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Germany's Synthetic Fuel Industry 1927-1945

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Germany has virtually no petroleum deposits. Prior to the twentieth century this was not a serious problem because Germany possessed abundant coal reserves. Coal provided for commercial and home heating; it also fulfilled the needs of industry and the military, particularly the navy. In the opening decade of the twentieth century, Germany's fuel requirements began to change. Two reasons were especially important. First, Germany became increasingly dependent on gasoline and diesel oil engines. The appearance of automobiles, trucks, and then airplanes made a plentiful supply of gasoline essential. Moreover, ocean-going ships increasingly used diesel oil rather than coal as their energy source. Second, Germany's continuing industrialization and urbanization led to the replacement of coal with smokeless liquid fuels that not only had a higher energy content but were cleaner burning and easier to handle.

Petroleum was clearly the fuel of the future, and to insure that Germany would never lack a plentiful supply, German scientists and engineers invented and developed two processes that enabled them to synthesize petroleum from their country's abundant coal supplies and to establish the world's first technologically successful synthetic liquid fuel industry. Friedrich Bergius (1884-1949) (Figure 1) in Rheinau-Mannheim began the German drive for energy independence with his invention and early development of high-pressure coal hydrogenation or liquefaction in the years 1910-25 (Figures 2,3,4). A decade after Bergius began his work Franz Fischer (1877-1947) and Hans Tropsch (1889-1935) at the Kaiser-Wilhelm Institute for Coal Research (KWI) in Mülheim, Ruhr, invented a second process for the synthesis of liquid fuel from coal. By the mid-1930s chemical companies like IG Farben and Ruhrchemie had started to industrialize synthetic liquid fuel production, resulting in the construction of twelve coal hydrogenation and nine Fischer-Tropsch (F-T) plants by the time World War II ended. Several breakthroughs contributed to the success of coal hydrogenation, the most significant of which were the sulfur resistant catalysts and the two stage liquid-vapor phase hydrogenation that Matthias Pier (1882-1965) at IG Farben developed in the late 1920s. For the F-T synthesis, the cobalt catalysts that Fischer and his co-workers prepared in the 1920s-30s were crucial to its success.

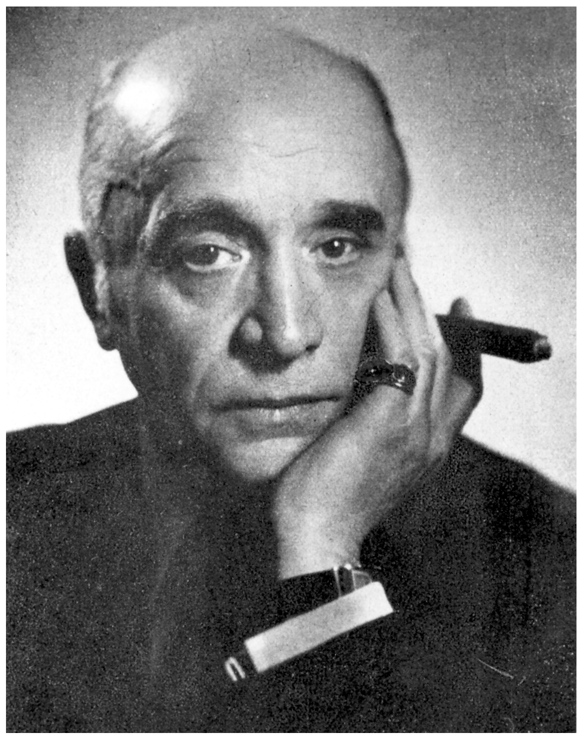

Figure 1. Fredrich Bergius, probably after receiving the Nobel Prize in 1931, which he shared with Carl Bosch for their contributions to chemical high-pressure methods.

Because of synthetic liquid fuel's high production cost, the industry benefited from the financial incentives Germany's Nazi government offered beginning in December of 1933, and because liquid fuel was crucial to Germany's war effort, the synthetic fuel industry became a major part of Adolf Hitler's *Four Year Plan* of 1936. As the war dragged on, the synthetic fuel industry, like many German industries, experienced serious labor shortages, and to avoid any loss of production and slowdown of the war effort, some of the plants used forced labor provided by the German government.

