



FUELCELL COALMINE VEHICLE DEMONSTRATION PROJECT

**Final Progress Report
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Table of Contents

List of Terms and Abbreviations- Figures and Tables.....	3
Abstract.....	4
Fuelcell Coalmine Vehicle Demonstration Project.....	4
Highlights/Significant Findings	6
Translation of Findings	6
Outcomes/Relevance/Impact.....	7
Background	8
Specific Aims	8
Determine which coalmine vehicle will be modified into a fuelcell vehicle	8
Demonstration Mine location for the underground hydrogen fuelcell locomotive	15
Generate O ₂ from H ₂ O	16
Produce Hydrogen from Coal-bed Methane	17
Electric Power Takeoff	19

List of Terms and Abbreviations

- 1.) Fuelcell: A proton exchange membrane, hydrogen to electricity conversion module.
- 2.) SMR-Steam Methane Reformer: onsite industrial reformer used to separate hydrogen from coal-bed methane for use in the fuelcell vehicles.
- 3.) CBM-Coal-Bed Methane: Trapped natural gas typically found in coal seams.
- 4.) UMWA: United Mine Workers of America
- 5.) Duty cycle: power as a function of time, operating conditions of the vehicle mapped over a fixed time period

Figures and Tables

Figure 1: Successfully demonstrated fuelcell metal mine locomotive (left) and a successfully demonstrated hydrogen-hybrid switch locomotive (right).	5
Figure 2: Example of a duty cycle, power as a function of time, for a switch locomotive operating in a rigorous environment, the Port of Long Beach, California, USA.....	9
Figure 3: Photograph of the 20 ton locomotive to be converted to fuelcell power.....	10
Figure 4: Mechanical drawing of the locomotive before conversion plan.....	10
Figure 5: Powerplant and hydrogen storage shown inserted into the vehicle.....	11
Figure 6: Underground coalmine vehicle using the Ballard HD-6 fuelcells.....	12
Figure 7: Metal-hydrides have high volumetric storage density, long dormancy, reversible operation for very pure hydrogen and low storage pressure.....	13
Figures 8-9: CAD drawing and photograph of the hydrogen storage in Figure 8 and a CAD overlay of the HD-6 fuelcell system with the existing powerplant.....	14
Figures 10-11: Two SD70MACs, loading a Somerset train at Consol's Blacksville #2 and the aerial view of the mine exit facility in West Virginia.....	15
Figure 12: Electrolysis oxygen generation process with hydrogen storage and PEM power utilization.....	16
Figure 13: Production stages of a coal-bed methane well (adapted from Rice, 1997).....	17
Figure 14: Skid with the Stuttgart Steam Reformer Unit	18
Table 1: Performance requirements of loader metal-hydride storage [Miller et al 2006].....	13

Abstract

Fuelcell Coalmine Vehicle Demonstration Project

Coalmining is a highly regulated industry in the U.S. and continues to look for innovative solutions that improve worker health and production performance in parallel. The coalmine industry has an opportunity through the use of fuelcells to enhance the health and safety of underground traction power. Conventional power technologies — tethered, diesel, and battery — are not simultaneously clean, safe, and productive. Tethered vehicles are power-dense and clean, but the tether has safety risks inherent to a trailing cable, which also interferes with mobility and productivity. Battery vehicles are clean and mobile but take eight hours to recharge and have to be towed when batteries are exhausted. Diesel vehicles are more mobile and theoretically more productive, but their compliance with government-mandated emissions controls reduces actual productivity, and their abated emissions continue to present a hazard to miners' health.

A fuelcell-powered coalmine vehicle will incorporate the best advantages of electric and diesel-powered vehicles while avoiding their disadvantages: It combines the workplace environmental benefits of a battery vehicle with the energy density and mobility of a diesel. The proposed vehicle will be fueled by hydrogen, derived from coal-bed methane, stored onboard safely and compactly as a reversible metal hydride.

The Coalmine fuelcell vehicle technology defined in this phase I project is a significant advancement for coalmining worker safety, mine disaster mitigation, onsite energy generation and mine environment improvement resulting in lower operating costs for mine operators. The United Mine Workers of America and Vehicle Projects Inc have combined experience in mining operations, mine safety procedure development, vehicle fuelcell integration, onsite hydrogen generation, mobile emergency oxygen source, advanced on-board hydrogen storage, and effective vehicle takeoff power for underground tool operations.

The United Mine Workers of America work closely with mine operators and working American miners to advance worker safety, mine working environment and worker productivity in coalmining operations. The knowledge and experience of the UMWA was important in determining vehicle choice, project location and demonstration specifics in a real world operating coalmine.

Vehicle Projects Inc has extensive experience in fuelcell technology and is a recognized leader in fuelcell vehicle integration and zero-emissions system development. Vehicle Projects successfully designed, built, and demonstrated a mining locomotive for metal mine operations and a fuelcell switch locomotive for commercial rail yard operations. (Figure 1, below) Although fuelcells are manufactured commercially they need to be integrated into existing vehicle platforms replacing diesel-powered equipment or less mobile battery powered and tethered

technologies in coalmine operations. The balance of power systems are engineered and integrated into the coalmine vehicle by Vehicle Project professional staff and coalmine professional staff onsite at a Pennsylvania coalmine location.

This project to develop and demonstrate a fuelcell coalmine vehicle can strongly benefit both labor and industry. The vehicle will provide a health benefit to miners by replacing diesel-powered equipment with emissions-free, quiet fuelcell power. The fuelcell-battery hybrid will provide the safety benefit of being able to produce oxygen from water and thus serve as a mobile emergency oxygen source underground. While benefiting both the health and safety of miners, it will equal or exceed the productivity of a diesel vehicle. Hydrogen fuel, stored safely onboard the vehicle as a solid, will be produced aboveground from coal bed methane. With the current high price of diesel fuel, production of fuel from a byproduct of mining would afford a significant cost savings to the coalmine industry.



