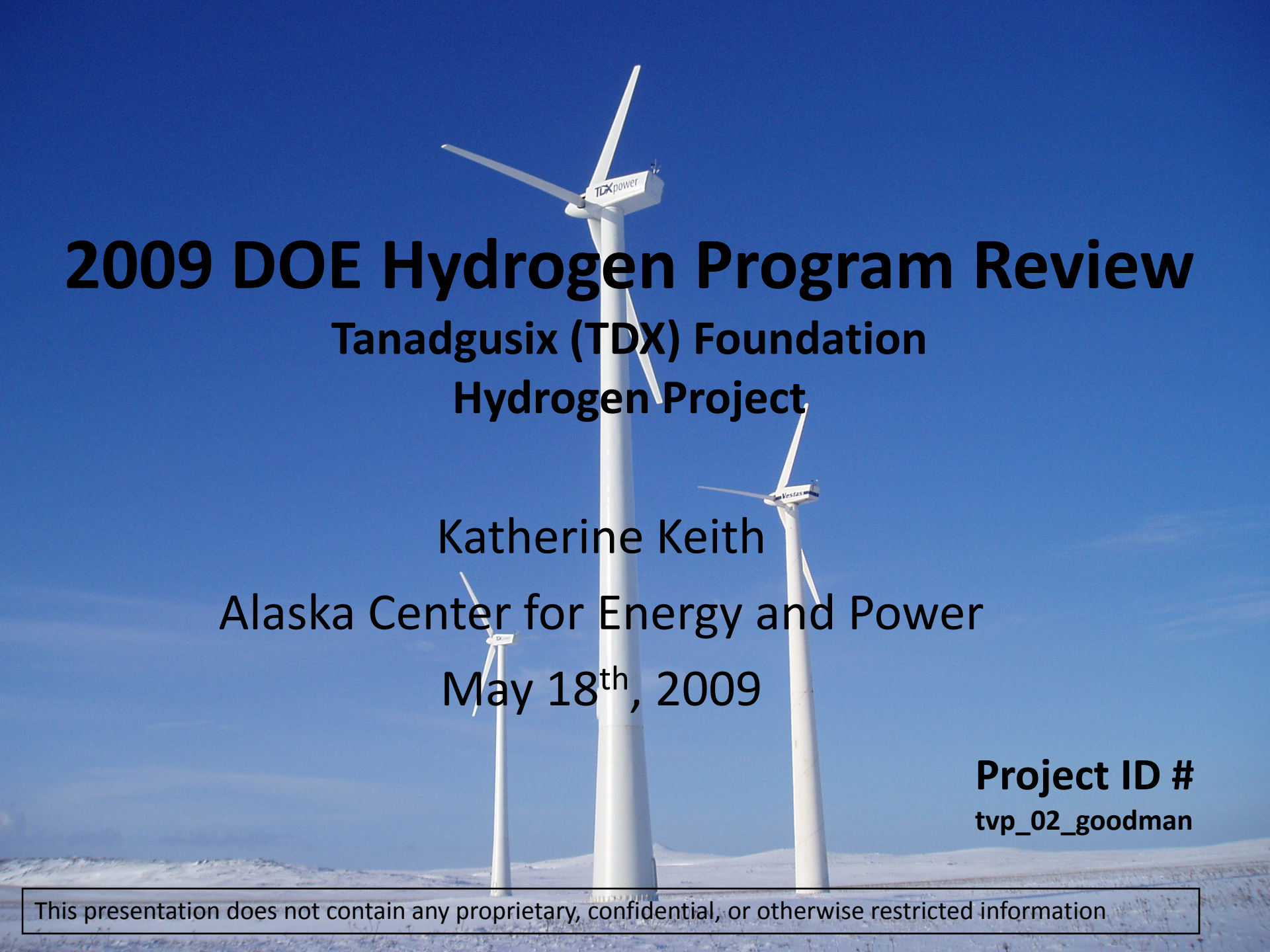


2009 DOE Hydrogen Program Review

Tanadgusix (TDX) Foundation Hydrogen Project

Katherine Keith

Alaska Center for Energy and Power

May 18th, 2009

Project ID #

tvp_02_goodman

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Start: September 15st, 2008
- Finish: March 30th, 2010
- Percent complete: 25%

