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CHANGING PERCEPTIONS

How Molten Salt Reactors Can Win the War on Coal

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TABLE OF CONTENTS

THE CHALLENGE: BALANCING ENERGY, THE ENVIRONMENT, AND AFFORDABILITY

The United States faces a serious challenge: protecting the environment while increasing energy production at a price point that allows American industry to compete in the world marketplace and allows average consumers to easily afford their energy needs.

Energy needs and costs are on the rise. Strong demand from developing nations, such as China and India, who are aggressively building domestic industries, has impacted global supply. As developing nations embrace individual energy consumption profiles comparable to the average American, the environmental effects will be pronounced.

Now more than ever, the United States needs to adopt a big-picture energy strategy to develop a reliable, cost-effective source of clean energy.

Coal and Next Generation Nuclear Energy Technologies

Federal and state governments have set a very high bar on emission and pollution standards. Coal is an economical, abundant fuel source, but converting it into a clean source of energy is expensive. In the past, inexpensive energy has often been equated with "dirty" energy, but that paradigm is changing. By pairing next-generation nuclear technology with American coal, the United States can benefit both the economy and the environment, increase production, give domestic industries a competitive edge, and keep energy affordable for American citizens.

Synthetic, affordable, coal-based fuels could revolutionize the United States economy. By harnessing next generation fission technologies, the costs of producing clean coal-based fuels would drop dramatically. This energy source would allow the U.S. and its allies to halt the purchase of crude oil from unfriendly nations and keep prices low for consumers and industry.

To understand how next generation energy technologies can transform the production of coal-based fuels; it is useful to take a closer look at the history, challenges, and opportunities of coal liquefaction.

COAL LIQUEFACTION

The process of converting coal into liquid transportation (CTL) fuels was first developed in a liquid fuel starved Germany in 1913, where high-pressure processes for ammonia and methanol production were applied to gasoline production from coal.

The Fischer–Tropsch process was then developed by Franz Fischer and Hans Tropsch at the "Kaiser-Wilhelm-Institut für Kohlenforschung" in Mülheim an der Ruhr, Germany in 1925. The process is a key component of solids to gas and gas to liquids technology, which produced a synthetic lubrication oil and synthetic fuel in the form of synthetic diesel fuel and synthetic kerosene and naptha, typically, from coal, natural gas, or biomass.

During the Second World War, Germany produced large amounts of transport fuels via Direct Coal Liquefaction (DCL) and Indirect Coal Liquefaction (ICL) technologies. This was an expensive process, adopted primarily due to German insufficiency of natural petroleum resources. Today, the world's largest Coal-to-Liquids (CTL) production capacity is located in South Africa, based on locally available low-cost coal. Numerous demonstration units have been built elsewhere, but only a few industrial plants are currently under construction and most of them are in China.

Performance and costs of coal liquefaction plants have been reviewed as the result of an interest in alternative production of transport fuels driven by the 2008 oil price peak. A study on liquefaction of Illinois No. 6 bituminous coal concluded that commercial coal to liquid plants using the U.S. Midwestern bituminous coal offer good economic opportunities. The investment cost of a CTL plant with a production capacity of 50,000 barrels per day of diesel and gasoline is around $4.85 billion USD. The coal preparation and gasification in the CTL process account for almost 50% of the total investment cost, the rest of the cost being for the GTL (Gas to Liquids) process.

The economic viability of these projects depends heavily on crude oil prices. A crude oil price of $72/bbl USD provides a 19.8% rate of return of investment (ROI). Oil prices higher than $44/barrel and $55/barrel provide rate of investment greater than 10% and 15%, respectively.

According to the Energy Information Agency, when the price of crude oil is considered, this technology would have been market competitive since 2005. The two largest reasons why this technology has not been widely adopted are:

- The risk of crude oil prices falling to a price that would not make this technology economically feasible.
- Because the coal to liquid process itself is powered by burning coal, large amounts of CO_2 are produced. Meeting present CO_2 emissions standards adds too much cost to the process for it to be competitive.

CUTTING-EDGE HIGH TEMPERATURE FISSION TECHNOLOGIES TO THE RESCUE

Proven next generation technologies like Liquid Core Molten Salt Reactors (LCMSRs) can produce working heat at a temperature needed to power the conversion process without producing CO_2. Moreover, LCMSRs can power this process at a superior price point.

Cost estimates and nearly four decades of taxpayer funded research at national laboratories, that included an operating proof of concept research reactor, have shown that LCMSR designs can produce zero-carbon electricity at $.02 per kilowatt hour which is half the price of coal burning generated electricity. If applied at only a conservative 25% savings to the coal liquefaction process, which is already a robust and mature industrial technology, LCMSRs could reduce the price necessary for a 10% return on investment for an equivalent barrel of crude to $33 per barrel (a price not seen in a nearly a decade). This price is not just highly competitive— it is potentially market dominating.

LCMSRs show great promise in providing electric and heat for our homes and industry, but it is doubtful the technology could ever be made small enough and economically competitive to directly power automobiles. While LCMSRs could produce very large quantities of electric to power a large number of electric automobiles (as could coal), it is yet to be seen if average Americans will embrace the range and price limitations of the electric car.