Figure 1. Successfully demonstrated fuelcell metal mine locomotive (left) and a successfully demonstrated hydrogen-hybrid switch locomotive (right).

Highlights/Significant Findings

The five project highlights and significant findings are:

- 1.) Determine which coalmine vehicle will be modified into a fuelcell vehicle.
The vehicle chosen by the consortia to be modified into a fuelcell vehicle is the E-244, 25 ton battery locomotive utilizing two, GE-BT 2399-A1 motors and manufactured by Irwin Car and Equipment Company in Irwin, Pennsylvania. The locomotive was chosen by the consortia for conversion, because it is presently operating in the Blacksville number two mine.
- 2.) Determine which operating coalmine the demonstration would take place.
With the assistance of the UMWA, CONSOL Energy has consented to support a demonstration of the hydrogen coalmine locomotive at the Blacksville number two mine. Pennsylvania and West Virginia both share portals to this unique coalmine.
- 3.) Generate O₂ from H₂O on board the vehicle as an emergency oxygen source.
The system uses available coalmine water and water emissions from the onboard fuelcells to generate emergency oxygen using the electrolysis mode of a proton exchange membrane cell. The emergency oxygen generator would be a stand-alone system with a by-product of hydrogen, resulting in a hydrogen supply source for the locomotive's fuelcells. This closed loop emergency support system would allow continued oxygen generation for miners trapped and the added benefit of an energy source for power tools, lighting, heat, etc.
- 4.) Produce hydrogen from coal-bed methane on site.
Large-scale methods to produce hydrogen from natural gas are well developed and account for over 95% of all hydrogen produced in the U.S. and 48% globally. Smaller scale Steam Methane Reformers (SMR) plants are only recently available for use at industrial sites. Efficient conversion of coalmine methane to hydrogen and electricity, powering on-site fuelcell vehicles and plant electrical equipment, utilizes the resident energy carrier, thus reducing dependence on external energy sources.
- 5.) Electric power takeoff from the fuelcell vehicle.
Electric power takeoff allows the vehicle to be a mobile power source for electric mine tools or an emergency power source for trapped miners.

Translation of Findings

A fuelcell-powered coalmine vehicle demonstration in the CONSOL Blacksville number two mine will incorporate the best advantages of electric and diesel-powered vehicles while avoiding their disadvantages. The zero-emissions fuelcell-powered coalmine vehicle with low acoustic generation, electric power takeoff, on-board emergency oxygen generator, and coal-bed methane

as the primary energy supply, addresses many of the problems found in the coalmining industry today.

The proposed vehicle will be fueled by hydrogen, derived from coal-bed methane, stored onboard safely and compactly as a reversible metal hydride, thus reducing or eliminating the need for external energy sources. Environment-sensitive conversion of coal-bed methane into hydrogen and electricity combined with zero-emissions, low noise, electric power takeoff, and emergency breathable oxygen provided by the vehicle, strongly benefit both the health and safety of miners.

Outcomes/Relevance/Impact

The most relevant conclusion to this study is the potential outcome, leading to significant advancement for coalmining safety and health with the added benefit of realizing onsite energy security through reduced onsite use of imported oil energy sources, resulting in lower operating costs for mine operators. This study demonstrates an immediate impact on the coalmining industry by adding mobile survival equipment to existing stationary survival equipment; thus, enhancing mine disaster mitigation by adding another survival option for coalminers in the event of a mine collapse or disaster. The vehicle would provide mobile emergency breathable oxygen, electric power takeoff for mining tools and equipment, and operate quietly without exhaust emissions, realizing cleaner air and lower machine generated decibel levels in the working coalmine environment.

Background

Coalmining is a highly regulated industry in the U.S. and continues to look for innovative solutions that improve worker health and production performance in parallel. The United Mine Workers of America and Vehicle Projects Inc, through this study, propose to employ a combination of fuelcell and hydrogen-storage technologies that has been successfully developed by Vehicle Projects Inc in a mine locomotive and a mine loader for underground metal mines. The coal industry has an opportunity through the use of fuelcells to enhance the health and safety of underground traction power. Conventional power technologies — tethered, diesel, and battery — are not simultaneously clean, safe, and productive. Tethered vehicles are power-dense and clean, but the tether has safety risks inherent to a trailing cable, which also interferes with mobility and productivity. Battery vehicles are clean and mobile but take eight hours to recharge and have to be towed when batteries are exhausted. Diesel vehicles are more mobile and theoretically more productive, but their compliance with government-mandated emissions controls reduces actual productivity, and even their abated emissions may present a hazard to miners' health.

A fuelcell-powered coalmine vehicle will incorporate the best advantages of electric and diesel-powered vehicles while avoiding their disadvantages: It combines the workplace environmental benefits of a battery vehicle with the energy density and mobility of a diesel. The proposed vehicle will be fueled by hydrogen, derived from coal-bed methane, stored onboard safely and compactly as a reversible metal hydride.

This study for the proposed project to develop and demonstrate a fuelcell coalmine vehicle can strongly benefit both labor and industry. The vehicle will provide a health benefit to miners by replacing diesel-powered equipment with emissions-free, quiet fuelcell power. Moreover, the fuelcell-battery hybrid will provide the safety benefit of being able to produce oxygen from water and thus serve as a mobile emergency oxygen source underground. While benefiting both the health and safety of miners, it will equal or exceed the productivity of a diesel vehicle. Hydrogen fuel, stored safely onboard the vehicle as a solid, will be produced aboveground from coal-bed methane. The fuelcell coalmine vehicle will have electric takeoff allowing use of any tool or device needed during underground operation eliminating the need to employ additional electrical infrastructure to operate the electrical hand tools or devices.

Specific aims

1.)Determine which coalmine vehicle will be modified into a fuelcell vehicle.

