Novel H2 Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

eSteam™

Downhole Steam Generator

Repurposing Hydrocarbon Formations for Hydrogen Production costs ~$0.50/kg.

Our well sites are going to

net zero

The hydrogen future is here now.

.

novelh2.com

HIGHLIGHTS of Downhole eSteam Technology for Hydrogen Gas Production

The hydrogen future is here now.

"Discoveries are often made by not following instructions, by going off the main road, by trying the untried." - Frank Tyger.

- NovelH$_2$Fuel's system's low-cost hydrogen gas production costs ~$0.50/kg.
- Capital cost for eSteam technology is ~$5 million for 10 MMBtu/hr system.
- Transformative downhole eSteam technology produces hydrogen gas from repurposed, hydrocarbon formations.
- eSteam technology generates high-temperature steam not less than 930°F to thermally crack the hydrocarbon chain to release hydrogen gas produced from an in-situ underground reaction vessel created in the hydrocarbon formations.
- No competition – first-of-its-kind downhole eSteam technology for hydrogen gas production from hydrocarbon formations, e.g., coal, heavy oil, oil sands, light oil, and shale oil.
- Equipment includes proven downhole steam technology, skid-mounted plant with separation membranes to deliver 99% pure hydrogen gas to the storage tanks.
- Inflation Reduction Act hydrogen tax credit of $3.00/kg offsets taxable income.
- California's Low-Carbon Fuel Standard (LCFS) tax credit for hydrogen gas is worth about $0.65/kg.
- Generates carbon credit and/or Emissions Reduction Credit (ERC) revenue from emission offset buyers.
- Canadian operators costly per barrel carbon tax is avoided.

SOLUTION – DOWNHOLE STEAM TECHNOLOGY PRODUCES HYDROGEN GAS

Novel H_2 Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

- **Low-cost hydrogen gas production costs ~$0.50/kg.**
- 70% efficient electrolytic technology cost ~$7.20 kWh per kg of hydrogen. Requires about 48.3 kWh of grid electricity to produce 1 kg of hydrogen. $0.15 kWh x 48.3 kWh of grid electricity.
- Viable alternative to expensive electrolytic technology cost as high as ~$16.80/kg hydrogen from renewable solar and/or wind energy according to a report from S&P Global Commodity Insights in July 2022.
- The thermal cracking hydrocarbons does not present the emissions of polluting gases achieving a high degree of H_2 purity.
- eSteam technology is capable to produce hydrogen gas at a very large-scale. Calculations for a hypothetical hydrocarbon formations with 32 million tonnes of remaining oil show that the production of 125+ tonnes of hydrogen gas per day could be possible.
- **Capital cost for the 10 MMBtu/hr eSteam H_2 system is $5 million.**
- Produces low-carbon hydrogen gas and eliminates the threat of stranded hydrocarbon assets.
- eSteam produces hydrogen gas produced from an underground reaction vessel created by a minimum 930°F temperature steam in the formations.
- Hydrocarbon formations can be repurposed to produce low-cost hydrogen gas for ~$0.50/kg.
- Canadian operators costly carbon tax is avoided.
- Green hydrogen gas operates the eSteam system that avoids CO2 emissions.
- Minimal maintenance that helps reduce costly downtime – no moving parts downhole.
- Thermal fluid heater is scalable up to 120 MMBtu/hr.

eSteam is a transformational hydrogen gas production technology that is in a “class by itself“ and therefore "unique and innovative"

From the oil age to carbon neutrality … eSteam hydrogen technology’s aim is to inspire oil and gas companies to repurpose hydrocarbons for hydrogen gas production to help them achieve decarbonization and reach net-zero emissions by 2050.

eSteam technology is a novel, simple, and transformative proven downhole steam technology to repurpose hydrocarbons for hydrogen gas production.

Getting to

NET-ZERO EMISSIONS by 2050

eSteam™

Downhole Steam Generator

SOLUTION – Transformative eSteam technology produces low-cost hydrogen gas

Novel H_2 Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

<u>Introduction</u>

eSteam low-carbon hydrogen gas production technology generates 930°F high-quality steam that thermally cracks the hydrocarbon chain releases H_2 and simultaneously stores CO2 in the formation.

eSteam is a state-of-the-art clean energy technology for in-situ hydrogen gas production that meets Paris climate targets for net-zero emissions by 2050 and eliminates risk of 'stranded hydrocarbons.'

<u>Existing Hydrogen Processes</u>

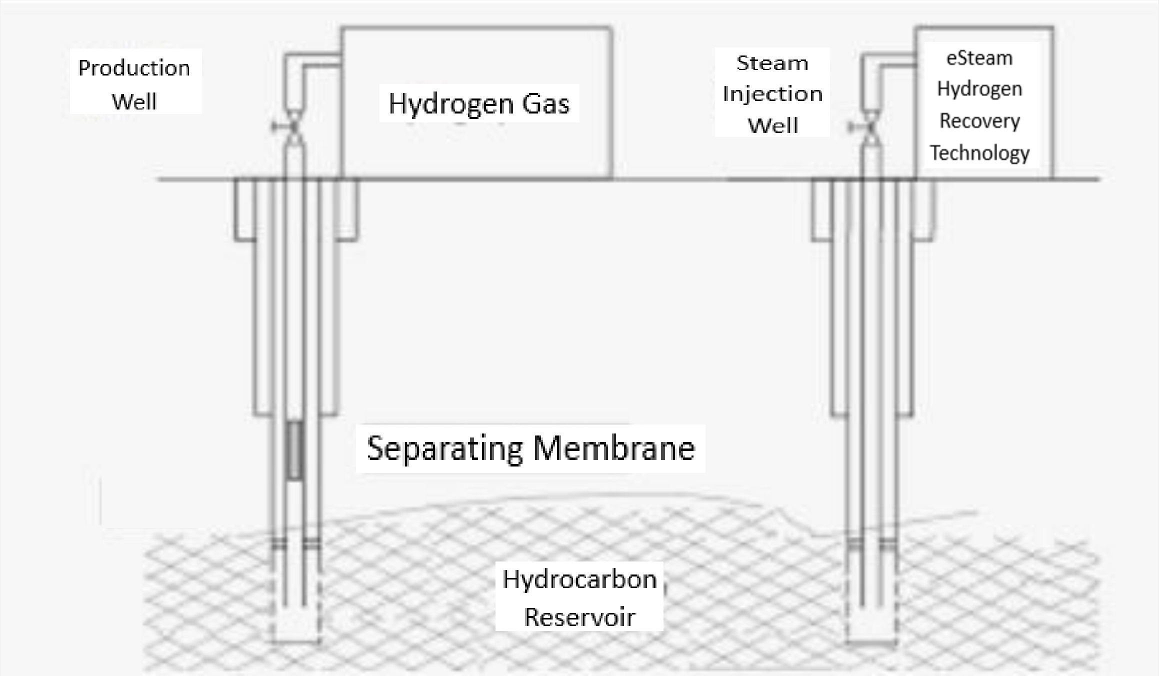
- Steam-Methane Reforming is a well-established technology producing hydrogen;
- Expensive electrolytic technology from renewable energy, i.e., solar and wind energy.