Budget

- Total project funding
  - DOE share: $246,000
  - Contractor share: $37,493
- Funding received in FY08
  - Q1-$61,500
- Funding for FY09
  - Q2-$61,500
  - Q3-$61,500
  - Q4-$61,500

Barriers

- Barriers addressed
  - Technical Target: Wind Water Electrolysis
    - Hydrogen Cost
    - Electrolyzer Energy Efficiency
  - Barriers
    - Capital Cost
    - System Efficiency
    - Commercial Vehicle Available

Partners

- Interactions/ collaborations
  - Alaska Center for Energy and Power
  - Alaska Wind Diesel Application Center
  - National Renewable Energy Lab
- Project lead
  - Katherine Keith, ACEP/WiDAC

Relevance

Life Time Project Objective

TDX Corporation operates four buses to transport tourists and local elders on remote St. Paul Island, Alaska. The rising price of imported fossil fuels makes this increasingly cost prohibitive. Using three 225 kW Vestas wind turbines, TDX would like to produce an alternative fuel for a new fleet of transit vehicles.

Year One Project Objective

TDX Foundation and team partners will conduct a feasibility study and evaluate the economics of hydrogen hybrid internal combustion engines, plug-in electric vehicles, and electric vehicle technology for an existing wind-diesel hybrid system.

Relevance
Wind to Vehicle Technology

Challenges

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.

