Fuel Cell at Fire Station 3

cathode side. Encouraged by a catalyst, electrons are stripped from the hydrogen atom. Freed of the electrons, the protons pass through the electrolyte, while the electrons are forced to take a different path to the cathode. As the electrons travel their separate paths, they create an electric current that can be captured. At the cathode, another catalyst rejoins the hydrogen atom, which then combines with the oxygen to create a molecule of water. The electricity is then routed into Fire Station 3's power system. By using a liquid-to-liquid heat exchanger, the waste heat is used to supply the domestic hot water system at the station. The only air emissions are small amounts of carbon dioxide and nitrogen.

Fuel cells are extremely quiet with no visible emission plume coming from the stack. While cost is still an issue for large scale fuel cell use, the technology is very promising as it provides reliable power and hot water without the pollution or monitoring and reporting requirements that traditional electricity production requires.

The production of electricity with minimal emissions has been a landmark demonstration for ENVVEST. Installed in June 2004, the fuel cell has operated nearly flawlessly and has had a system availability rate of 97%. The successful demonstration of the fuel cell further shows that alternative fuels can function well in a cold weather climate.

The Future of ENVVEST Projects

The investment portion of the ENVVEST program is now over, and no further funding will be made directly available for its projects. However, this does not mean that the influence of ENVVEST is over. In addition to individual project successes, ENVVEST made a great contribution to Elmendorf by standardizing the concept of emission reductions as part of the base Environmental Quality program. Projects such as surface coating operations and the road paint truck also introduced the idea that environmental and cost savings can be realized while improving performance. The CNG program will also continue on base with the commitment made by the Logistics Readiness Squadron's Vehicle Operations Flight to place a standing order for CNG fleet vehicles. This has moved CNG vehicles from a test project to being fully integrated into the vehicle fleet stationed on Elmendorf. Through these successes, ENVVEST and Elmendorf have achieved their original aim of demonstrating superior environmental performance.

The most important success is that investments made under ENVVEST will positively influence the air quality for people stationed on Elmendorf and residents of Anchorage for some time to come.

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Demonstrating Superior Environmental Performance Through ENVVEST

ENV.VEST
Environmental Investment

On December 15, 1999, Elmendorf Air Force Base entered into an agreement with the ADEC and EPA under a program called ENVVEST – **ENV**ironmental In**VEST**ment. The program tested new ways of meeting environmental goals by allowing Elmendorf to develop alternative methods of achieving compliance with specific regulatory requirements of the Clean Air Act. Through ENVVEST, Elmendorf developed a diversified and less costly air emission source permitting structure. Savings realized were redirected to projects aimed at reducing basewide air pollutant emissions. This brochure provides a brief background on all the successful programs realized through ENVVEST.

Elmendorf's emissions are regulated under the Clean Air Act and permitted through a State-run permitting program (as provided under Title V of the Clean Air Act). The base's Title V operating permit requires Elmendorf to keep track of the amount of emissions released and report the amounts to ADEC periodically.

Prior to signing the ENVVEST agreement, Elmendorf was considered a single air contaminant emission source by ADEC. This meant that all the emissions sources on the base were combined together as one group and permitted based on one SIC code (Standard Industrial Classification code). This SIC system categorizes facilities by industry type according to their product or process (e.g., hospital, power generation plant, oil refinery). Elmendorf was permitted entirely under SIC Code 97 (National Security). This required large amounts of administrative manpower and money for Elmendorf to track, manage, and report the data necessary to maintain compliance with their single, comprehensive Title V operating permit.

ENVVEST followed EPA guidance to break up Elmendorf into 11 separate SIC codes that provided the foundation to develop multiple but streamlined Title V permits, which would result in a cost savings over time. Using that potential savings, ENVVEST was able to transfer money budgeted for Title V permitting requirements into Pollution Prevention (P2) projects that otherwise had no funding source available. ENVVEST resulted in spending approximately $1.5 million on those projects, which was equal to the estimated reduction in the costs of monitoring, recordkeeping, reporting, and management.

By using ENVVEST, Elmendorf was able to more efficiently comply with the Clean Air Act while implementing emission reduction projects (such as introducing compressed natural gas vehicles) rather than spending the money on monitoring, recordkeeping, reporting, and management, which would not necessarily have reduced emissions on their own.

Elmendorf conducted a study to see what types of projects would be best to reduce emissions. The report was then used to select projects for the ENVVEST program based on emission reduction potential, cost, practicality and usefulness,

ADEC = Alaska Department of Environmental Conservation.