<u>eSteam technology Process Summary</u>

- Requires injection/production wells (can be one well – huff & puff);
- Steam injection phase begins;
- Continuous steam injection of 930°F temperature causing thermal cracking of the hydrocarbon chain in hydrogen-rich formations;
- Steam injection is stopped;
- Production well is opened, and hydrogen gas is allowed to produce;
- Production well has unique semi-permeable membrane (SPM) for CO2 sequestered in-situ and only allows hydrogen gas production;
- Steam cycle is repeated.

<u>eSteam Technology Advantages</u>

- Produces pure low-carbon hydrogen gas from hydrocarbons;
- Sequesters CO2 in the formations;
- Eliminates the threat of stranded hydrocarbon assets.



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Downhole Steam Generator

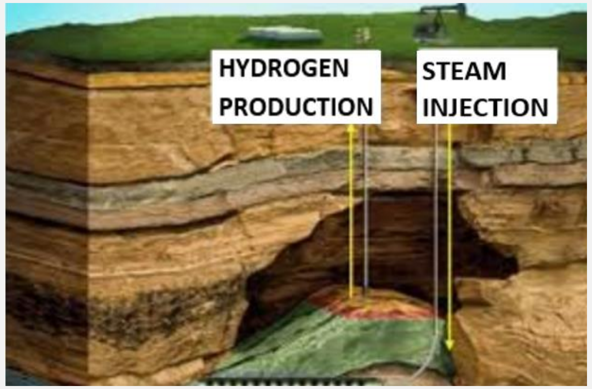
VALUE PROPOSITION

eSteam low-cost hydrogen gas will be extremely profitable.

- Low-cost hydrogen gas production costs ~\$0.50/kg. Capital cost for eSteam's 10 MMBtu/hr H_2 system is \$5 million.
- California's Low-Carbon Fuel Standard (LCFS) tax credit is worth about \$0.65/kg.
- Inflation Reduction Act hydrogen tax credit of \$3.00/kg.
- High-temperature 930°F steam is injected into hydrogen-rich formations causing thermal cracking of the hydrocarbon chain to release hydrogen.
- Canadian operators costly per barrel carbon tax is avoided.
- No competition – First-of-its-kind steam-enhanced hydrogen gas production system from hydrocarbon formations.
- Hydrogen gas production leverages existing energy assets by repurposing orphaned or idle wells.
- California and Canadian operators have existing thermally completed wells in which to insert the eSteam technology thereby avoiding the cost of new wells.
- Very economical and environmentally-friendly compared to steam methane reforming grey hydrogen used for industry feedstock.

Lower Costs = Higher Profit Margins

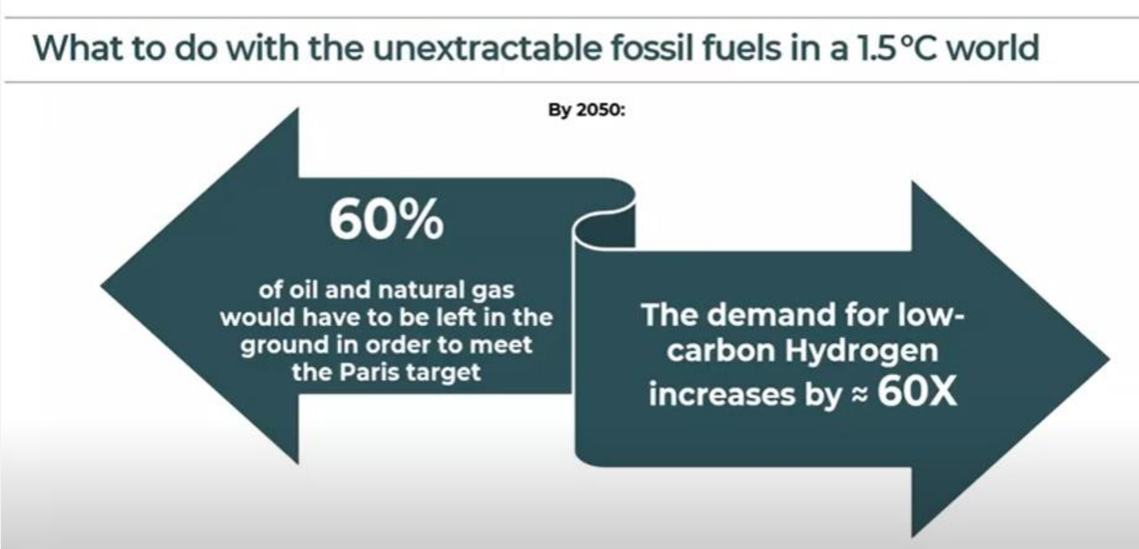
- eSteam technology achieves the lowest hydrogen gas production cost in the industry.
- eSteam technology is committed to delivering best-in-class, low-cost hydrogen gas ~\$0.50/kg.
- Mission Statement: Seamlessly integrate the eSteam hydrogen recovery technology to provide cost-effective solution.
- Company's Motto: Achieve the lowest cost hydrogen gas production.
- Long-Term Vision is to help the oil industry transition to a decarbonized economy with low cost, low-carbon hydrogen gas production.