The vehicle chosen by the consortia to be modified into a fuelcell vehicle is the E-244, 20 ton battery locomotive utilizing two, GE-BT 2399-A1 motors and manufactured by Irwin Car and

Equipment Company in Irwin, Pennsylvania. This particular locomotive was chosen by the consortia for conversion, because it is presently operating in the Blacksville number two mine. Vehicle choice is important because the conversion specifications need to meet or exceed the selected vehicles manufacturer specifications. The rational starting point for engineering design of a fuelcell-hybrid vehicle is the duty cycle. Below is the duty cycle for a Switch Locomotive in Figure 2. That is, function $P(t)$, where P is vehicle power and t is time – recorded from an in-service yard switching locomotive. The vehicle’s required mean power, maximum power, power

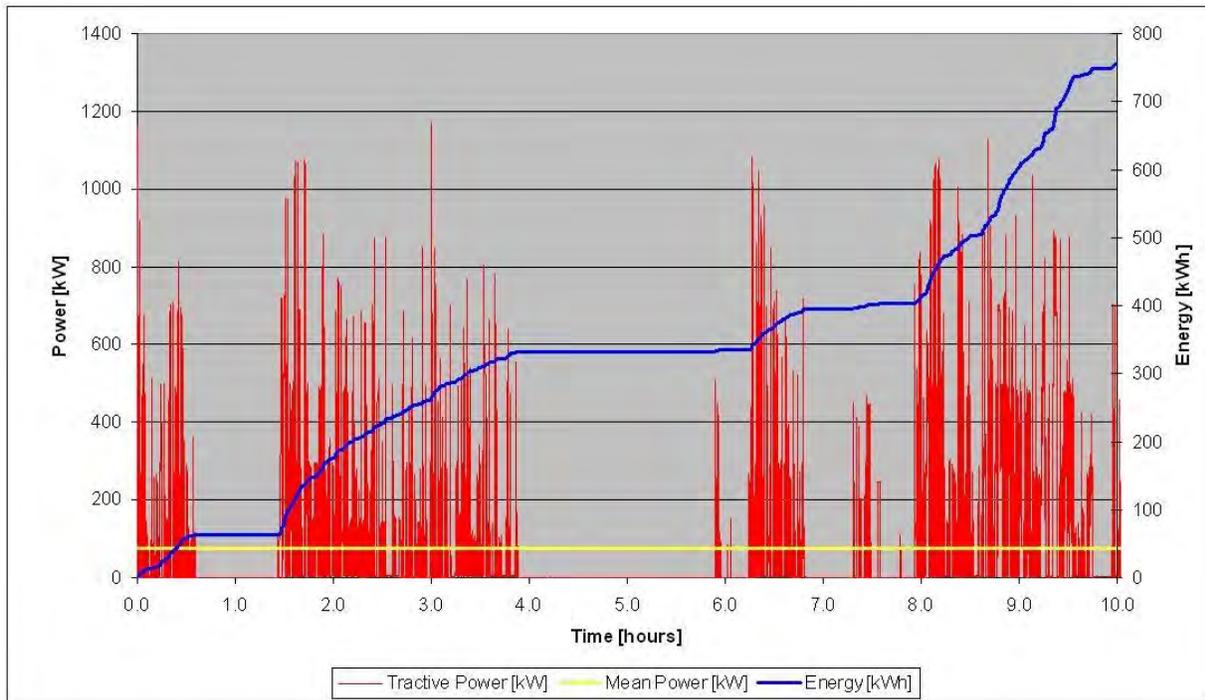


Figure 2 – Example of a duty cycle, power as a function of time, for a switch locomotive operating in a rigorous environment, the Port of Long Beach, California, USA

response time, and power duration are calculated from function P ; its energy storage requirements are calculated from the integral of P . As shown, peak power commonly reaches 600-1100 kW for durations of no more than several minutes, usually corresponding to acceleration of train cars or uphill movement. Between the peaks, however, the power requirements are minimal when coasting a load, or zero when idling between move operations. The idle time, varying from minutes to hours between operations, usually accounts for 50-90% of the overall operation schedule. These characteristics of the duty cycle are ideal for a hybrid powerplant, in which the prime mover operates at or above the relatively low mean power and an auxiliary energy/power device (battery) augments power to overcome the peaks.

The locomotive chosen by the consortia to be modified into a fuelcell vehicle is shown in Figure 3, below.



Figure 3. Photograph of the 20 ton locomotive to be converted to fuelcell power.