Of the two processes, hydrogenation was the more advanced and contrib-

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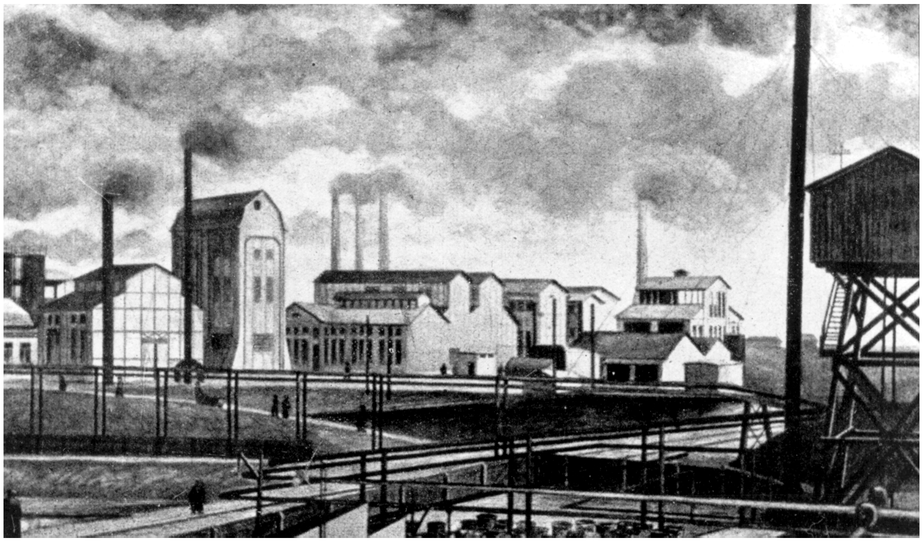
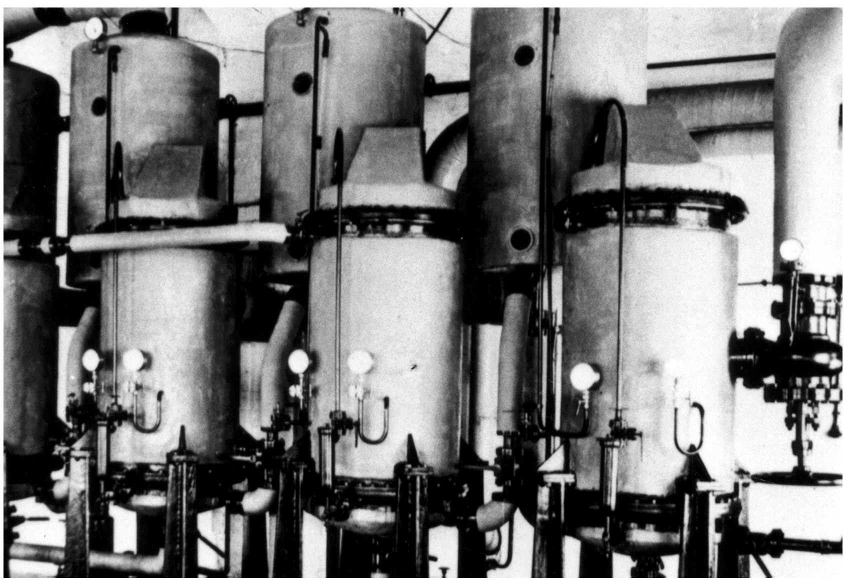


Figure 2. Bergius factory in Rheinau, Germany

Germany's technologically successful synthetic fuel industry continued to grow during the 1930s and in the period 1939-1945 produced eighteen million tons of liquids from coal and tar, and another three million tons of liquids from the F-T synthesis. After the war ended, German industry did not continue synthetic fuel production because the Potsdam (Babelsberg) Conference of July 16, 1945 prohibited it. The Allies maintained that Germany's Nazi government had created the industry for strategic reasons under its policy of autarchy and that in postwar Germany there were, economically, better uses for its coal than synthetic fuel production. Four years later, the Frankfurt Agreement ordered dismantling of the four coal hydrogenation plants in the western zones, all of which were in the British zone. But shortly after the formal establishment of the West German government in September 1949, a new agreement, the Petersberg (Bonn) Agreement, quickly halted the dismantling process in an effort to provide employment for several thousand workers. The West German government completely removed the ban on coal hydrogenation in 1951, although by this time Ruhröl GmbH (Mathias Stinnes) had deactivated the Welheim plant, and the plants in Scholven, Gelsenberg, and Wesseling after design modifications,



Figures 3-4. Reactors inside the Rheinau factory.

uted much more significantly to Germany's liquid fuel supply than the F-T synthesis. Coal hydrogenation produced high quality aviation and motor gasoline, whereas the F-T synthesis gave high quality diesel and lubricating oil, waxes, and some lower quality motor gasoline. The two processes actually were complementary rather than competitive, but because only coal hydrogenation produced high quality gasoline, it experienced much greater expansion in the late 1930s and war years than the F-T synthesis, which hardly grew at all. F-T products were mainly the raw materials for further chemical syntheses with little upgrading of its low quality gasoline by cracking because of unfavorable economics. Hydrogenation also had experienced greater development because brown coal (lignite), the only coal available in many parts of Germany, underwent hydrogenation more readily than a F-T synthesis. In addition, the more mature and better developed hydrogenation process had the support of IG Farben, Germany's chemical leader, which had successfully industrialized coal hydrogenation beginning in 1927.