BENEFITS

- Low CapEx - $5 million for each 10 MMBtu/hr. turnkey system.
- Low-cost hydrogen gas production is ~$0.50/kg.
- ~930°F high-quality steam delivered in hydrocarbon formation.
- In-situ thermal cracking the hydrocarbon chain releases hydrogen gas.
- Steam methane reforming alternative in underground hydrocarbon formation.
- Tolerates brackish water and reduces H2O treatment cost.
- Off-the-shelf proven equipment
- Hydrocarbons include natural gas, coal, shale oil, heavy oil, oilsands, and light oil.
- Hydrogen gas operates the zero-emission eSteam system.
- No competition producing H2 from subterranean hydrocarbon formations.
- Generates carbon credit revenue.
- IRA hydrogen tax credit is $3/kg.
- California's Low Carbon tax credit is ~$0.65/kg.
- Canada's hydrogen Investment Tax Credit (ITC) provides subsidies for H2 equipment.

NovelH$_2$Gas Best-in-Class System is a Transformative Green Hydrogen Technology for ~$0.50/kg.



The hydrogen future is here now.

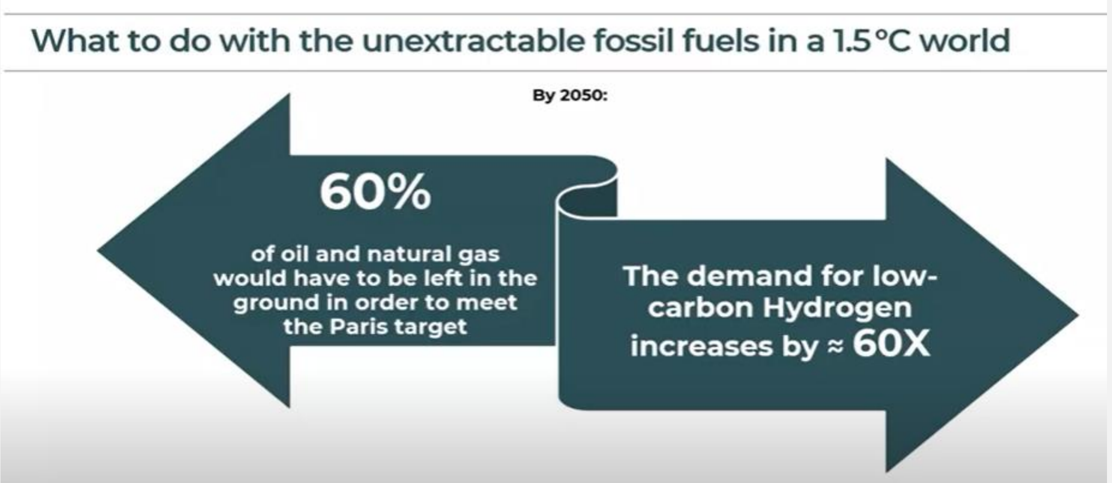
BENEFITS of Downhole eSteam Technology for Hydrogen Gas Production

NovelH2Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

- Low CapEx - $5 million per 10 MMBtu/hr system.
- Low-cost hydrogen gas production is ~$0.50/kg.
- 930°F temperature high-quality steam delivered in hydrocarbon formation.
- In-situ thermal cracking the hydrocarbon chain releases hydrogen gas.
- Steam methane reforming alternative in underground hydrocarbon formation.
- Tolerates brackish produced water and eliminates H2O treatment cost.
- Hydrocarbons include natural gas, coal, shale oil, heavy oil, oil sands, and light oil.
- Hydrogen gas operates the zero-emission eSteam system.
- No competition for proven downhole steam technology producing H2 from subterranean hydrocarbon formations.
- Generates carbon credit revenue.
- IRA hydrogen tax credit is $3/kg.
- California's Low Carbon tax credit is ~$0.65/kg.
- Canada's Clean Hydrogen Investment Tax Credit (ITC) provides direct subsidies for capital costs associated with equipment purchase to produce green hydrogen.

eSteam technology is a novel, simple, and transformative proven downhole steam technology for hydrogen gas production in hydrogen-rich hydrocarbon formations.

NovelH$_2$Fuel's transformative downhole eSteam technology extracts low-cost hydrogen gas in hydrogen-rich hydrocarbon formations for a cost of ~$0.50/kg.



An alternative use of hydrocarbon reserves is to convert them into a source of clean hydrogen gas.

The hydrogen future is here now.

eSteam™
Downhole Steam Generator

NovelH2Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

eSteam is a low-cost hydrogen gas production technology for hydrocarbon formations.

There are four main sources for the commercial production of hydrogen: natural gas, oil, coal, and electrolysis; which account for 48%, 30%, 18% and 4% of the world's hydrogen production, respectively.

As public pressure is rising to limit global warming to 1.5 degrees Celsius, global leaders are grappling with how to best take on this unprecedented challenge, which has spurred renewed interest in hydrogen. One novel approach is to extract hydrogen from hydrogen-rich oil formations.

