the potential to be an important energy source for both energy and agriculture. System engineers have an important role to play in developing systems to produce, store, and distribute renewable ammonia. They can also develop strategies for integrating renewable ammonia into existing energy and agricultural systems. Finally, system engineers can explore the potential of using renewable ammonia for other applications such as fuel cells and industrial processes.

7.3 Technological scope for Renewable Ammonia

The development of a renewable ammonia system presents numerous opportunities for industrial engineering. To begin with, the system should be designed to maximize efficiency in order to reduce the overall cost of production and use. Additionally, the system should be designed to maximize environmental sustainability and reduce the environmental impacts of production and use. This includes designing systems that have minimal energy and water requirements, and that are able to capture and recycle any waste products. In addition to designing efficient and sustainable systems, engineers should also focus on developing processes that are able to efficiently convert renewable energy sources into ammonia. This includes designing systems that can convert solar, wind, and other renewable energies into usable forms of energy, as well as systems that can capture and store renewable energy (Mukelabi et al. 2022).

8. Conclusion

From the above-developing study discussion, it has been observed that renewable ammonia production is the growing need for reducing the pollution threats and the increasing burden on natural sources. It needs to be realised that the growing rate of ammonia production and the country-wise differences in scope is generating. Without looking at the applicable area for renewable ammonia scope of understanding the development is limited. It has been analysed that the regional market and the uses of industrial processing are developing as the whole processing is changing with development. The benefits and challenges of the use of renewable ammonia are analysed through the use of different aspects that includes energy and the agricultural industry.

9. Future Scope

Worldwide base data has been analysed to understand the practices and the changes happening regarding renewable ammonia production. It needs to be understood that worldwide evaluation sometimes limited the chances of specific country change identification. Limited time and the vast information processing make it a burden to recognise the change is happening. Growth of energy association and the improving capability of ammonia plants are observed but the way of generating more information for success in achieving the path for renewable ammonia integration is not enough covered. Country-specific information searching is required to improve the chances of working with the better potential of renewable ammonia production.

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