EPA = U.S. Environmental Protection Agency.

ENVVEST = Environmental Investment.

Emissions = A substance released into the air.

SIC = Standard Industrial Classification.

P2 = Pollution Prevention. The goal of P2 is to reduce waste at the source, before it is generated. ENVVEST's P2 program is designed to help incorporate pollution prevention ideas and principles into daily operations at Elmendorf.

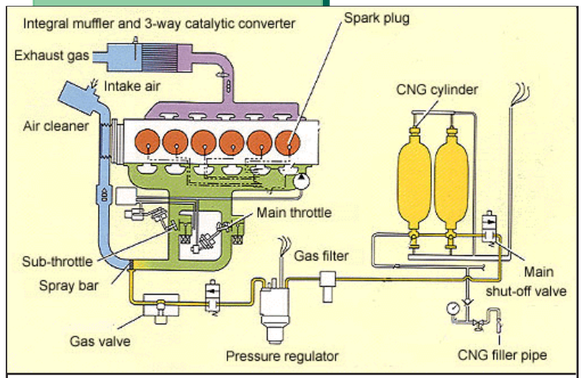
etc. Decisions about what to spend the money on were made by a group of stakeholders that included members of the public, State of Alaska, EPA, and Elmendorf representatives. During public meetings (held yearly or as required), potential projects were presented to the stakeholders, and they chose which projects to fund. Projects that would reduce carbon monoxide (CO) were emphasized in support of an Anchorage-wide push to lower CO levels as well as those that focused on reduction of hazardous air pollutants.

The ENVVEST program lasted 5 years (1999-2004) and resulted in spending approximately $1.5 million. This money was spent on a variety of P2 opportunities:

- Compressed Natural Gas (CNG) fueling station
- Conversion of vehicles to CNG
- Purchase of dedicated CNG vehicles
- New/improved surface coating equipment
- Takeoff and landing emissions inventory
- Fuel cell installation
- Training for the above activities, where required

CO Reduction Through Compressed Natural Gas

Elmendorf's main P2 project was the introduction of a CNG fleet and fueling station. Using CNG, Elmendorf was able to support the Municipality of Anchorage and the State of Alaska's effort to reduce CO levels in the Anchorage urban area. Testing the use of CNG-powered vehicles also assists the Municipality and State in demonstrating the usefulness of CNG in a cold weather climate, which may benefit other Alaskan communities. After 25 years of not meeting federal clean air standards, the EPA designated Anchorage as an area that officially meets the CO standard in 2004. CO reduction strategies must continue if Anchorage is to keep on meeting the standard.



CNG Engine Operation

Source: http://media.mitsubishi-motors.com/pressrelease/e/products/detail629.html

CNG is natural gas (mainly methane drawn from gas wells or produced alongside crude oil) that has been compressed and stored in cylinders. The gas is released from these cylinders and passes through a pressure regulator that brings the gas to almost atmospheric pressure. The gas then passes to an air-mixer, where it is combined with air in the gas-to-air ratio required by the engine for ignition. The gas then flows into the engine's intake air stream for combustion.

CNG has a number of advantages over gasoline or diesel. Unlike gasoline, CNG is odorless, colorless, and tasteless. It is non-toxic and poses no threat when spilled. If spilled, CNG dissipates rapidly and has a much lower explosion risk than gasoline. Overall CNG-powered vehicles are as safe as gasoline-powered ones. CNG use can also increase the life of a vehicle because it burns cleaner than gasoline, making the engine more efficient. As a result, the oil in CNG vehicles does not need to be changed as often as there are fewer deposits in the oil. With a CNG-dedicated engine, power, acceleration, and cruise speed can be greater than a

Stakeholder = Any party that has an interest in an organization. In this case, the ENVVEST stakeholders include Elmendorf, ADEC, EPA, local public officials and agencies, and the Anchorage community.

CO = Carbon monoxide. CO is a poisonous gas produced by the incomplete combustion of fossil fuels (gas, oil, coal) and wood used in boilers, engines, oil burners, gas fires, water heaters, and open fires.

CNG = Compressed natural gas.

Natural gas = A common fuel that comes from underground. It has been found to be one of the most environmentally friendly fuels. Its simple, one-carbon molecular structure (CH_4) makes possible its nearly complete combustion (clean burning).
Source: http://www.energyquest.ca.gov/transportation/CNG.html

SUV = Sport utility vehicle.