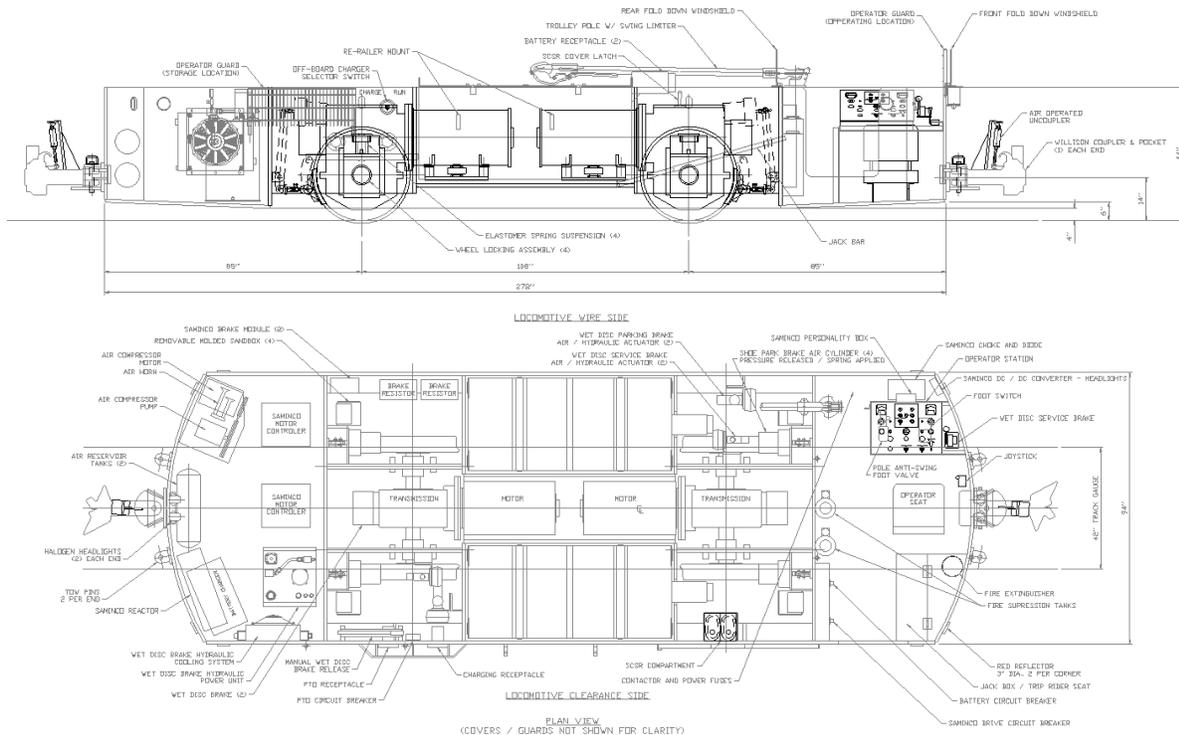


Figure 4. Mechanical drawing of the locomotive before conversion plan

The first of two plans for conversion of the underground coalmine locomotive into a zero-

emissions coalmine locomotive is shown in Figure 5, below. This plan utilizes the existing powerplant and hydrogen storage provided by the Department of Energy. The loader powerplant is shown in green with peak continuous power of 74 kW (95 hp) net. The powerplant would need to be repackaged, as the present configuration is too tall for the locomotive mine specifications. The powerplant produces 140 kW (180 hp) net for short durations of time (minutes), this is achieved through the vehicles hybridity characteristics. The locomotive will have two-7 kg reversible metal hydride hydrogen storage units shown in blue.

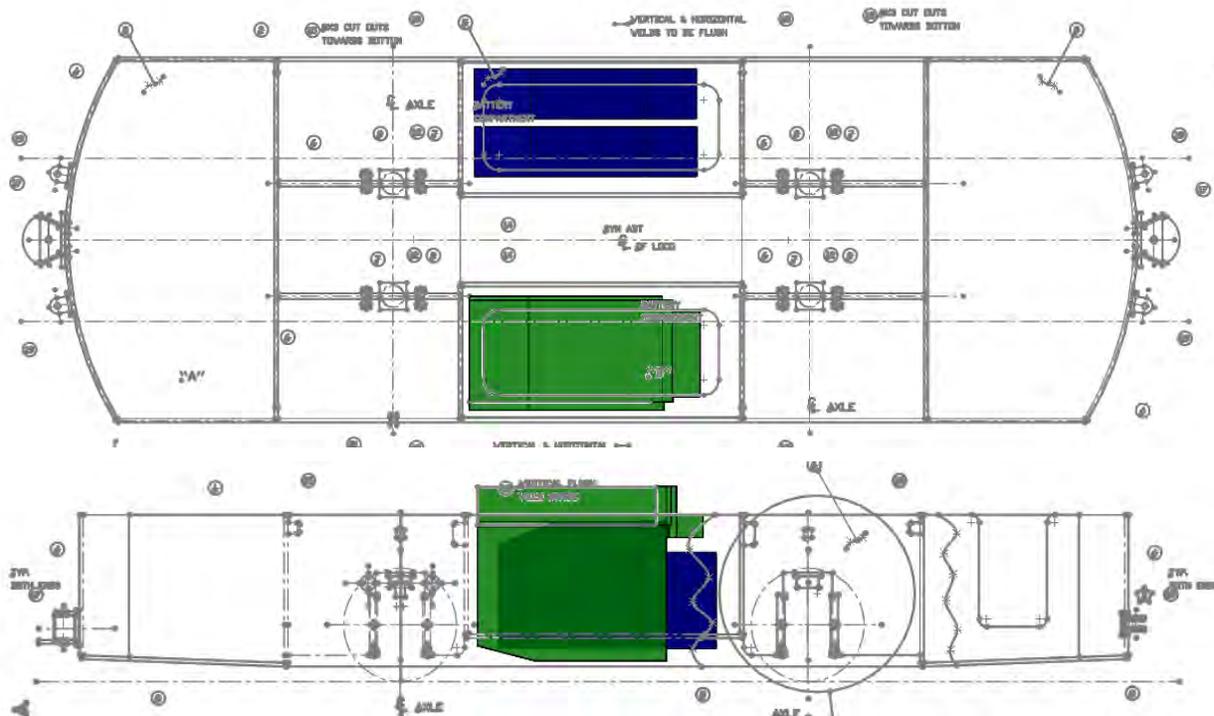
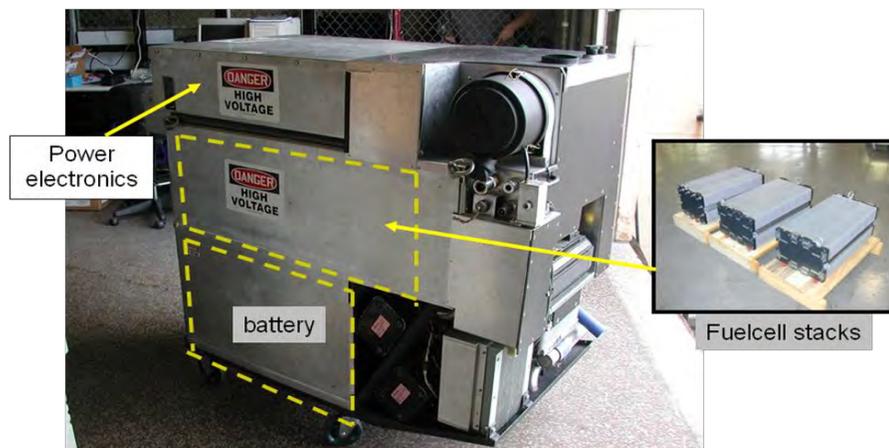


Figure 5. Powerplant and hydrogen storage shown inserted into the vehicle.