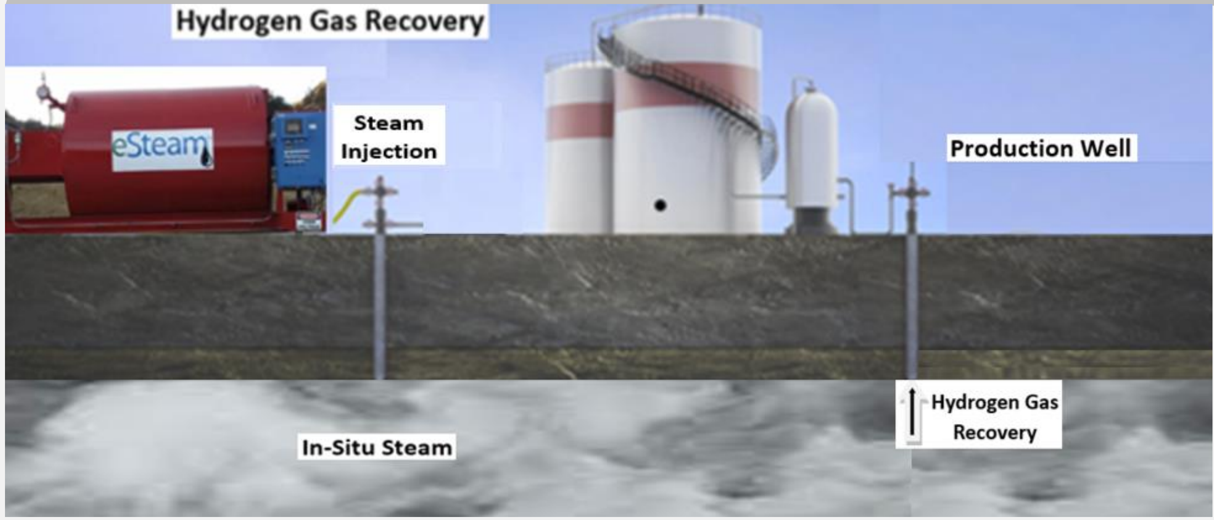
eSteam is a low-cost hydrogen gas production technology from hydrogen-rich hydrocarbon formations costs ~$0.50/kg.

eSteam is an extremely low-cost hydrogen gas production technology compared to a 70% efficient electrolytic technology which cost about $7.20 kWh per kg of hydrogen.

Hydrogen gas is produced from hydrocarbon formations by thermally cracking the hydrocarbon chain.

The hydrocarbon reservoir acts as the underground reaction vessel dramatically reducing the capital for surface equipment.

Steam injection produces hydrogen gas in hydrocarbon formations.



Oil companies are looking to transition their business, and hydrogen gas production in hydrocarbon formations is a natural fit.

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TECHNOLOGY METRICS AND CO_2 ABATEMENT

Novel H_2 Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

Summary of Features Hydrogen Production Technologies	NovelH$_2$Fuel	Competitor #1 Electrolysis with Renewable Solar Energy	Competitor #2 Electrolysis with kWh Electricity From the Grid	Competitor #3 Steam Methane Reforming
Hydrogen cost/kg	~$0.50/kg	As high as $16.80/kg	~$7.20/kg	~$1.80/kg
CapEx and OpEx	Very Low	High	Extremely High	Extremely High
System Efficiency	~95%	~70%	~70%	~74%
Fuel Source	Hydrogen Gas	Electricity from Solar Energy	Electricity from the Grid	Natural Gas and Electricity
CO_2	No	No	No	Yes

CO2 Comparison for Hydrogen Gas Production Technologies

CO2 Comparison	NovelH2Fuel using produced H2 Gas	Electrolysis using Solar Energy	Electrolysis using Grid Electricity	Steam Methane Reforming	
Energy Used	0	0	49 kwh	MMBtu	
Factor	N/A	N/A	0.533606 lb/kWh	53.02 kg CO2/MMBtu	
CO2 Emissions (mt)	0	0	0.0576	0.0090	
				4.5 cubic meter gas to produce	
lb	26.146694			1 kg Hydrogen Gas	
kg	57.64300159			1 MMBtu=26.8 cubic meters	
mt	0.057643002			0.17 MMBtu/kg Hydrogen Gas	
				9.0134	kg CO2
				0.0090134	CO2 mt

DOE launches $1B plan to drive demand for clean hydrogen

7/06/2023

The Biden administration's broader plans for hydrogen — which include making low-carbon versions of the fuel as cheap as emissions-intensive, natural-gas-derived types [Steam Methane Reforming] as soon as 2031 — still face significant challenges.

https://www.eenews.net/articles/doe-launches-1b-plan-to-drive-demand-for-clean-hydrogen