Road Paint Truck

Road and airfield painting operations (such as center line stripes) were a significant source of HAPs on Elmendorf. The HAPs emissions inventory found that actual emissions from these activities were nearly 6 tons during the 1998 season.

Road Paint Truck

Emissions could be lowered to almost zero if Elmendorf used water-based paints that contain low to no HAPs/VOCs. Besides significantly reducing emissions, these paints are also much cheaper and could result in substantial annual cost savings. However, due to water-based paints' different components and consistency, a special style of application truck was needed. A new truck was considered as an ENVVEST project due to the high level of emission reductions possible, but the project ultimately received funding from another source. In 2002, Elmendorf received funds for the new application truck from federal level Air Force P2 programs. Thanks to identification of the problem and discovery of a solution, the road paint truck is still a success for ENVVEST. The momentum created by the ENVVEST project led to another source of funds being found for the truck's purchase.

The application truck has been in use since summer 2003. Reports from staff have been positive, and they have been happy with paint quality and durability. The truck was also shipped to other Air Force installations in Alaska to provide airfield and roadway striping, furthering the air quality benefits beyond Elmendorf.

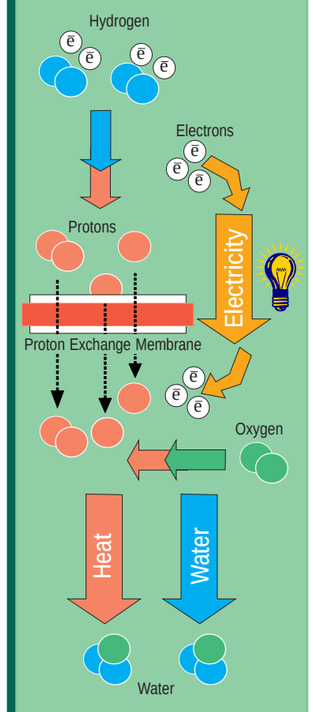
Fuel Cells

Fuel cell technology was not initially included as a potential ENVVEST project due to the high costs involved. However, since the start of the ENVVEST project, costs have gone down, and it was decided that a small fuel cell project would be a useful demonstration of clean electricity production. A number of buildings were compared with the required criteria for the installation of a fuel cell, and Fire Station 3 was selected after meeting all criteria. Further testing was completed to check the electricity demand at the 4-man station. It was found that power demand at the station would always be greater than the amount of energy produced by the fuel cell (5 kilowatts). While this meant that additional power would need to be provided by the standard power grid on base, it also meant that the fuel cell could operate at a constant power output. By allowing the fuel cell to operate constantly, the cell will have a longer life and will operate at peak efficiency – leading to greater long-term savings.

Several types of fuel cells are available. The type chosen for this project was the Proton Exchange Membrane Fuel Cell (PEMFC) technology. This type of fuel cell is widely available from vendors, is relatively low cost ($70,000), has a high-power density, has a low operating temperature, and a rapid startup. The PEMFC can be bought ready for use, simply requiring connection to a power panel and fuel source (natural gas).

PEMFC systems work using a simple chemical process that combines hydrogen and oxygen from the air to produce electric power without combustion. Natural gas (fuel) is fed into the anode of the fuel cell. Oxygen (from air) is fed into the

How Fuel Cells Work



There are many paint gun models with a variety of tip sizes that work with most coatings. Clogging problems can slow down operations if the technician is not familiar with the equipment or the application techniques. As part of the ENVVEST program, Elmendorf staff were trained in HVLP use. Having properly trained staff further increased the transfer efficiency and further decreased emissions. It is hoped that when trained staff move on to other bases, they bring with them the good techniques and practices learned through ENVVEST projects. Spreading environmentally friendly practices to other bases helps to increase the overall long-term environmental benefits of ENVVEST investments made in Alaska throughout the nation.

Automatic Spray Gun Washers

In addition to the benefits of less overspray and less total paint volume used by HVLP, Elmendorf also made other changes to the surface coating process to make further environmental improvements. HAP reductions during painting were achieved by a combination of HVLP spray guns, training for personnel (designed to improve transfer efficiency), new paint partition and mixing systems, and automatic spray gun washers. Using the paint partition and mixing systems to mix only the specific amount and color needed for each individual paint job results in material cost savings, which further reduces costs through waste reduction.

