Final Technical Report for:

Tanadgusix (TDX) Foundation Hydrogen / Plug-in Electric Vehicle (PEV) Project

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ABSTRACT

TDX Foundation undertook this project in an effort to evaluate alternative transportation options and their application in the community of Saint Paul, Alaska an isolated island community in the Bering Sea.

Both hydrogen and electric vehicle technology was evaluated for technical and economic feasibility. Hydrogen technology was found to be cost prohibitive. TDX demonstrated the implementation of various types of electric vehicles on St. Paul Island, including side-by-side all terrain vehicles, a Chevrolet Volt (sedan), and a Ford Transit Connect (small van).

Results show that electric vehicles are a promising solution for transportation needs on St. Paul Island. Limited battery range and high charging time requirements result in decreased usability, even on a small, isolated island. These limitations were minimized by the installation of enhanced charging stations for the car and van.

In collaboration with the University of Alaska Fairbanks (UAF), TDX was able to identify suitable technologies and demonstrate their applicability in the rural Alaskan environment.

TDX and UAF partnered to engage and educate the entire community of Saint Paul – fom school children to elders – through presentation of research, findings, demonstrations, first hand operation of alternative fuel vehicles.

INTRODUCTION

Tanadgusix (TDX) Corporation is an Alaska Native Village Corporation, established under the 1971 Alaska Native Claims Settlement Act, passed by the United States Congress to provide economic well being for the indigenous peoples that resided in the village of St. Paul, Alaska. TDX Foundation is a non-profit arm of TDX Corporation and shares the mission of its parent corporation through outreach, research, and education.

TDX Corporation has long supported alternative energy development as a way to create sustainable communities in rural Alaska. TDX currently operates a wind farm on St. Paul Island that provides both heat and electricity to its facility. This project was envisioned as a way to bring renewable energy solutions to the local transportation sector and further enhance the quality and sustainability of life in St. Paul.

Figure 1 - St. Paul Island Wind Farm

LOCATION

Saint Paul Island is one of five islands in the Pribilof group, located over 250 miles offshore in the Bering Sea. The islands are volcanic but inactive.

Figure 2 - St. Paul Island location in the Bering Sea

PROJECT OUTLINE

The Challenge

Tanadgusix (TDX) Corporation operates four (4) buses to transport ecotourists and local elders on remote St. Paul Island, Alaska. TDX also has several trucks and cars for business purposes and there is an opportunity to lease All-Terrain Vehicles (ATVs) to ecotourists. Difficult to obtain and volatile in price, imported fossil fuels are no longer affordable or increasingly even available as a source of heat, electricity, and transportation for much of rural Alaska. TDX Foundation has a vision to meet its on-island transportation needs in their wind rich homeland by using the clean electricity from three 225 kW Vestas wind turbines to provide transportation services in addition to electricity and heating services.

Transportation needs for the ecotourism business and senior/disabled residents has been quantified as follows:

Project Specifications	
Occupancy	15-20 passengers/bus
Tour Route Mileage	100 miles -100 days a year
Residential Route Mileage	40 miles year round
Total Annual Mileage	24,600 miles/year

Figure 3 - Transportation Specifications for St. Paul buses

Technologies to exploit local renewable energy resources are emerging as economic and environmental necessities worldwide. The people of St. Paul Island have the desire and wherewithal to be on the cutting edge of this exciting new power evolution.

We believe the isolated small size of our island home gives us an advantage in developing an alternative transportation system.

OBJECTIVES

The primary objective of this project was to evaluate technical feasibility and the economics of alternative fuel vehicles for use on St. Paul Island. There is excess wind capacity installed on the island that could be used to meet transportation needs in addition to its current use providing electricity and heating services. Both hydrogen and plug-in electric vehicle technology were evaluated.

Engaging and educating the community of St. Paul Island is an important part of the process. Community interest, concerns, support, and workforce readiness were considered in the selection of the most appropriate technology. Through education, we believe that the community will embrace the new technology.

PROJECT SCOPE

TDX and their partners on this project evaluated the technical feasibility and economics of hydrogen fueled vehicles and plug-in electric vehicles compared to fuel efficient diesel/gasoline powered buses, including analysis of the wind resource, fuel demand, transit route requirements, interface of wind turbines and hydrogen generation system, remote location considerations, and climate (temperature, salt, dust, etc.). An economic analysis included research on the commercial availability and cost of the equipment and vehicles, as well as a comparison between the cost of diesel and the cleaner, alternative technologies.

Each project was evaluated in accordance to a list of assessment metrics. These metrics were broken down into the following categories:

- Technical Feasibility
- Economic Analysis
- Commercial Availability
- Environmental Benefit
- Climate and Geographic Challenges
- Risk
- Operation and Maintenance
- Ability to Meet Community Needs

The categories which saw the largest difference in rating were, in order of decreasing impact: economic analysis, risk, and commercial availability. Hydrogen vehicles saw the lowest scoring in economic analysis because of the high project cost without the ability of retaining the capital because the vehicles could only be leased. Hydrogen vehicles also saw the lowest rating in risk because the technical risk is high, the economic risk is high, and there is the added risk of this project not being sustainable in the long term. Interestingly enough, the technical risk among these projects was relatively close. The wind resource is sufficient to enable the production of hydrogen for the specifications required by St. Paul Island. At this time, it does not appear to be feasible to implement hydrogen technology in a rural application.