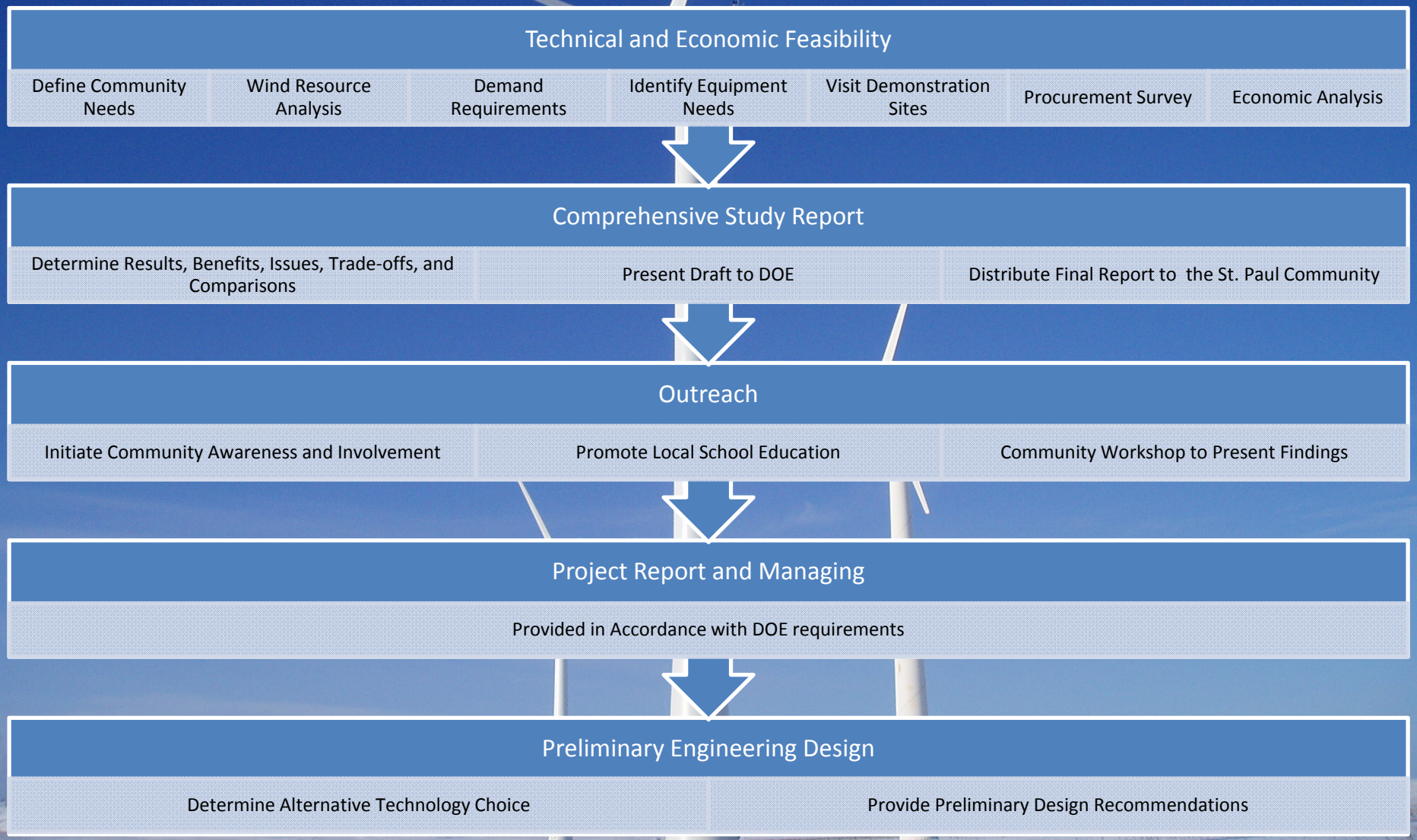
Technical Targets

Small Scale Wind Water Electrolysis	• 2012 Target: 27% of electricity generated from wind to produce hydrogen
Electrolyzer Cost	• 2012 Target: $350/kW • 2012 Target: $0.80/gge H2
Hydrogen Cost	• 2012 target: 3.10/gge H2

Milestones

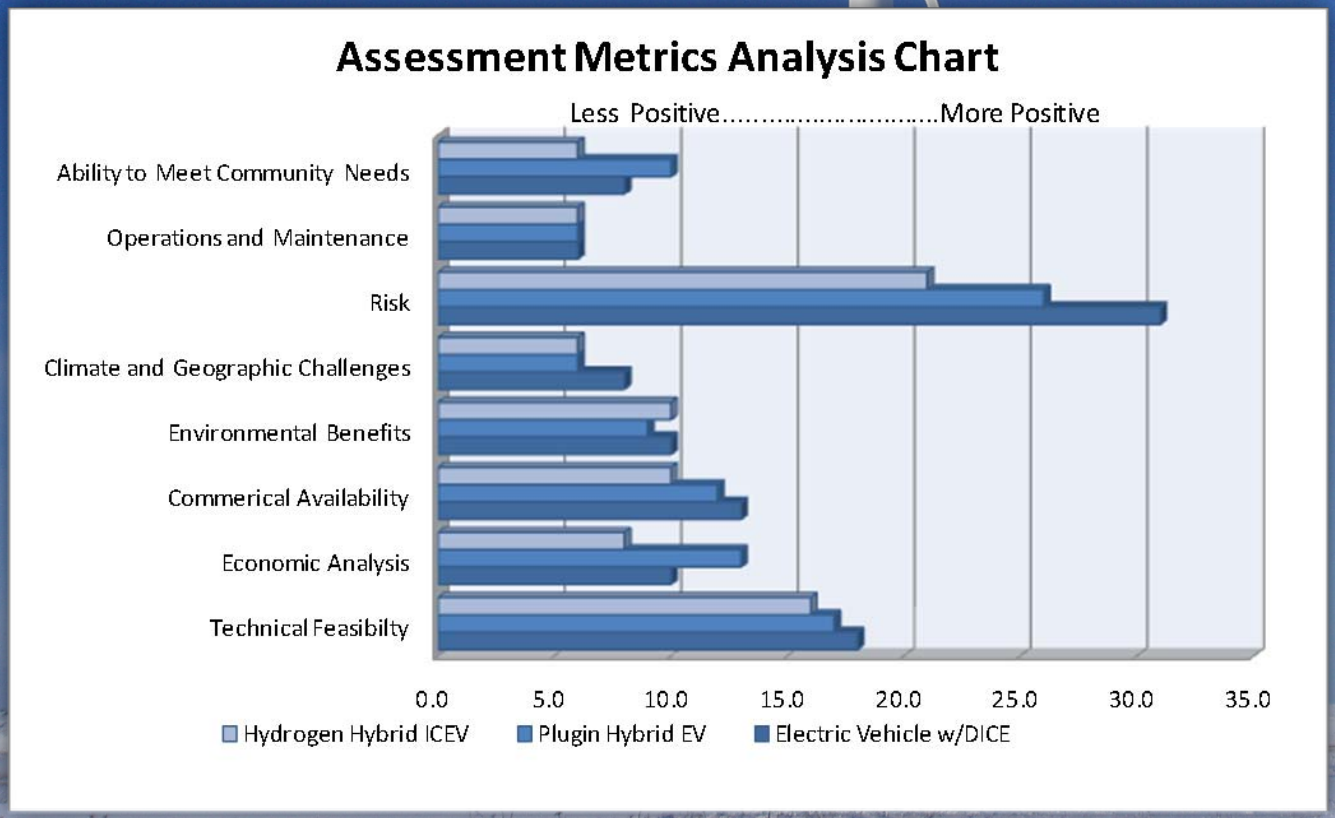
Task Number	Task Description	Project Milestones	Task Completion Date			Progress Notes
			Original Planned	Actual	Percent Complete	
1	Technical and Economic Feasibility Study	Assessment Metrics	3/31/09	3/15/09	100%	Complete.
2	Comprehensive Study Report	Draft Report of Technical and Feasibility Study	6/30/09		30%	On-Track.
2	Comprehensive Study Report	Final Report of Technical and Feasibility Study	9/30/09		0%	On-Track.
3	Outreach	Determine Alternative Technology Choice	9/30/09		10%	Not started.
4	Project Management & Reporting	Provided in Accordance with DOE Requirements	ongoing		25%	On-Track.
5	Preliminary Engineering Design		12/31/09		0%	Not started.