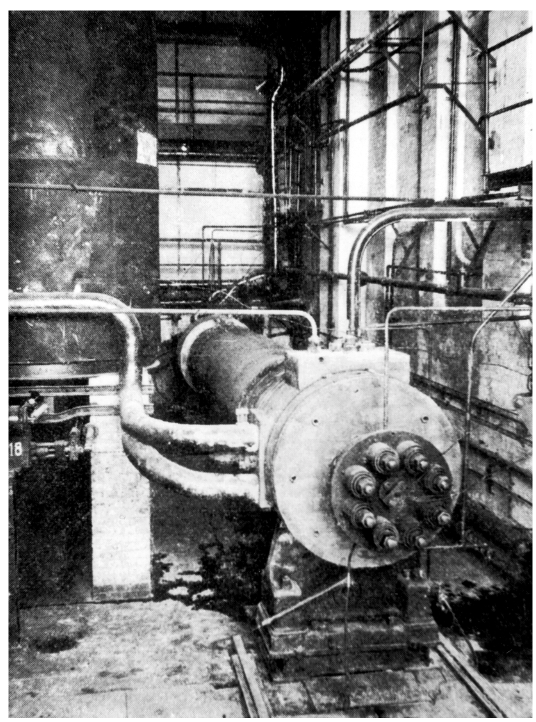


Figure 4.

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"Ashes to Energy"

The Coleman Power Plant Ash Recovery Inauguration

Not since Mark Twain published "Life on the Mississippi" have the banks of the famous river seen such media attention. On August 14th, Western Kentucky Energy's Coleman Power Plant was the gathering place of scientists, journalists, and politicians. All were there to celebrate a new project developed by CAER staff that has both economic and environmental impacts.

The technology will recover fuel and useful products from coal combustion waste. Development has begun on a processing facility to produce multiple products from the coal-waste land filled at the slurry ponds of the Coleman Station.

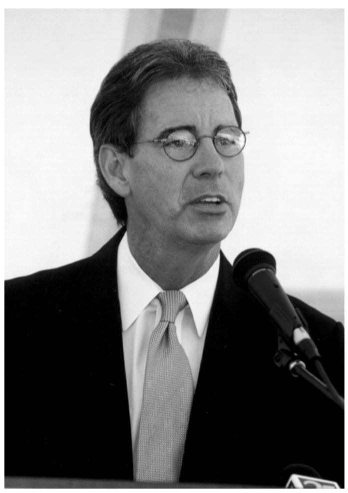
The project is an effort by a utility to recover multiple products from its waste. This will contribute in a critical way to the utilization of coal by-products nationally, paving the way for projects in many other parts of the country, while having a significant environmental impact.

This is the much sought after scenario whereby industry-academia-and federal agencies work together to solve both an environmental and economic problem. It is sponsored in part by the US Department of Energy, Western Kentucky Energy and the University of Kentucky. The technology used here was developed by researchers at CAER over the past 10 years and recovers a variety of marketable products from stored coal combustion ash.

Speaking at the media day event were:

- Debbie Dewey, VP Operations WKE
- Representative Ron Lewis, United States Congress
- Richard Noceti, US Department of Energy
- Ari Geertsema, Director, UK Center for Applied Energy Research
- Senator Mitch McConnell, United States Congress
- Bob Berry, Plant Manager, Coleman Power Station
- Tom Robl, Scientist, UK Center for Applied Energy Research
- Jack Groppo, Mining Engineer, UK Center for Applied Energy Research