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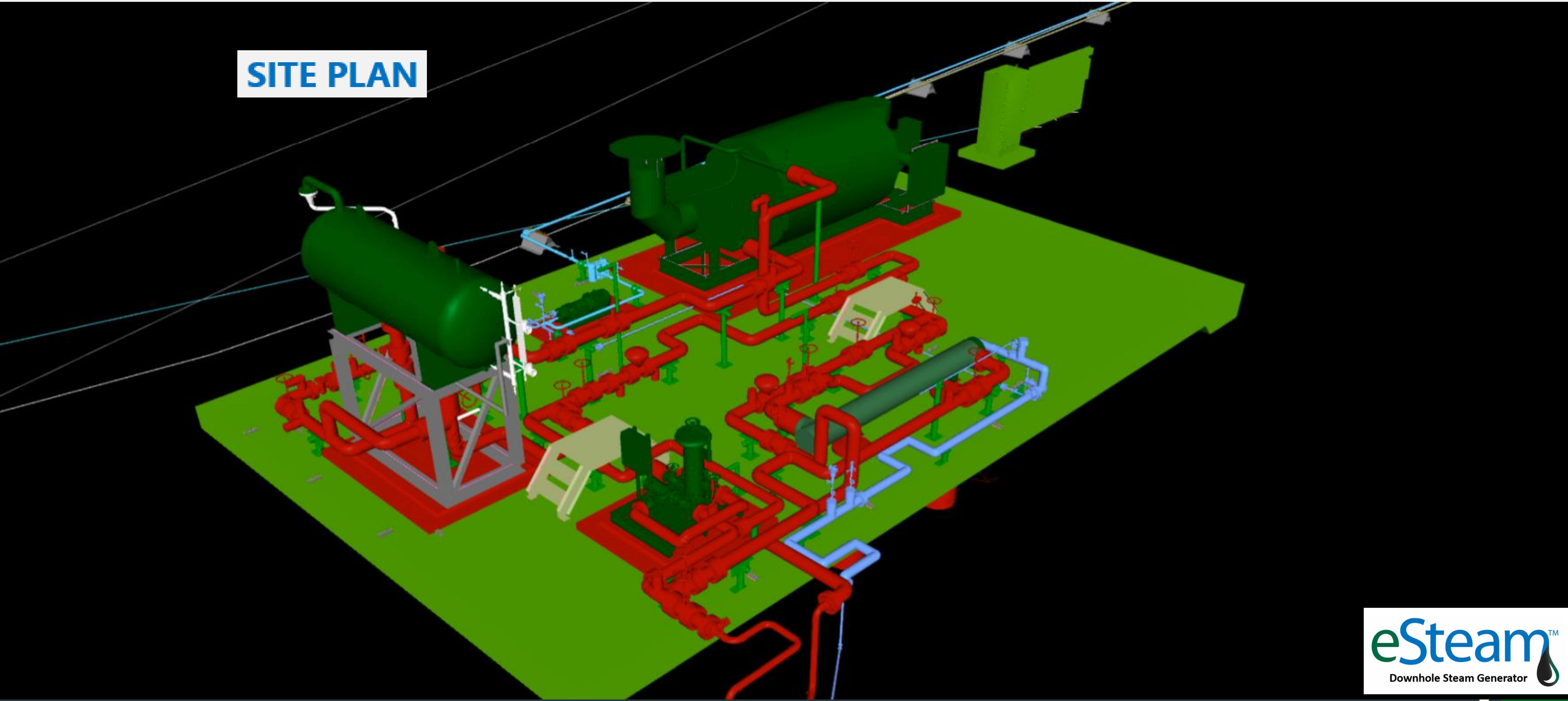
EQUIPMENT SITE PLAN

Novel H2 Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg



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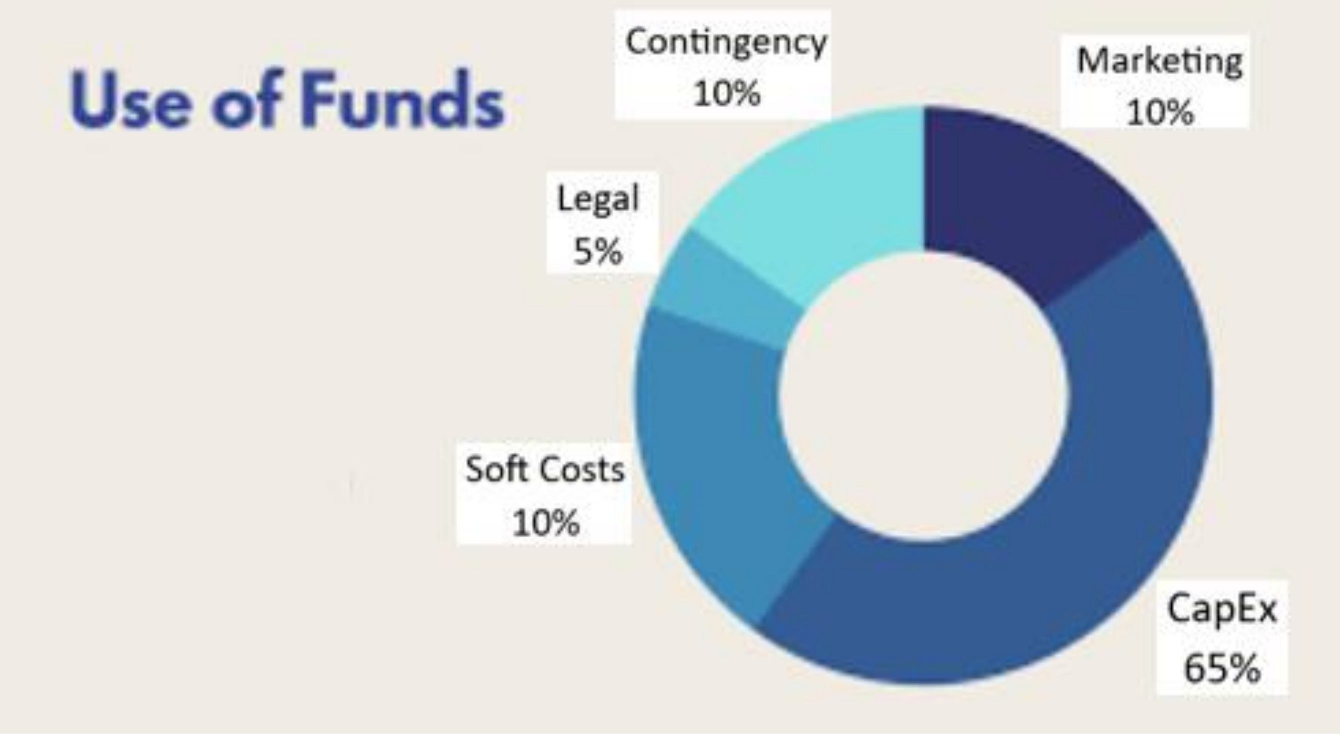
USE OF FUNDS