Plan and Approach



Technical Progress

Transportation Alternative	Three Year Project Cost	Gallons Diesel Consumed	Electricity Required	Final Score	%	Grade
Hydrogen Hybrid Internal Combustion Engine	$2,281,932	n/a	1,427 MWh/yr	*83.0*	*63.8%*	*D*
Plugin Hybrid Electric Vehicle	$1,124,525	1,889 gal/yr	3.8 MWh/yr	*99.0*	*76.2%*	*C+*
Electric Vehicle Combined with Efficient Diesel	$987,100	833 gal/yr	18.8 MWh/yr	*104.0*	*80.0%*	*B*
Diesel Internal Combustion Engine Vehicle	$171,301	2,444 gal/yr	n/a	*Base Case*		



Assuming a 20 year project life, the cost to run a leased Ford H2ICE Hydrogen Hybrid Internal Combustion Engine is $13/mile.

Technical Progress

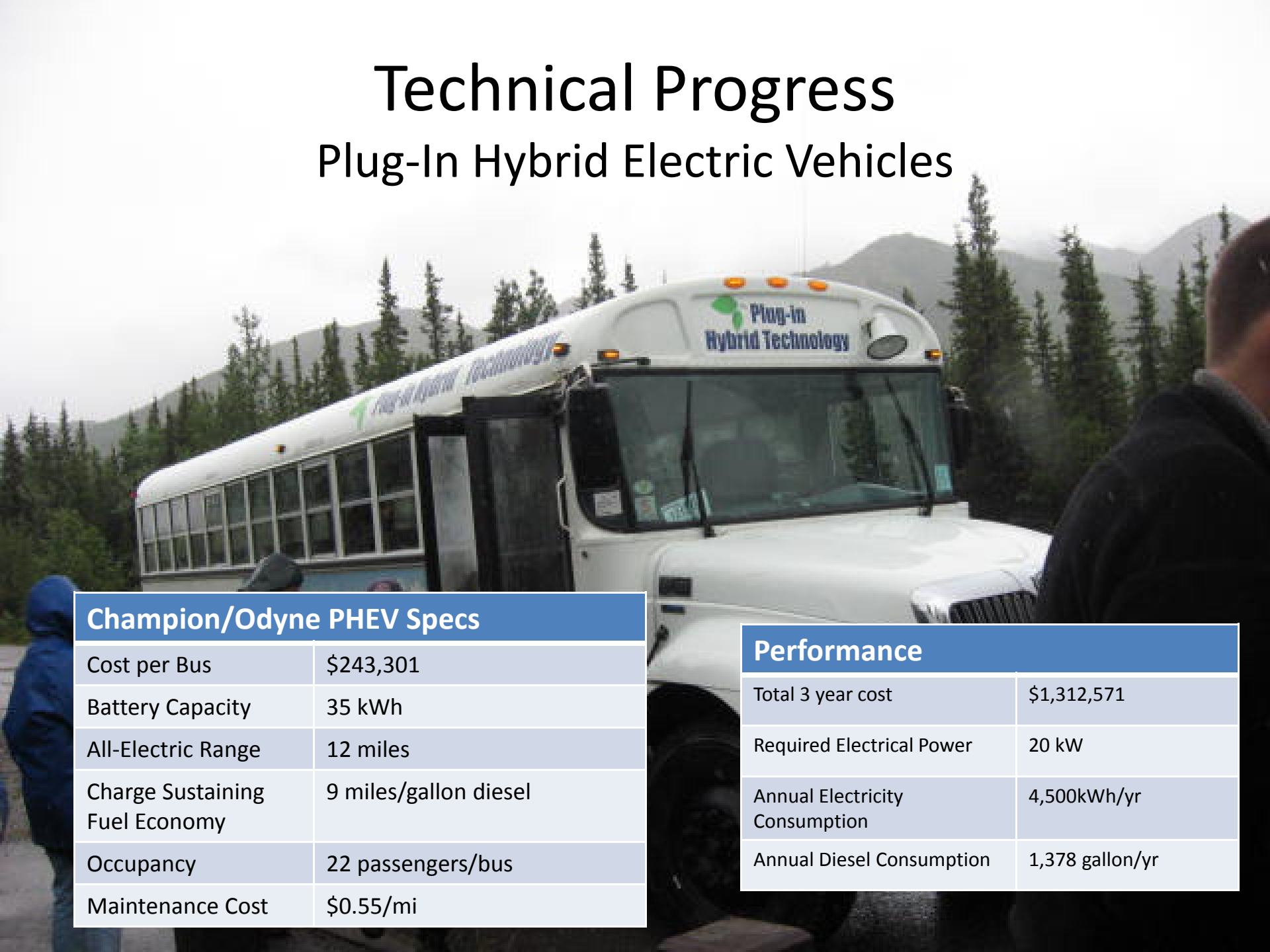
Hydrogen Hybrid Internal Combustion Engine