Batteries offer a set of complex problems, such as the environmental impact of disposing of spent batteries, and sourcing the materials for battery production. While battery technology has come a long way, it is still expensive and much less energy dense than fossil and synthetic fuels. Barring a quantum leap in battery technology, battery energy storage will not be a viable option for the foreseeable future.

Given these circumstances, it makes sense to transition coal to liquid transportation fuel production over the next 30 years while using LCMSRs to generate electric for consumers and industry. This is a concept similar to how France transitioned its electric industry to nuclear, leaving its oil imports for use as transportation fuel.

ENERGY DENSITY CHART

Storage material	Energy type	Specific energy (MJ/kg)	Energy density (MJ/L)
Uranium (in breeder)	Nuclear fission	80,620,000[2]	1,539,842,000
Thorium (in breeder)	Nuclear fission	79,420,000[2]	929,214,000
Hydrogen (compressed) at 70 MPa)	Chemical	142	5.6
Diesel / Fuel oil	Chemical	48	35.8
LPG (including Propane / Butane)	Chemical	46.4	26
Jet fuel	Chemical	46	37.4
Gasoline (petrol)	Chemical	44.4	32.4
Fat (animal/vegetable)	Chemical	37	
Ethanol fuel (E100)	Chemical	26.4	
Coal	Chemical	24	
Methanol fuel (M100)	Chemical	19.7	
Carbohydrates (including sugars)	Chemical	17	
Protein	Chemical	16.8	
Wood	Chemical	16.2	
TNT	Chemical	4.6	
Gunpowder	Chemical	3	
Lithium battery (non-rechargeable)	Electrochemical	1.8	4.32
Lithium-ion battery	Electrochemical	0.36[4]–0.875	0.9–2.63
Alkaline battery	Electrochemical	0.67	1.8
Nickel-metal hydride battery	Electrochemical	0.288	0.504–1.08
Lead-acid battery	Electrochemical	0.17	0.34
Supercapacitor	Electrical (electrostatic)	0.018	
Electrostatic capacitor	Electrical (electrostatic)	0.000036	

Source

BENEFITS

There are a myriad of benefits to developing a next-generation fission-powered coal liquefaction process, including:

- Developing an important new market for coal products, reenergizing a strategically vital American industry
- Jumpstarting the U.S. economy, thanks to an abundant, affordable, reliable supply of environmentally-friendly electricity and fuel
- Building a pathway to true energy independence by reducing the need for crude oil imports from unfriendly countries
- Creating new, well-paid American jobs

- Reducing America's carbon footprint to a point beyond that suggested by the Kyoto Protocols Accord
- Curtailing risks of environmental disasters due to oil spills
- Eliminating the significant carbon footprint of crude oil transport vessels
- Limiting military presence in unstable regions of the world necessary to maintain reliable crude oil imports
- Providing synthetic fuels, produced from a coal liquefaction process, allows the creation of environmentally cleaner fuels than those produced from crude oil.

WHY NEXT GENERATION COAL LIQUEFACTION, AND WHY NOW?

Some may ask "Why invest in coal when the United States has plenty of cheap and clean natural gas?" It is estimated that the United States has a 100-year supply of natural gas. That estimate, however, holds true only if America has no economic expansion and does not export any of its domestic natural gas. Changes in these two factors could raise prices and reduce reserves.

With foreign markets paying much more for natural gas than Americans pay at home, exporting this resource is an economically attractive proposition. Additionally, an influx of American natural gas could stabilize many world energy markets, reducing the possibility of future military conflict. However, as we become more dependent on natural gas domestically, exporting our natural gas resources will necessarily mean a rise in our domestic natural gas costs. It will also increase the overall consumption rate of our reserve. In this scenario, we could realistically be able to realize only a 30-year supply of natural gas, if vast recoverable supplies are not found elsewhere.

A good step toward jumpstarting the U.S. economy would be lowering gasoline and diesel prices to 1990 levels through the development of liquid coal fuels, and exporting natural gas abroad. That maximizes the potential return on natural gas, while creating a reliable domestic source of affordable clean energy.

MAKING IT HAPPEN

The eGeneration Foundation has identified a path towards a revival of the coal industry and the economic recovery of the United States:

- Educate Policy Leaders about Liquid Core Molten Salt Reactor (LCMSR) Technology

    - The successful use of thorium as a nuclear fuel in traditional reactors
    - The development of LCMSR technology for the Aircraft Nuclear Propulsion (ANP) program
    - The successful proof of concept, for civilian power application, MSR Experiment (MSRE) conducted at Oak Ridge National Laboratory

- Confirm Technical and Economic Benefits

    - Technical feasibility study of the next generation coal liquefaction process
    - Economic feasibility study of the next generation coal liquefaction process
    - Environmental impact analysis study of the next generation coal liquefaction process
    - Economic impact and job creation study relating to coal producing states
    - Economic impact and job creation study relating to the entire United States
    - Form eGeneration industry alliance to promote the next generation of coal liquefaction, based on Liquid Core Molten Salt Reactor next generation nuclear technology

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