Novel H2 Fuel
H2 Recovery in Hydrocarbon Formation ~$0.50/kg

Novel H2 Fuel
Hydrogen Recovery in Hydrocarbon Reservoir

Technology Budget

Total Use of Funds	**$ 5,000,000**
Hard Costs	$ 4,172,500
Soft Costs	
Engineering and Design	244,000
Petroleum Engineer	90,000
Oil field service company	143,000
Legal	25,000
Insurance	25,500
Future Energy LLC	300,000
Total Use of Funds	**$ 5,000,000**



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BUDGET - $5 MILLION

Novel H2 Fuel
H2 Recovery in Hydrocarbon Formation ~$0.50/kg

Vendor	eSteam Hydrogen Technology	Estimated Budget
Hard Costs		
Sigma Thermal	10 MMBtu/hr. Thermal Fluid Heater and associated equipment	1,200,000
Tejas Tubular, Houston	Concentric tubulars	
	3.5" corrosion resistant alloy for steam injection	90,000
	Two 1.33" U-shaped corrosion resistant alloy for thermal fluid	110,000
Vallourec S.A.	Vacuum Insulated Tubing (VIT)	275,000
GENERON or Air Liquide	On-site skid-mounted membrane H2 separation plant	400,000
Hydrogen tanks	Hydrogen tank storage	300,000
Pipe & Supply	Pipes, Valves, and Flanges	40,000
Concrete Slab for Pad Site	80 ft. x 50 ft. pad site for heater, fluid filter & pumps	62,000
Electric	Hook up heater, control panel, pumps, and electric line	114,000
Emerson Company	Flow meters for thermal fluid, gas and water	32,000
Thermal Fluid	2,000 gallons of non-toxic thermal fluid fluid	38,000
Dwyer Instruments Inc.	Sensors for gas and water	12,000
Flow Control Devices	Thermal Fluid heat transfer fluid, gas and water	32,000
Thermal Fluid fluid filter	Thermal Fluid fluid filter and cartridges	38,500
Crane	Crane to lift the thermal fluid heater onto pad site	5,500
Program Logic Controller	Allen-Bradley PLC to operate thermal fluid heater & filter	32,000
Thermal Products Inc.	Heat Exchanger to heat the feedwater on the surface	36,000
Water and Gas line	Purchase and install water and gas lines to the pad site	38,000
Welhead	Wellhead fabrication	16,500
On-Site Construction		
Construction Company	Assemble surface pipes, flanges, valves, pumps, & HEX	140,000
Electricity	Electricity for pumps, controls, etc.	12,000
Natural Gas	Gas for each steam cycle before use of hydrogen gas	48,000
Thermal Fluid Heater	Set up and start-up Thermal Fluid heater	135,000
Water for steam injection	Zero hardness fresh water	13,000
Wellhead	Install the wellhead	8,000
Wellbore Installation	Install 3.5" & two 1.33" U-shaped tubulars downhole	95,000
Contingency		850,000
	Total Hard Costs	$ 4,172,500
Soft Costs		
Engineering and Design	Engineer system design for equipment assembly	244,000
Petroleum Engineer	Reservoir engineering	90,000
Oil Field Services Company	Equipment preparation and installation	143,000
Legal	License Agreement	25,000
Insurance	General liability insurance and workmans comp	25,500
Future Energy LLC	Equipment preparation	300,000
	Subtotal Soft Costs	827,500
	Total Hard & Soft Costs	$ 5,000,000

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ENVIRONMENTAL, SOCIAL, AND GOVERNANCE (ESG)

NovelH2Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

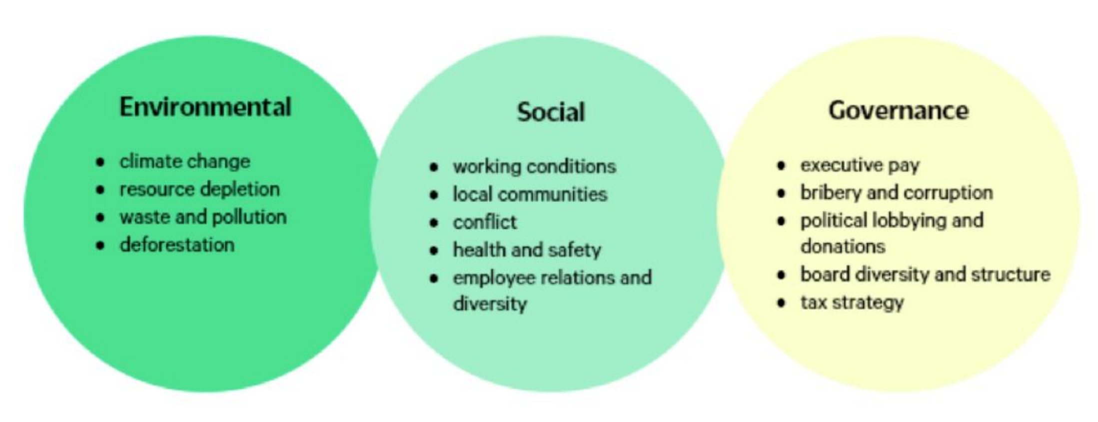
The global race for clean hydrogen means new geopolitical realities.
If the 1990s were the decade of wind, the 2000s the decade of solar, and the 2010s the decade of batteries, the 2020s could launch us toward a next frontier of the energy transition: hydrogen. Hardly a week goes by without a major new hydrogen project or breakthrough. In just the past five years, more than 30 countries have developed or started to prepare national hydrogen strategies (IEA 2022). The Paris climate goals have been a key driver to shift to greener fuels.

Hydrogen battles
The pathway for clean hydrogen growth remains contentious, however. Two primary fault lines have emerged: how to produce it and in which sectors to deploy it.

Future Energy LLC has been involved in the development of California heavy oil projects for over 30-years. We are bringing a transformative zero-emission green technology that is a first-of-its-kind carbon-neutral hydrogen production technology branded as eSteam™.