Ford E450 H2ICE Shuttle Specs	
Lease Rate	$7,000/month per vehicle
Length of Lease	36 months
Fuel Capacity	30 kg H2 @5000 psi
Range	150 miles
Fuel Economy	4.4 miles/kg H2
Occupancy	12 passengers/bus
Maintenance Cost	$0.55/mi

Performance	
Total 3 year cost	$2,281,932
H2 Production Capacity	32 kg/day
Required Electrical Power	163 kW
Annual Electricity Consumption	1,427,880 kWh/yr
Annual Hydrogen Consumption	5,585 kg H2/yr

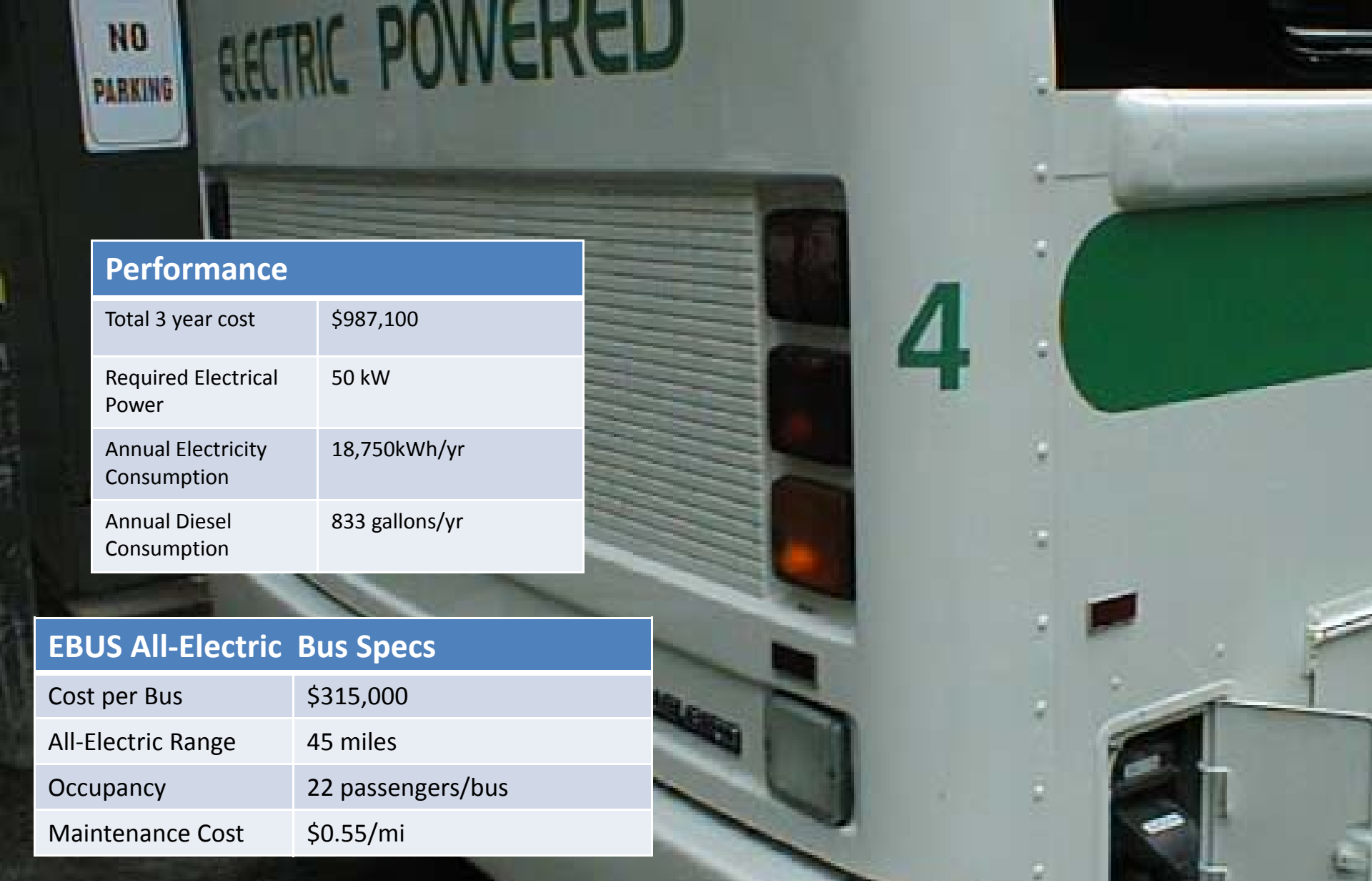
Technical Progress

Plug-In Hybrid Electric Vehicles



Champion/Odyne PHEV Specs	
Cost per Bus	$243,301
Battery Capacity	35 kWh
All-Electric Range	12 miles
Charge Sustaining Fuel Economy	9 miles/gallon diesel
Occupancy	22 passengers/bus
Maintenance Cost	$0.55/mi

Performance	
Total 3 year cost	$1,312,571
Required Electrical Power	20 kW
Annual Electricity Consumption	4,500kWh/yr
Annual Diesel Consumption	1,378 gallon/yr



Performance	
Total 3 year cost	$987,100
Required Electrical Power	50 kW
Annual Electricity Consumption	18,750kWh/yr
Annual Diesel Consumption	833 gallons/yr

EBUS All-Electric Bus Specs	
Cost per Bus	$315,000
All-Electric Range	45 miles
Occupancy	22 passengers/bus
Maintenance Cost	$0.55/mi