Hydrogen

Hydrogen vehicles were the primary focus during the early stages of this project.

Unfortunately, current technology does not allow efficient production of hydrogen fuel. As our partner, Alaska Center for Energy and Power, discovered, realistic “wind to vehicle” efficiency with current technology would be ~15-28%, including the following:

- 50-60% electrolyzer efficiency (includes stack efficiency, parasitic losses)
- 7.2% compression losses
- 35% peak hydrogen ICE efficiency OR 50% hydrogen fuel cell efficiency

Coupled with the inefficient conversion process, hydrogen vehicles were found to be unavailable in a commercial market and cost prohibitive where available. Primary barriers to implementation of hydrogen vehicle technology are listed here:

Capital Cost	• The capital cost of water electrolysis systems are prohibitive to widespread adoption for hydrogen production.
Commercial Availability of Hydrogen Vehicles	• Zero hydrogen fuel cell buses available. • Hydrogen Hybrid ICE buses available on a lease only basis.
Hydrogen Cost	• Develop low-cost hydrogen production from electrolysis using wind.
Renewable Electricity Generation Integration	• More efficient integration is needed to reduce costs and improve performance. • Optimization and improved efficiency of system components is needed.

Figure 4 - Primary Barriers to Hydrogen Technology Implementation

A trip was planned to visit sites where hydrogen technologies that would be required for the Saint Paul demonstration are currently being deployed . These technologies include: electrolysis, compression and storage, dispensing, and vehicle operation. Important information collected included cost estimates, thermodynamic efficiency, availability of commercial devices, and reliability.

There were four locations visited: the hydrogen facility at the NREL wind test site near Golden, Colorado; the public hydrogen fueling station in 1000 Palms, California operated by Sunline Transit; the bus refueling station operated by AC transit in Oakland, California; and the offices of Setram/Hy-Energy, suppliers of equipment for the evaluation of materials used for hydrogen storage. This trip resulted in several important findings for the Saint Paul Hydrogen project. These included:

- The price of a hydrogen refueling station—compression, storage and dispensing—is about $450,000. All the components are commercially available, but hydrogen is not being sold by the kilogram at the stations we visited.
- Electrolyzers are commercially available, but they are not cheap—and they are less efficient than our previous estimates.
- Fuel cell powered busses are operating on transit routes, but the cost of the best busses are higher than previous estimates ($3.2M as compared to $1.6M several years ago). These busses are hybrids, get about 7 miles per kg, but have problems with the traction batteries. Fuel Cells are lasting about 4000 hours, next generation should go for 8,000 hours. Most of the bus cost is the fuel cell.
- Ballard busses are not operating well, using more fuel than conventional diesel busses—but UTC based fuel cell busses are operating well at atmospheric pressure, though at higher cost. IC engine vehicles are not being tested at any of the sites we visited, and they are thought to be significantly less efficient than fuel cell vehicles.
- All fuel cell vehicles have tags from the manufacturer, though they can operate on public highways.
- Net conclusion: a hydrogen project on St. Paul Island is possible, but cost would be in the range of $2.6M for hardware ($1.1M for electrolyzer, $500K for compression, storage and dispensing, and $1M for 4 vehicles leased for 3 years from Ford).

Electric Vehicles

Plug-in Electric Vehicles were chosen as the most expedient and realistic option for alternatively fueled vehicles at this time. The focus of this project shifted to demonstrate the technology.

Several types of vehicles were selected, based on transportation needs on the island coupled with functionality of available models.

Polaris Range side-by-side all terrain vehicles were explored as an option for ecotourism, primarily for birders. The intent was to loan or rent the vehicles to tourists who could then access bird colonies that would otherwise be inaccessible by car or truck. 3 Polaris Rangers were purchased and tested by TDX personnel on St. Paul Island.

Enhanced Charging Stations

Usability of the electric vehicles was initially hampered by the limited battery range and

Enhanced charging stations at the POSS Camp. The vehicles are located in a central facility that is protected from the extreme weather previously encountered.

Increased use of the vehicles has been observed since the charging station enhancements were completed, primarily due to improved charging performance.

CONCLUSIONS

Based on the findings from the feasibility study, TDX determined that plug-in electric vehicle technology is the most appropriate alternative transportation solution available today. This technology provides the most likely option for a technically and economically successful application. Although products are commercially available, our research shows that options are only practical for limited applications, primarily due to battery range limitations and charging duration.

Of those two primary limitations, we were able to address the charging duration by installing improved (higher voltage) charging stations for the Chevy Volt and the Ford Transit Connect. The improved charging time was found to have a significant impact on usibility. A partial recharge at midpoint in the day often allows for continued operation whereas previous use was limited to either the morning or the afternoon. Complications with staff vehicle assignments were minimized with the enhanced charging stations as well.

Although hydrogen powered vehicle technology was found to be severely limited on a commercial level, TDX was able to procure and test several types of commercially available electric vehicles on St. Paul Island. Fully enclosed vehicles with extended battery range seem to hold the most promise for continued use in this application.

Pricing, variety, and availability of electric vehicles is steadily and quickly improving. The vehicles demonstrated in this project show real promise for remote application, especially newly available four-wheel drive models such as the Toyota Rav4.

Community interest was very high, and alternative fuels provide real hope as a sustainable solution to meet rural transportation needs.