What sets Future Energy apart is our novel green technology will help oil and companies to achieve reduced emissions. Future Energy's green technology will help oil companies diversify into carbon-neutral hydrogen production and generate carbon credit revenue to achieve higher net revenue. NovelH_2Fuel system will help Canadian operators avoid the costly carbon tax. NovelH_2Fuel system is an extremely low CapEx and OpEx. NovelH_2Fuel system helps oil companies offset their greenhouse gas emissions, to achieve decarbonization and net-zero emissions by 2050.

Future Energy is pleased to support Social Contract value and is building a purpose driven technology license business that can help operators successfully implement our green technology to enhance their objectives to help them achieve Environmental, Social and Governance (ESG) standards that safeguard the environment. We desire to help the community's citizens health and well-being to provide the societal benefits to the environment by improving air quality, reducing water consumption, and maintaining high paying jobs improving the local economy.



CONTACT INFORMATION

Novel H2 Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

info@futureenergyllc.com

novelh2.com

Oil companies are looking to transition their business, and hydrogen gas production in hydrogen-rich hydrocarbon formations is a natural fit.

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APPENDICES

Novel H_2 Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

Problem – **In-Situ Combustion............ 16**

Research – **In-Situ Combustion .... 17 & 18**

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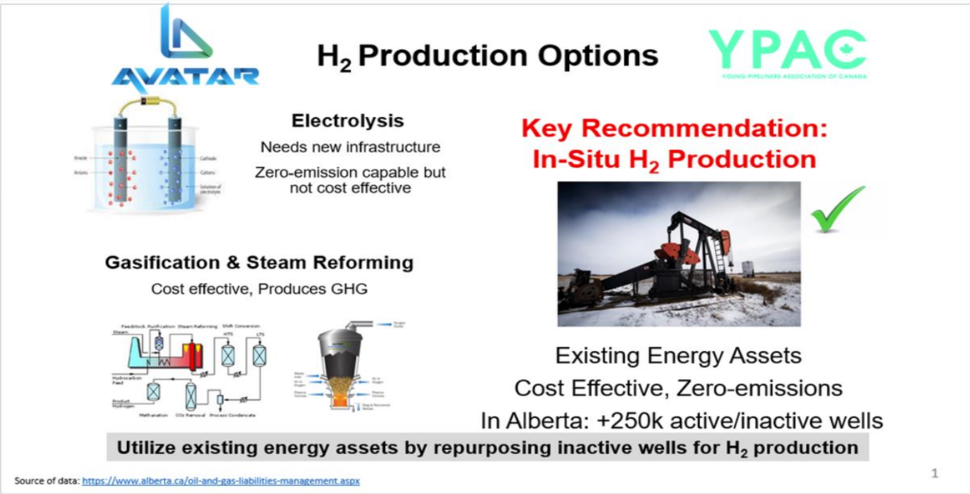
PROBLEMS with in-situ combustion WILL NOT be successful to produce hydrogen gas.

Novel H_2 Fuel
H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

- The main obstacle will be achieving a temperature of 500°C or 930°F.
- Due to gravity override of the injected gases, the combustion front may not advance uniformly in the vertical direction. Hence, the sweep efficiency may be reduced by the preferential flow of the gases to one or more wells of the pattern.
- Requires a combustion front into immobile oil, and this causes much lower oxygen injectivity rates.
- A challenge is overcoming the limitations of low sweep efficiency of the combustion heat.
- A big disadvantage is the high-cost air compressor units to create oxygen to be injected into the reservoir to maintain the fire.
- Another big disadvantage is the high concentration of nitrogen, NOx, CO2, CO, and unreacted O2 that needs to be mitigated at the surface in high-cost separation equipment and subsequently disposed or sequestered that adds significant additional cost.
- A stable combustion needs not only a reasonable gas injection speed but also a matching exhaust speed, otherwise, the combustion effect will inevitably be affected.
- Low process control resulting in poor sweep efficiency and adversely affecting the ignition of the in-situ fire.
- The question most frequently asked is where the in-situ combustion front is located.
- The biggest challenge is to achieve 500°C or 930°F heat to produce large amounts of hydrogen.
- Another challenge is the yield efficiency, i.e., amount of hydrogen extracted per amount of oxygen injected.
- ISC began in the early 1920s for heavy oil viscosity reduction, but its inefficiency was superseded by a once- through steam generator (OTSG) in the early 1960s that are still being used today.