Photograph of the powerplant, showing the location of the power electronics, fuelcell stacks, and the battery. The existing powerplant is too high for the locomotive and would require repackaging to conform to vehicle specifications. . The module consists of 3 PEM fuelcell stacks rated at 290V, 300A, 87 kW



gross output power along with 108 Nickel Metal-Hydride (NiMH) batteries capable of an additional 75 kW for about 5 minutes. Peak power is about 140 kW net for short durations, such as loading the bucket with ore or tramping up an incline.

The second conversion plan for the underground coalmine locomotive shown in Figure 6, below, utilizes the existing reversible metal hydride hydrogen storage modules provided by the Department of Energy. This plan uses new fuelcell technology from Ballard Power Systems Inc. The Ballard HD-6 driven powerplant provides peak continuous power at 120 kW net (155 hp) and may require a small/medium peak shaving battery (not shown).

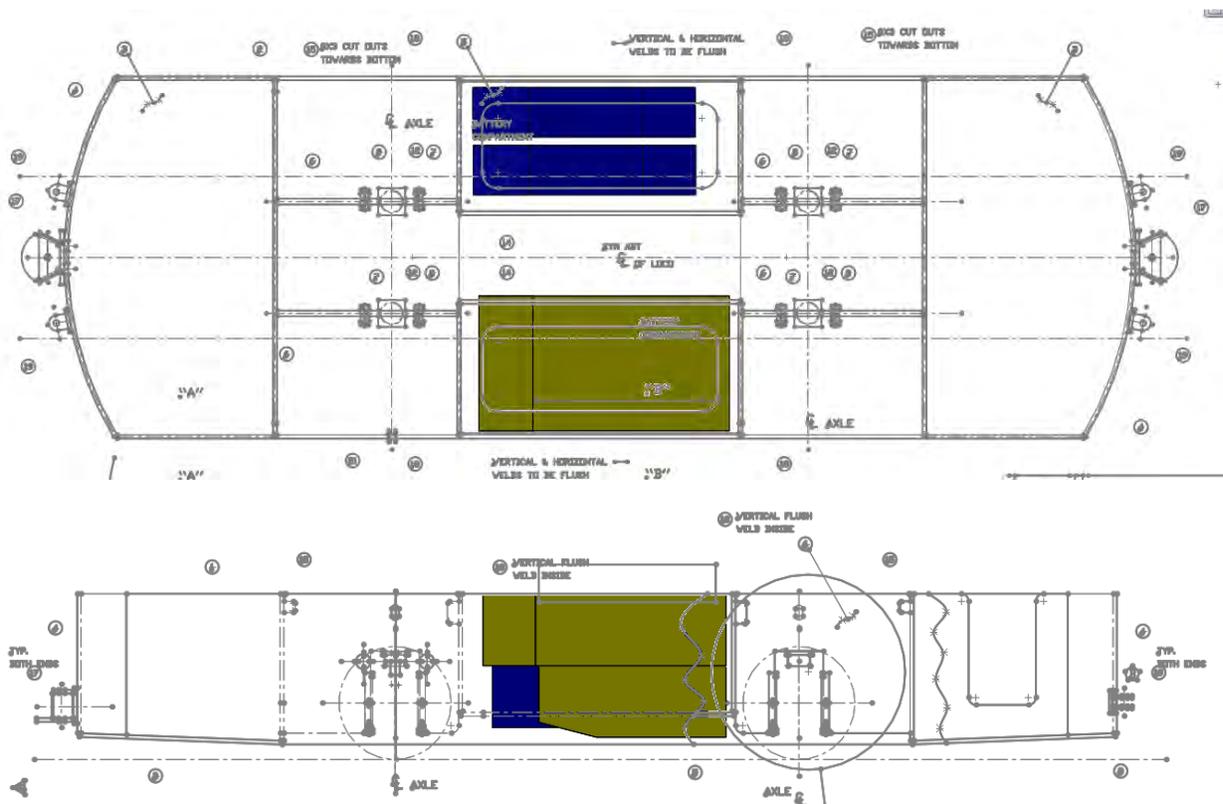


Figure 6. Underground coalmine vehicle using the Ballard HD-6 fuelcells.

The technological fundamentals of fuelcell power must fit within safe coalmine operating requirements. This includes the safety of storage and use of hydrogen. The hydrogen storage choice is the reversible metal-hydride alloy which provides low pressure and diffusivity which meets the following basic hydrogen storage requirements.

- Low release rate if ruptured
- Sufficient capacity for at least one work shift of a vehicle
- Sufficient capacity for more than one work shift for stationary application
- Refueling underground

- Rapid refueling, timeframe of conventional diesel vehicle refueling
- Refueling by the vehicle operator during production work, and
- Storage medium will not be so heavy as to exceed total vehicle weight limitations and to maximize the efficiency of the vehicle (payload relative to empty vehicle weight)

The metal-hydride storage was required to meet the following performance specifications in Table 1.

