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Directing the Wind Toward Sustainable Agricultural Communities: Techno-Economic Feasibility of Green Ammonia for Farmers and Community Economic Viability

ABSTRACT

There has been increasing interest in low-carbon technologies to reduce climate change impacts. However, careful assessments of their implications for the vibrancy of local economies are rare. This paper employs techno-economic analysis to assess the technical and economic feasibility of investment in one such technology: local green ammonia production and its contribution to the economic viability of the local economy. The analysis considers price projection and debt financing options, and alternative energy-to-ammonia technologies. The approach is broadly applicable and here is illustrated using a case study in which 248,188 MT of traditional ammonia are replaced with local wind energy-produced ammonia for farmers in Southwest Kansas, USA. Economic feasibility is defined as the ability to accrue enough discounted cash flow at the end of the turbines' 25-year lifespan to enable their replacement. The alternative technologies are the traditional Haber-Bosch and the emerging solid oxide electrolysis cell (SOEC). The results show how economic feasibility sensitivity to technology and financing options are evaluated and communicated to scientists, policymakers, and farmers. The 6.5 MWh/MT wind energy-to-ammonia SOEC technology presented the best economic results under all price projections. The community's investment yielded the highest return when debt was used to finance 50% of the capital investment. Returns exceeded the average annual S&P return of about 7% from 1957 to 2021. The work shows how consideration of technology efficiencies and creative financing strategies can contribute to the economic welfare of farmers and their communities even as they contributed to reducing crop production's carbon footprint.

INTRODUCTION

- Ammonia is one of the most-produced chemicals, with an annual global production of over 176 million metric tons.
- 80 percent of total global ammonia output is used as fertilizer mainly in small towns and rural (STAR) communities.
- The study focuses on locally produced green ammonia production in USDA Agricultural District 30 - Southwest Kansas, and the possibility of engendering economic viability in the region.
- The region is a major contributor to grain and livestock and depends heavily on the Ogallala for its irrigation.
- This area has a good to excellent availability of wind for the desired energy production.

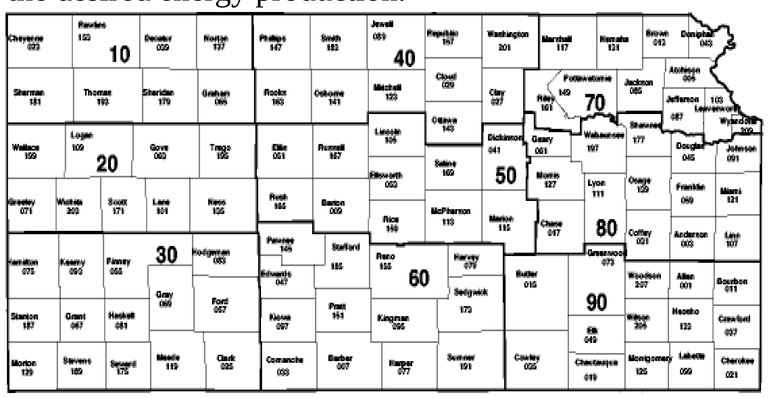


Fig. 1: Map of Kansas showing USDA District 30

- Ammonia's current production method has a high carbon footprint using the Haber-Bosch process.
- This research explores the feasibility of the solid oxide electrolysis cell (SOEC) technology as an alternative ammonia production solution using wind energy.

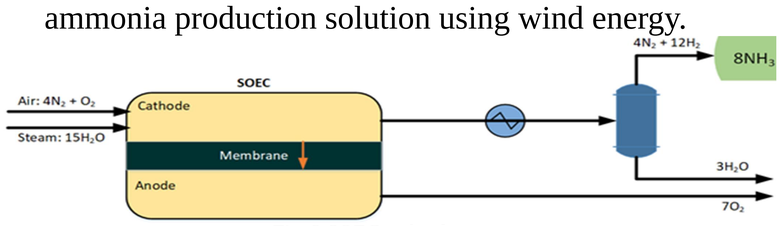


Fig. 2 SOEC technology
Source: Adapted from Ghiyati, 2021

- Locally produced ammonia using the SOEC technology will help reduce the carbon footprint of ammonia and increase community economic development through wealth retention and diversification of economic base

METHOD

- The study used financial analysis of cash flows over 25 years to explore the feasibility of local green ammonia production in Southwest Kansas.
- This analysis used Vestas V100-1.8 turbine with an 1800KW capacity.
- We conducted the analysis using the higher-efficiency SOEC technology with two energy-to-ammonia rates; 6.5 MWh/MT and 8.1 MWh/MT.

RESULTS

- The study assumes 23% Ammonia Price Discount, 30% Dividend, and 5% Discount Rate Over 25 Years.