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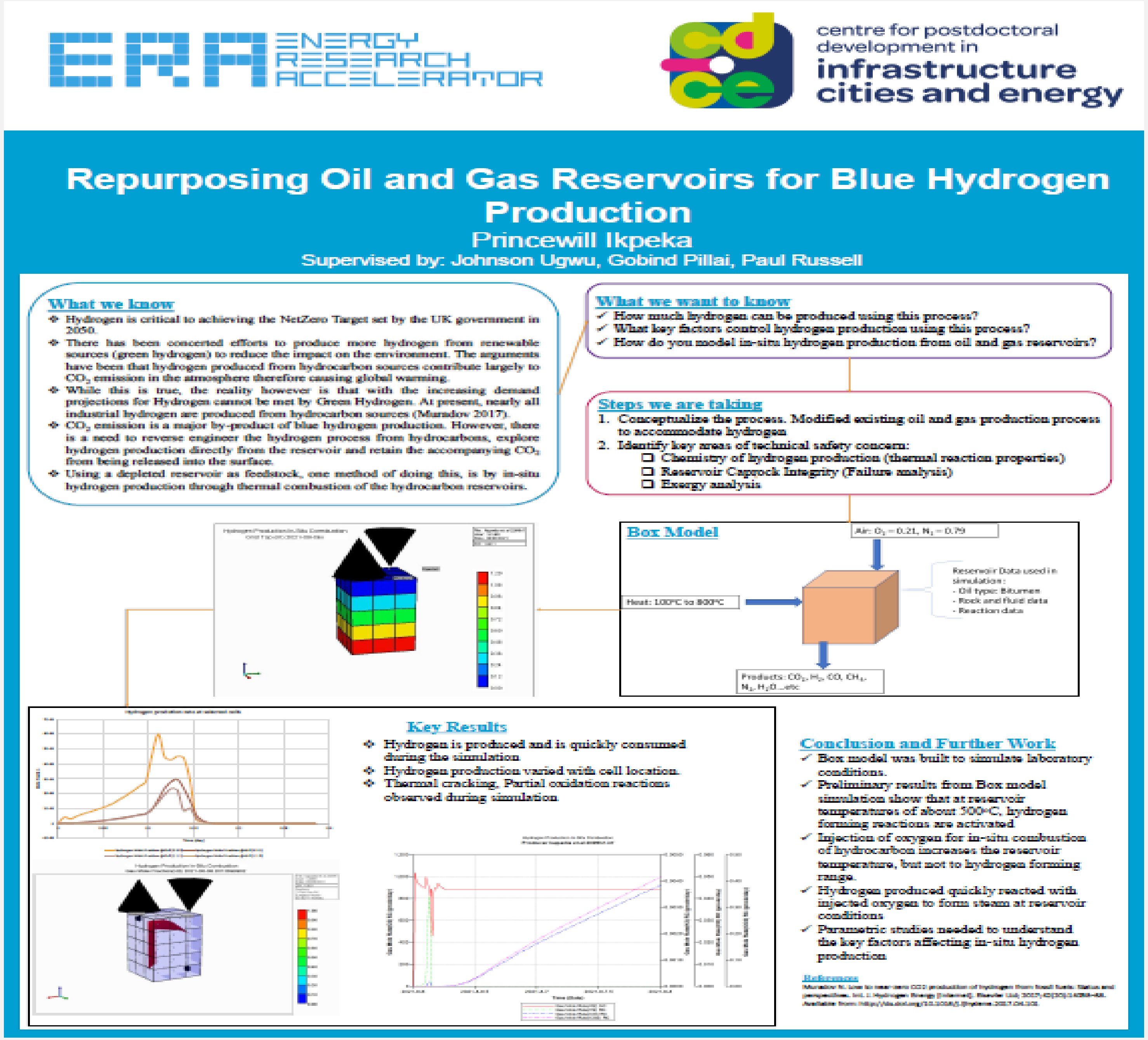
RESEARCHER'S HYDROGEN FOCUS IS IN-SITU COMBUSTION

In-situ combustion WILL NOT be successful to produce hydrogen gas from hydrocarbon formations.



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RESEARCH FOR IN-SITU COMBUSTION TECHNOLOGY

Novel H_2 Fuel

H_2 Recovery in Hydrocarbon Formation ~$0.50/kg

In-Situ Combustion WILL NOT be successful to produce hydrogen gas from hydrocarbon formations.

Published: October 6, 2022 - Department of Physical Chemistry, Alexander Butlerov Chemistry Institute, Kazan Federal University, Kazan Russia

Abstract

The generation of hydrogen from unconventional oil is expected to increase significantly during the next decade. It is commonly known that hydrogen is an environmentally friendly alternative fuel, and its production would partially cover the gap in energy market requirements. However, developing new cheap catalysts for its production from crude oil is still a challenging area in the field of petroleum and the petrochemical industry. This study presents a new approach to synthesizing and applying promising catalysts based on Ni, Co, and Ni-Co alloys that are supported by aluminum oxide in the production of hydrogen from extra-heavy crude oil in the Tahe Oil Field (China), in the presence of supercritical water (SCW), it was shown that it can be realized in the presence of core and ex-situ prepared Ni-based catalyst, under high pressure up to 207 atm, but at temperatures not lower than 450C.

Published: June 6, 2011 - Science Direct - Volume 90, Issue 6, Pages 2254-2265

Abstract

The volume of heavy oil and bitumen in Alberta, Canada is estimated to be about 1.7 trillion barrels. The potential for in-situ combustion (ISC) of hydrogen by gasification of bitumen reservoirs offers an attractive alternative, which can also have both economic and environmental benefits. For example, hydrogen generated from bitumen gasification can also be used for in-situ upgrading as well as feedstock for ammonia and other chemicals. The water–gas shift reaction also generates carbon dioxide which could be potentially sequestered in an in-situ gasification process so that emissions to the atmosphere are reduced. This in-situ combustion technology provides a potential clean method to produce hydrogen fuel from bitumen.

Published: March 27, 1985 - Paper presented at the SPE California Regional Meeting, Bakersfield, California.

Abstract

BP Resources Canada Ltd. is operating an oxygen in-situ oil recovery pilot at Marguerite Lake, part of the Cold Lake heavy-oil deposit in part of the Cold Lake heavy oil deposit in eastern Alberta. The pilot consists of two principal areas: a three-well, wet air principal areas: a three-well, wet air combustion test and an infill-drilled, four five-spot, wet oxygen combustion project on five (5) acres. All the wells were initially steam fractured and operated through several cycles. The present study was undertaken in order to better understand the flow and reaction processes that generate hydrogen in-situ and thereby to suggest ways of influencing its production. The results are interpreted in hydrogen production.

Published: Science Direct - 23 September 2022

Abstract

GTI Energy's Sub-surface Technologies for the Generation and Production of Low-carbon Hydrogen from Hydrocarbon Resources. The research intends to inform and stimulate stakeholder thoughts around the future research needs on underground generation and production of hydrogen by addressing techno-economic challenges, societal and regulatory barriers to deployment. The project is expected to kick off in 3Q 2022. A Review and Techno-economic Analysis of Subsurface Technologies for Hydrogen Production from Fossil Fuel Resources. Conversion of depleted hydrocarbon reservoirs into underground energy conversion systems that are accessible through available well infrastructure offers a promising pathway to leverage existing fossil fuel assets for low-carbon energy.