Automatic spray gun washers have a number of environmental benefits:

- Cleaning solvent can be reused, reducing consumption by 50 to 75%.
- Volatile organic compound (VOC) emissions can be reduced by as much as 75 to 90% as compared to a solvent sink.
- Less solvent is lost through evaporation compared to a solvent sink.
- Spray guns are more effectively cleaned using the spray gun washers.
- The washing cycle is only 30 to 60 seconds compared to 5 to 20 minutes for manual cleaning.
- Solvent costs and disposal costs are reduced through reuse.
- Worker exposure to toxic substances is reduced as the spray gun washer is sealed during use.

Elmendorf also established a basewide move to high solids/low VOC paints. These paints contain lower levels of HAP solvents such as toluene, xylene, and methyl ethyl ketone (MEK).

Paint booth carbon adsorption unit

In addition to these efforts to minimize the generation of emissions, the Corrosion Control Facility was selected for the installation of new paint booths equipped with carbon adsorption units. While the Corrosion Control Facility already had state-of-the-art emission controls in its large aircraft paint booth, two frequently used booths for smaller items had no such controls. These new units remove approximately 85% of solvents (VOCs) from paint booth vent emissions, further decreasing basewide VOC emissions. High Efficiency Particulate Air (HEPA) filters that trap fine particulates were also installed on paint removal "blaster" equipment, further reducing emissions.

VOC = Volatile organic compound.

MEK = Methyl ethyl ketone.

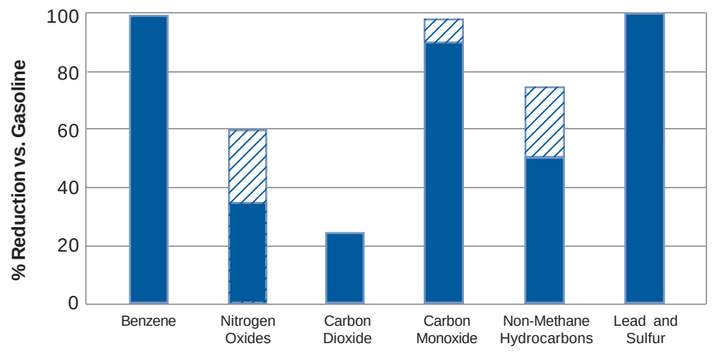
HEPA = High Efficiency Particulate Air.

PEMFC = Proton Exchange Membrane Fuel Cell.

gasoline-powered engine. In heavy duty vehicles, CNG engines are generally less noisy than diesel powered engines.

Using CNG, instead of gasoline, can potentially reduce emissions by up to 97%. The chart below shows the potential reductions in emissions for some of the criteria air pollutants when using CNG instead of gasoline.

Potential Reduction in Emissions for CNG vs. Gasoline



Note: The hatched extensions on the bars represent ranges in results (e.g., range of 35 to 60% reduction for nitrogen oxides).

Source: www.trianglecleancities.org/fs-cng.htm.

The total cost of CNG-related activities during the ENVVEST project was $902,300 (60% of total ENVVEST funds).

CNG Fueling Station: The CNG fueling station has a 250 cubic feet per minute (cfm) compressor, a series of cascading storage tanks, and two filling stands. The station tracks fuel use through a computerized system. The addition of the canopy made the station more user friendly by reducing the need for winter snow removal. The cost of running the CNG station is similar to the cost of running a regular fuel station.

Training: CNG cylinders need to be regularly inspected by certified inspectors. In 2003 the Vehicle Operations Flight received training on CNG cylinder inspection. The CNG program is more cost-efficient if the system is operated and maintained by Elmendorf staff.

Vehicle Conversions: Costs per vehicle vary, but the average cost was $9,000. Vehicles were selected for the conversion process based on:

- Engine type (EPA-approved CNG conversion kits are not available for all engine types)
- Usable cargo space (CNG tanks take up cargo space, usually the trunk)
- Frequency of use (high use vehicles were given priority)
- Availability of vehicles on Elmendorf

Timeline of CNG Project by Fiscal Year:

1999 Design and construction of CNG fueling station

2000

2001 Conversion of vehicles to CNG (2000-2002)

2002 Bus conversion to dedicated CNG; Canopy added to CNG fueling station

2003 CNG cylinder inspection and training course

HAP = Hazardous air pollutant.

AEI = Air Emission Inventory.

HVLP = High-volume low-pressure.

psi = Pounds per square inch.

Vehicles converted included SUVs, pickup trucks, telephone maintenance trucks, and a 44-passenger shuttle bus. The vehicles are dual-fuel (CNG and gasoline) with the exception of the bus, which runs on a dedicated CNG engine.