Capacity	Hydrogen storage capacity of 14kg for operation of approximately one shift
Hydrogen Flow	Full-power hydrogen flow of 840L/min at 3.1 bar. Half-power hydrogen flow of 420L/min at 1.9 bar
Maximum Pressure	Hydrogen pressure limited to 7.8 bar during vehicle operation in a mine
Refueling	Heat transfer kinetics to allow refueling in less than 30 minutes. Metal hydride system is capable of being refueled in situ or off the vehicle
Layout	Storage system has low profile so it does not interfere with operator visibility
Mechanical	The system must withstand shock and vibration associated with coalmine locomotive service

Table 1: Performance requirements of loader metal-hydride storage [Miller et al 2006]

The HERA metal-hydride storage system (Figure 7) can be refueled in 15 minutes. This was demonstrated successfully with the hydrogen storage module in Figure 7. Safety of the metal-hydride system has also been increased by reducing the pyrophoricity of the metal-hydride. The



Figure 7: Metal-hydrides have high volumetric storage density, long dormancy, reversible operation for very pure hydrogen and low storage pressure.

trade off for the fast refueling rate is complexity of the heat exchanger while the trade off for reduced pyrophoricity of the metal-hydride is somewhat lower hydrogen density than originally specified and desired.

Few options under current research show the flexibility of storage provided by metal hydrides. Compressed hydrogen, while another proven and extensively tested storage option, is restricted to the volume of hydrogen that can be stored and suffers from negative consequence anticipation.

The 14 kg of hydrogen are stored in

four separate canisters. Waste heat from the fuelcells desorbs the hydrogen from the metal-hydride for use by the fuelcells. Since the fuelcell-battery hybrid coalmine locomotive is to be demonstrated underground in restricted environments, the amount of heat provided to the metal-hydride will be closely controlled to minimize the pressure in the canisters and ultimately the amount of free hydrogen in the system. Cooling fluid transfers' fuelcell and battery waste heat to the metal-hydride heat exchangers to release hydrogen for power production and removes heat. The heat absorbed by the storage system reduces the heat load on the vehicle's excess heat radiator.

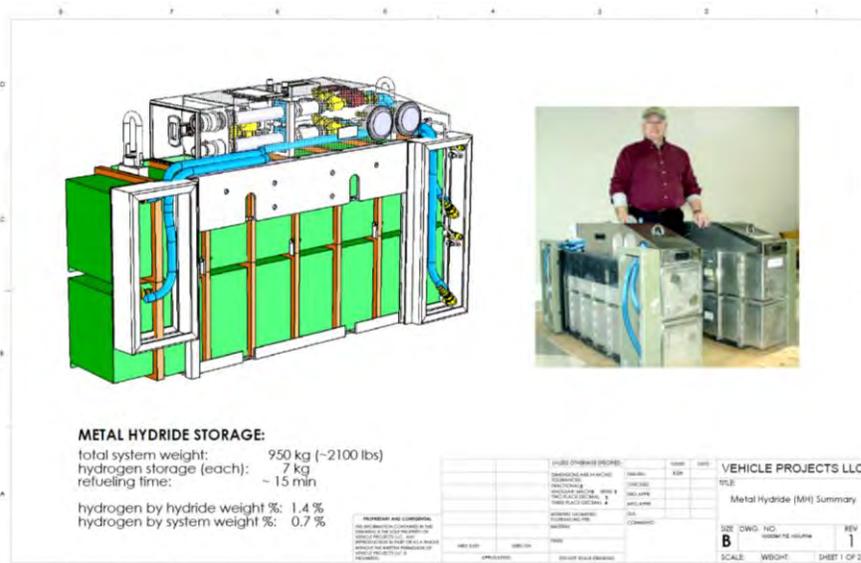
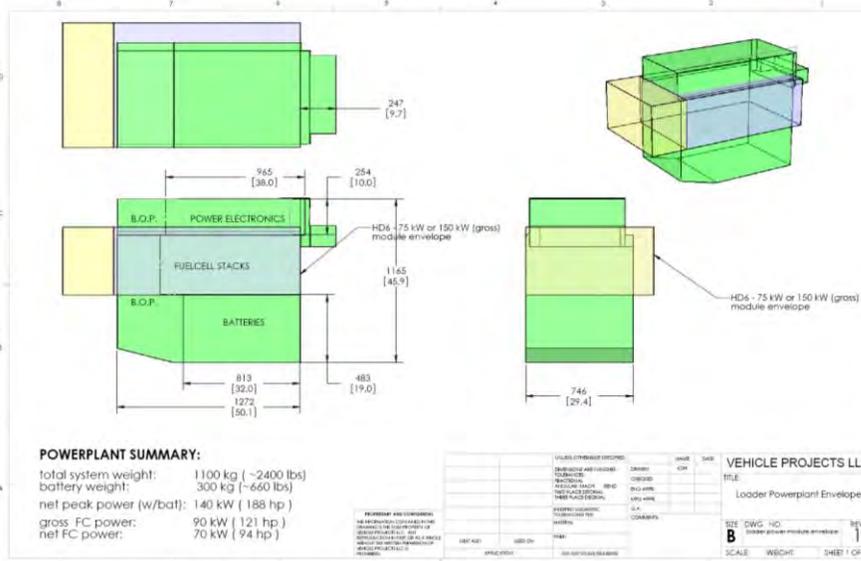


Figure 8.



Figures 8-9. CAD drawing and photograph of the hydrogen storage in Figure 8 and a CAD overlay of the HD-6 fuelcell system with the existing powerplant.

2.) Demonstration Mine location for the underground hydrogen fuelcell locomotive

The second, specific aim of the project was to identify a suitable operating coalmine capable of supporting the project, request and receive permission from the mine owner and mine personnel to operate the underground hydrogen fuelcell locomotive at the chosen site. With the influence and assistance of the United Mine Workers of America, CONSOL Energy was approached and through the course of several meetings, became a member of the consortia, offering to demonstrate the locomotive in the Blacksville number two mine. Coal mined at the Blacksville Number 2 mine is a small part of the Pittsburgh Number 8 Seam. The Pittsburgh Number 8 Seam extends from just north of Pittsburgh, Pennsylvania, south to Clarksburg, West Virginia and from just east of Appalachian Mountains and then in a westerly direction past the Ohio River and on into Central Ohio. The coal in the Pittsburgh Number 8 Seam consists primarily of bituminous coal, and, at least at this mine, is accompanied by fairly large amounts of methane and other associated gases. These gasses present several safety and operational issues, which can be



Figures 10-11. Two SD70MACs, loading a Somerset train at Consol's Blacksville #2 and the aerial view of the mine exit facility in West Virginia.

mitigated by effectively extracting and converting the gas into usable energy by the fuelcell locomotive and the mine's overall electrical needs.