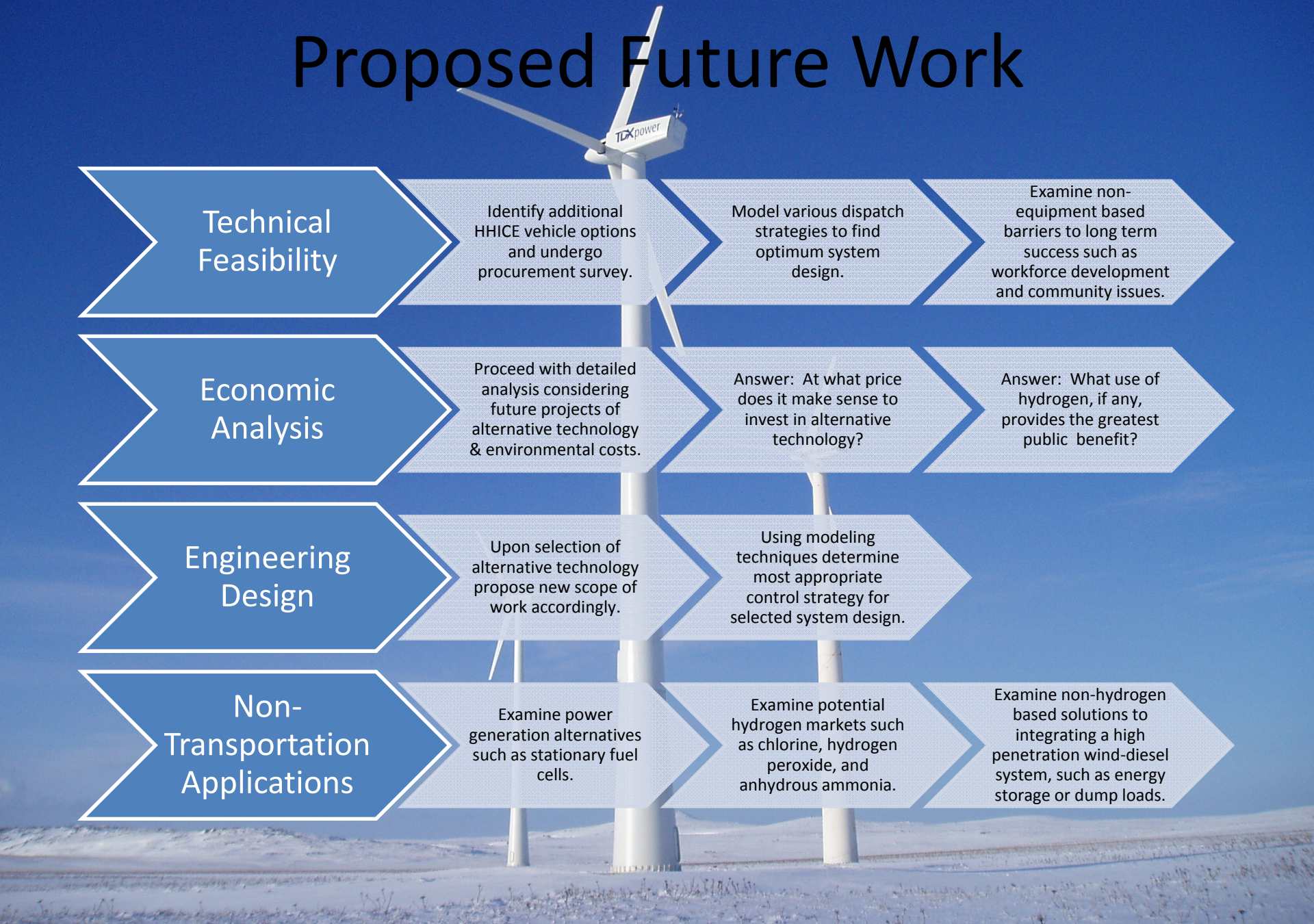
Technical Progress

Electric Vehicle plus Diesel ICE

Collaborations

- Partners
  - Alaska Center for Energy and Power
  - Alaska Wind Diesel Application Center
  - National Renewable Energy Lab

Proposed Future Work



Technical Feasibility	Identify additional HHICE vehicle options and undergo procurement survey.	Model various dispatch strategies to find optimum system design.	Examine non-equipment based barriers to long term success such as workforce development and community issues.
Economic Analysis	Proceed with detailed analysis considering future projects of alternative technology & environmental costs.	Answer: At what price does it make sense to invest in alternative technology?	Answer: What use of hydrogen, if any, provides the greatest public benefit?
Engineering Design	Upon selection of alternative technology propose new scope of work accordingly.	Using modeling techniques determine most appropriate control strategy for selected system design.	
Non-Transportation Applications	Examine power generation alternatives such as stationary fuel cells.	Examine potential hydrogen markets such as chlorine, hydrogen peroxide, and anhydrous ammonia.	Examine non-hydrogen based solutions to integrating a high penetration wind-diesel system, such as energy storage or dump loads.

Project Summary

Relevance	Approach	Technical Accomplishments and Progress	Collaborations	Proposed Future Research
•Using wind water electrolysis to address remote transportation needs. •Determining the status and market needs of mass transit hydrogen vehicles. •Identifying barriers which impede Wind to Vehicle applications.	•After completion of technical and economical feasibility determination will be made of alternative technology using assessment metrics. •Broaden the original scope of work to determine the best possible use of hydrogen while meeting the project specifications.	•Current system designs are cost prohibitive relative to the existing transportation system. •Reduced commercial availability of shuttle vehicles drastically impacts the economic feasibility of using hydrogen hybrid internal combustion engines.	•Active partnership with Alaska Center for Energy and Power, Alaska Wind Diesel Application Center, and others.	•Identify new system design which will reduce overall cost. •Identify uses for hydrogen other than transportation. •If unable to select ideal use of a wind-diesel-hydrogen system, other high penetration wind diesel designs will be considered. •Proceed with detailed modeling to determine most appropriate system configuration.

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