Vehicle Acquisition: In October 2002, 19 new factory-direct dual-fuel CNG vehicles were delivered (these vehicles can operate on either CNG or gasoline). As part of the spread of new ideas to the rest of Elmendorf stemming from the ENVVEST program, the Logistics Readiness Squadron's Vehicle Operations Flight has placed a standing order for CNG fleet vehicles. As part of this process, 26 crew cab pickup trucks were delivered in 2004. All vehicles purchased in 2004 use factory-installed CNG systems. Even though the ENVVEST program has now ended, the CNG fleet will continue to grow through new purchases, increasing the long-term environmental gains of the investments made under ENVVEST.

In total (as of December 2004) there are 77 CNG vehicles on Elmendorf, the majority of these are 6-passenger crew-cab pickup trucks.

CNG Fueling Station, clockwise from top left: First customer, CNG fueling station dedication ceremony, April 2000; canopies were added in 2002 to enhance usability and maintenance by protecting the gas cylinders and dispenser island; Elmendorf's 44-passenger shuttle bus was converted to a dedicated CNG engine; state-of-the-art fuel dispenser is integrated with a Fuel Master® tracking system, which logs gas usage by vehicle.

Hazardous Air Pollutant Reduction

In 1999 the Institute for Environment, Safety, and Occupational Health Risk Analysis conducted a hazardous air pollutant (HAP) emissions reduction survey on Elmendorf. As part of this process, the base's Air Emission Inventory (AEI) and Title V Permit Application were reviewed to determine which processes were responsible for the greatest actual and potential HAP emissions, and also those processes that would benefit the most from a project designed to reduce emissions. The survey identified five areas that could benefit from an emissions reduction project: surface coating operations, internal combustion engines, incinerators, gasoline distribution, and aircraft engine testing. Surface coating operations were the largest source of HAP from this list and were chosen to receive ENVVEST funds because the greatest environmental benefits could be gained from the investment.

Timeline of HAP Projects by Fiscal Year

1999	Hazardous Air Pollutant Projects Development Study
	Spray Gun Parts Washer for Corrosion Control Paint Shop
	High Volume-Low Pressure (HVLP) Spray Guns for Vehicle Maintenance Paint Shop
2000	HVLP Spray Guns for Corrosion Control Paint Shop
	HVLP Spray Guns and Sanders for Vehicle Maintenance Paint Shop
	Paint Partition & Mixing System for Vehicle Maintenance Paint Shop
	HVLP Spray Paint Training for Elmendorf Painting Personnel
2001	Landing & Takeoff Emissions Inventory
	Design of Paint Booths for Corrosion Control and Vehicle Maintenance
2002	Paint Booth Construction – Corrosion Control
2003	Fuel Cell Project
2004	Fuel Cell Project Continuation
	Fuel Cell Operation & Maintenance Training for Civil Engineering Personnel
	Spray Gun Washer Rebuild Kits
	HEPA Filters for Corrosion Control Blasters

The total cost of HAP-related projects was $612,801 (39% of total ENVVEST funds).

Surface Coating Operations

A total of 15 HVLP Spray Guns were purchased with ENVVEST funds. This kind of spray gun has many environmental advantages over high pressure systems. HVLP systems produce a fine spray of paint by delivering a high volume of air at a low pressure (less than 10 pounds per square inch [psi]). Because the paint particles are sprayed at a low rate, less paint is lost as overspray, bounce, and blow back. Typically the transfer efficiency with HVLP paint systems is 50 to 65% (compared with 25 to 30% for conventional systems). The HVLP paint spray system also uses less paint than high pressure systems, can be used in a wide variety of painting applications, and results in smoother finishes due to the finer paint particles produced.

Using HVLP spray gun on Air Force plane

What are HAPs and VOCs?

Hazardous Air Pollutants (HAPs) are 188 air pollutants identified by EPA that, when their emissions are not controlled through available technology, are most likely to have the greatest impact on air quality and human health. HAPs are pollutants that are known or suspected to cause cancer or other serious health effects or adverse environmental effects. Most air toxics originate from human-made sources, including mobile sources (e.g., cars, trucks, buses) and stationary sources (e.g., factories, refineries, power plants), as well as indoor sources (e.g., some building materials and cleaning solvents). Some air toxics are also released from natural sources such as volcanic eruptions and forest fires.

Many HAPs are also **Volatile Organic Compounds** (VOCs); for example, benzene (found in gasoline) is both a HAP and a VOC. VOCs are organic chemicals that form vapors at normal temperatures and play a part in creating smog.