The Blacksville Number 2 Mine was started in the 1970's and since very early in its operational life has had effects in 2 states - Pennsylvania and West Virginia, where the exit for the mined coal is. This is important because now, West Virginia state mining laws govern the operation of the mine, regardless of where the actual digging is taking place. (Mining operations are also governed by Federal mining and occupational safety and health regulations.) Conversely, taxes are paid to each of the two states in proportion to the amount of coal taken from each state. Environmental impacts of the mine's operations are governed by both Federal laws and by the laws and regulations of the particular state effected. However, this does serve to complicate the operations of the mine.

CONSOL is acquiring an active, Pennsylvania and West Virginia centric oil and gas company. This acquisition remains consistent with capturing and converting underground coal-bed methane gas into a viable, local energy source.

3.)Generate O2 from H2O

Implemented in 2006, the Mine Improvement and New Emergency Response Act (MINER), a federal mandate that enhanced safety measures in mines as well as emergency response measures such as, rescue chambers, clearly marked escape routes, wireless tracking systems, and self-rescuing breathing devices. The rescue chambers are airtight safe houses that provide four days of clean air for up to 15 people, as well as a supply of food and water, communication and toilet facilities. They are located within 1,000 feet of worker areas and are spaced no more than 30 minutes apart. Each miner carries a self rescuer unit (SRU), which is worn on the safety belt, while working underground. The SRU provides enough breathable air to travel 4,500 feet, or how far a miner can walk in 30 minutes. The SRU and directional life-lines are the first emergency equipment available to miners if a disaster occurs. Head lamps will generate light for six-teen hours, if initially fully charged, and long term survivability depends on the miner's ability to locate and operate a rescue chamber.

A logical next step is to provide additional survival equipment as part of the working underground vehicle fleet. The mobile equipment is used throughout the work day, usually manned by miners, while performing work related tasks in the underground coalmine. The underground locomotive proposed in this study would be able to provide breathable oxygen and power to operate electrical tools, heaters or lighting in a mine disaster. The miners would not be required to immediately travel to rescue shelters that may not be accessible because of roof collapse, tunnel cutoff or flooding.

Figure 12, below, depicts the electrolysis process, which splits water into oxygen and hydrogen.

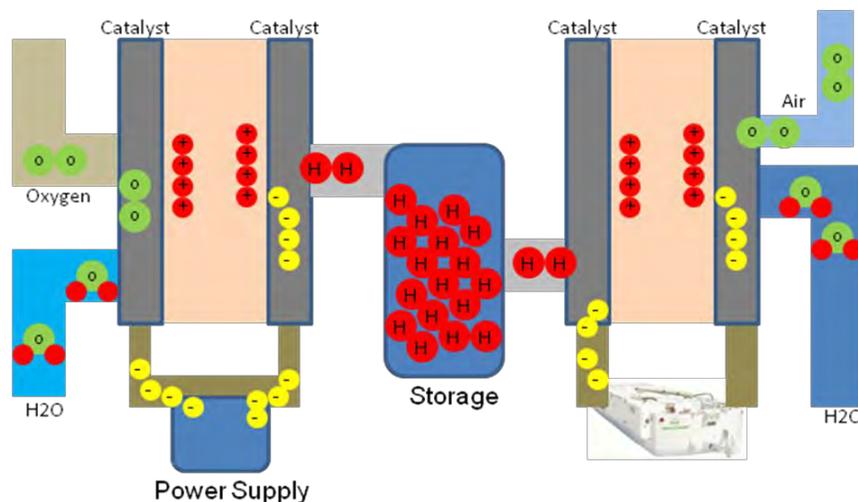


Figure 12. Electrolysis oxygen generation process with hydrogen storage and PEM power utilization.

As shown in the figure, water, H₂O, enters the cell and is split at the surface of the membrane to form protons, electrons and gaseous oxygen. The gaseous oxygen leaves the cell into the surrounding environment or is collected for direct use. The protons move through the membrane under the influence of the applied electrical field and electrons move through the external circuit. The protons and

electrons combine at the opposite surface to form pure gaseous hydrogen, which would then be used as an energy source to power equipment or tools in the form of electricity, or could be stored for use at a later time.

The initial water needed for the process would be stored on board, but the process would be able to be sustained with mine water, typically found in abundance in the coalmine and introduced into the system by the trapped miner.

The captured hydrogen would be used to provide additional fuel to the PEM fuelcells resulting in an energy-power source for electrical needs such as lighting, motors or tools. The emissions resulting from this process is water which in turn could be provided back to the electrolysis process.

4.) Produce hydrogen from coal-bed methane

Coal-Bed Methane (CBM) commonly held in the seam by water pressure and unless properly managed is a dangerous component of coal mining. The extraction and collection of the methane from the coal seam is an additional mine product and consequently another revenue stream opportunity for mine owners. Regulation and environmental concerns require the extraction and sequestration of CBM in most mining operations conducted in the U.S. today, thus making the on-site use of CBM as the energy feedstock for steam methane reforming, a logical transition.

Figure 13 shows the production stages of a coal-bed methane well.