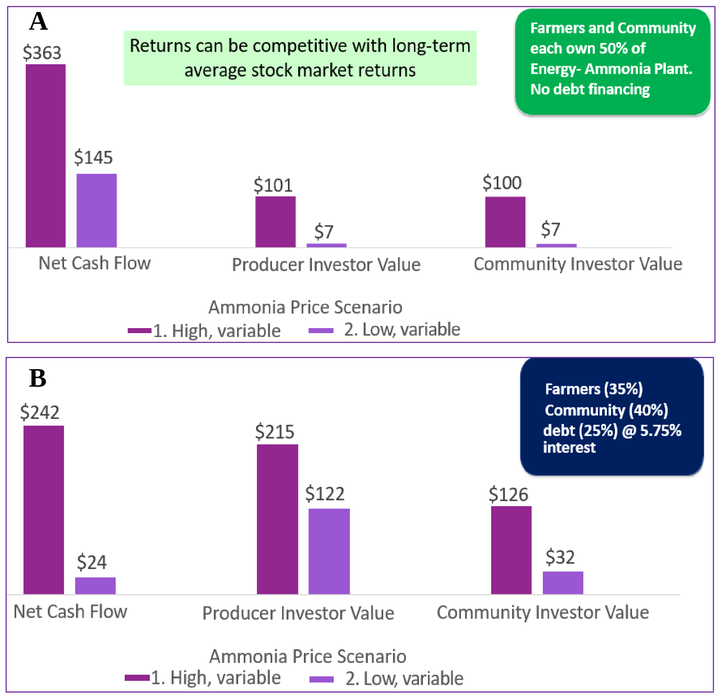


Fig. 3A and 3B: Investment Performance by Ammonia Price Scenario

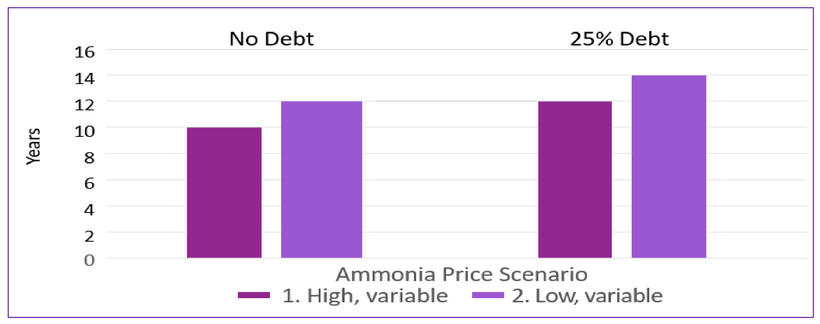
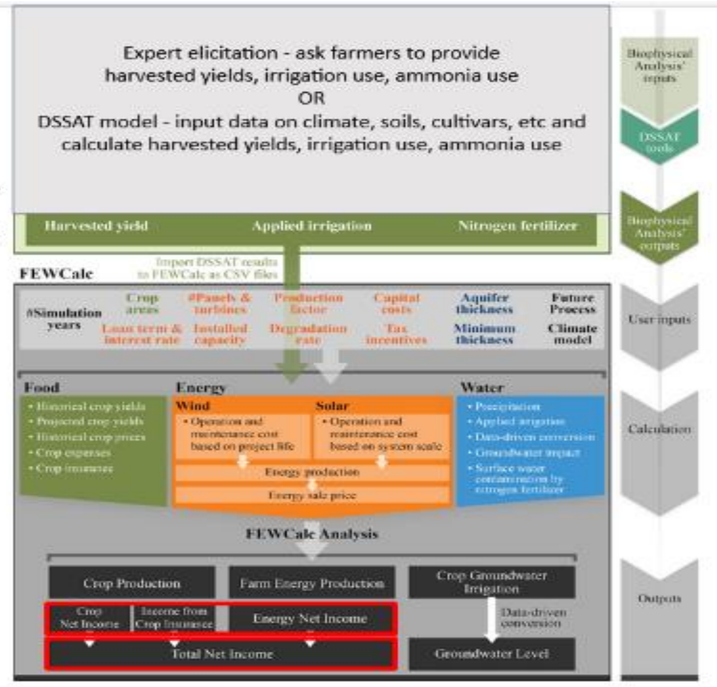


Fig. 4: Discounted Payback Period

APPLICATION WITH EMPHASIS ON ECONOMIC CONTRIBUTION

Provide for expert elicitation as an option to help farmers feel comfortable using FEWture Farms to consider long term climate change impacts.

Integrate economics – Capital and operating costs, price scenarios, summary statistics for economic viability. Graphs of income over time



CONCLUSION

- Local production of green ammonia using the SOEC technology is economically feasible using producer and community funds combined with some debt financing.
- With current ammonia prices reaching over $1100/MT, this project was found to be economically feasible given the energy-to-ammonia conversion rate.