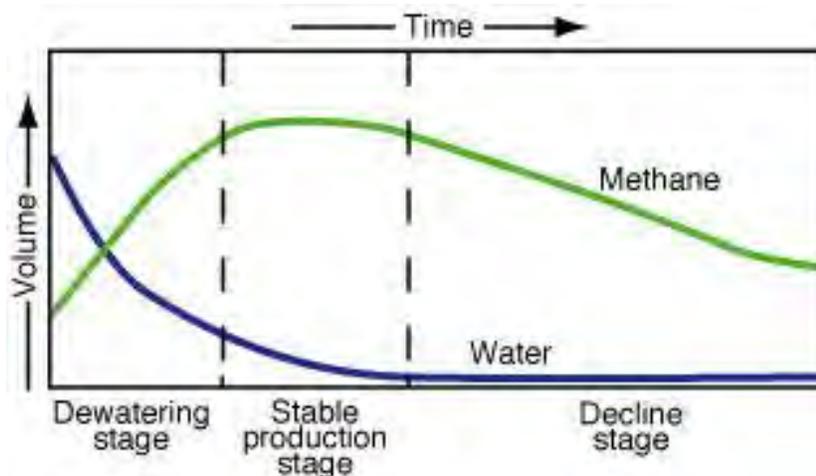


Figure 13--Production stages of a coal-bed methane well (adapted from Rice, 1997).

Hydrogen, the energy carrier used for PEM fuelcells, will be produced onsite by steam reforming the CBM gas in a Steam Methane Reformer (SMR) skid mounted, and sized to the anticipated demand of the individual mine. SMR methods to produce hydrogen from natural gas are well developed and account for over 95% of all hydrogen produced in the U.S. and 48% globally. CBM accounts for almost 7% of the natural gas supply in the U.S. today. Steam reforming of

CBM provides an efficient, economical, and commonly used process for hydrogen production, offers energy security, stability, and environmental benefits to the coalmine site. Presently, most hydrogen is produced via steam reforming of natural gas at oil refineries, although gas producers are investing in stand-alone plants and then transporting the hydrogen to customers through pipelines or in tank trucks. The majority of all hydrogen produced today, is used by oil refineries and petrochemical plants to refine fuel and manufacture industrial commodities.



Figure 14: Skid with the Stuttgart Steam Reformer Unit

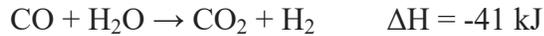
The stand-alone steam reforming process (above in Figure 14) is about 65% to 75% efficient, one of the highest current commercially available hydrogen production methods. Natural gas has proven to be a convenient, easy to manage, hydrogen feedstock with a high hydrogen-to-carbon ratio. It is also widely and readily available from a number of sources in North America. These developed processes readily transfer to coalmine use making CBM gas to hydrogen production for mine vehicle applications viable.

During the steam reforming process, a light hydrocarbon feedstock (CBM) reacts with steam at elevated temperatures (typically 700° C to 1100° C), and elevated pressures (15 to 31 bar) in nickel-based catalyst filled tubes to produce a synthesis gas. The typical ratio of this gas exiting the reformer is approximately 50% hydrogen, 10% carbon monoxide, with the balance being other gases. The economic cost of the steam drives the amount of steam used in the reaction and thus overall hydrocarbon conversion rate. The steam to carbon ratio is typically found in the 2.8 to 3.2 to 1 range. The primary endothermic reforming reaction is:



To address the endothermic reaction, the catalyst filled reactor tubes are heated from the combustion of CBM gas. In the steam reformer, the CBM gas is burned in multiple low NO_x burners that are mounted in the arch between adjacent rows of catalyst tubes, and fire downward.

Transfer of sensible heat from the hot combustion gases from the outer surface of the tubes to inside the tubes, where the reaction is taking place. The next step is to burn the Carbon Monoxide with water at 400 °C in the presence of a catalyst to get back more Hydrogen in the following reaction:



The energy produced in the second stage can be recovered by preheating the first stage producing a total enthalpy change of 165 kJ deriving 4 moles of Hydrogen, or 41.25 kJ/mol. This is better than electrolysis, (mine water) which consumes low entropy electricity at 286 kJ/mol, producing Hydrogen for use in the fuelcell mine vehicles. Coal (abundant in the mine) can also be used in steam reforming at 45 kJ/mol (has twice the CO₂ production). The Hydrogen and Carbon Dioxide will be separated or purified by the pressure swing adsorption (PSA) system located on the skid.

Because methane has a heating value of 55.7 MJ/kg, which translates to about 0.54 kg of methane for every kilogram of methane converted to hydrogen. This works out to 35 % of the methane from the feedstock input stream being diverted to power the process. The hydrogen will be stored in pressure vessels above ground and dispensed when fueling the fuelcell vehicles for work in mine operation. High pressure dispensing is not warranted in mine operations because of the employment of reversible metal-hydride hydrogen storage for underground operation, therefore, reducing the cost of dispensing the fuel without the need for expensive high pressure dispensing equipment.

The cost of CBM hydrogen produced by SMR on-site is dependent on the infrastructure cost to extract reform and store the hydrogen at the coalmine location. The mine owner/operator will not pay an outside supplier for the CBM feedstock but the actual cost of the gas is acutely linked to the infrastructure cost necessary to provide reliable clean hydrogen to the fuelcell vehicles and mine electrical demands.

5.)Electric power takeoff

Electric power takeoff is presently used in the rail industry for a number of applications, including track repair work. In subway repair work, the diesel generator rail cars are transported into the tunnels and then operated under very strict rules because of the amount of emissions the generator emits into the tunnel during repair operations. The air in the tunnels is not pushed, as in coalmine operations, by large fans but moved by the trains traveling through the tunnels. This creates a problem for the rail repair workers using the diesel generators in the tunnels because of air quality issues. Vehicle Projects Inc has demonstrated the use of power-to-grid capabilities from a fuelcell powered locomotive at Hill Air Force Base by providing all of the electrical power required to operate the rail facility from the hydrogen-hybrid fuelcell powered switch locomotive.

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The fuelcell electric power takeoff on the coalmine fuelcell powered locomotive will provide electric power to operate mine tools or lighting in an emergency situation. In the event of a mine collapse and mine infrastructure power supply disruption, the fuelcell vehicle would then become the primary provider of electric power for trapped miner survival.