Debbie Dewey



Ron Lewis

Richard Noceti

Ari Geertsema

Mitch McConnell

Bob Berry

Tom Robl

Jack Groppo

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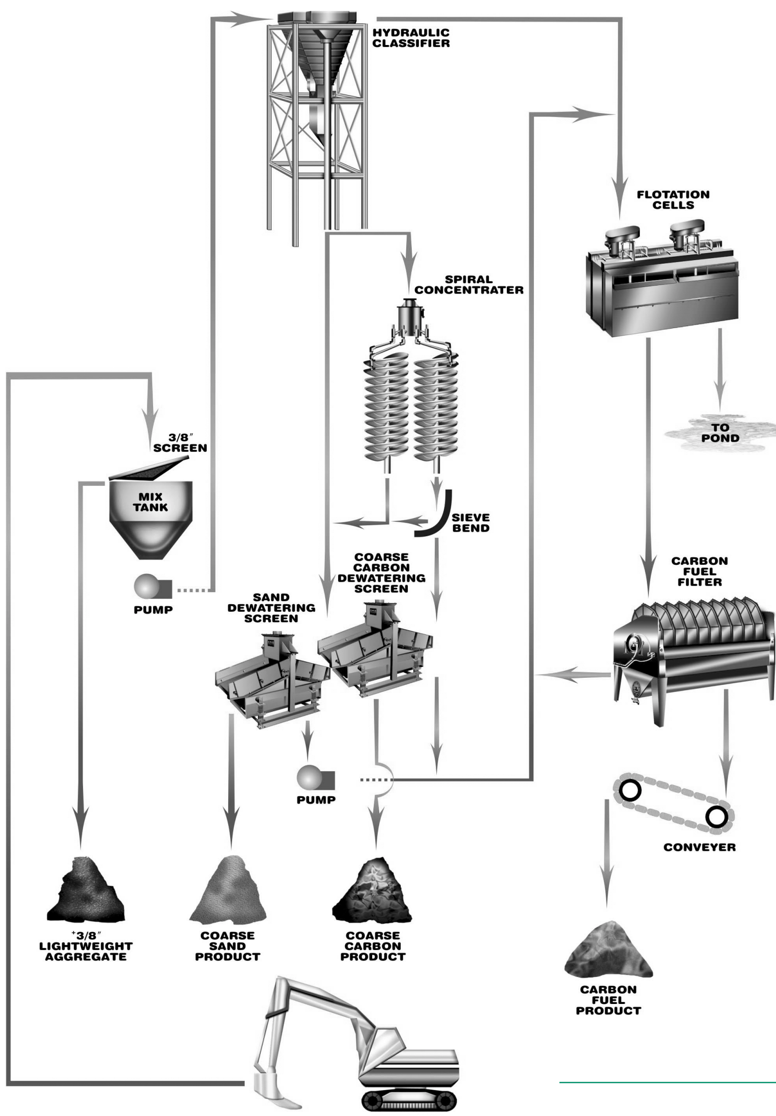
After brief comments by the panelists, Tom Robl and Jack Groppo described the project. This was followed by a demonstration of the Argo, a vehicle that will be used to locate heavy carbon areas and remove the carbon/ash from the pond.

Photos: Courtesy of Forrest Payne Photography

The Argo is an amphibious vehicle, which can travel both on land and into the sludge pond. It should prove invaluable in recovering samples.

A researcher attaches a drill to the Argo.

COLEMAN FUEL FLOAT FLOWSHEET



SETTING SAIL-

Perspectives from the Director

Ari Geertsema, Director CAER

Taking over command of a ship that is pretty well on course doesn't sound to be too hard to do. In many ways the CAER ship has a lot of momentum and it has in the past visited many ports. There are fond memories and achievements. With a new captain in an ocean with unfamiliar winds and current, it takes some time to consider the destination, the cargo and the crew. These and other factors (not to mention sharks) have to be put into perspective to ensure that CAER will reach the desired ports of destination in such a way that those who have an interest in the ship and the crew are experiencing satisfaction with a course well steered and goods delivered as agreed upon.

In the past few months I have received tremendous support from those have I met and with whom I have started collaborating. It is clear that there are very high expectations of CAER. The times call for innovative applied energy technologies based on top-notch scientific pursuit. This is what we are on about. We have already started working through the project portfolio, assessing our challenges and potential hurdles, and are progressing to identify the most promising projects. Some reorganization has taken place. All of the coal-related activities have been grouped together as "Environmental and Coal Technologies." Until we get a few things resolved about creating a position to head this group, I am taking on this responsibility. We shall recruit for an incumbent in the near future.

A current issue is the level of federal funding for coal-related research and development. We trust that appropriate funding for potential CAER projects will be made available in the near future. Another topic is the renewal of the NSF grant for the MRSEC Carbon Materials activities. Despite the loss of a number of key researchers, we are confident that with the promised actions at UK, we shall be back on track soon.

These concerns, however, will not keep us from building on the existing strengths at CAER to ensure a safe and expedient onward journey.

A new CAER Advisory Board is being appointed and is due to meet early in November. A revised Vision and Mission document was developed by CAER staff. This will be discussed at the first meeting. The main focus of the meeting will be on expectations from the Commonwealth of Kentucky as well as from UK under the new leadership of President Lee Todd. More about the future role and purpose of CAER in an upcoming issue of **Energeia**.

We are certainly not simply going to sail into the sunset. Instead, while returning to some familiar waters, we will also chart new courses as appropriate. We are ready to take on new opportunities created by the greater national emphasis on energy. At the same time we shall be prepared to deal with storms that might come our way. We'll sail on:
Success Ahoy!

Ari Geertsema

were hydrogenating and refining crude oil rather than hydrogenating coal.

The Russians dismantled the Magdeberg plant located in their zone and the three plants in Poland at Pölitz, Blechhammer, and Auschwitz. They used parts from the Magdeberg and Auschwitz plants to reconstruct a plant in Siberia that had an annual production capacity of one million metric tons of aviation fuel and a second plant in Kemerow-Westbirien that also produced aviation fuel from coal. The Pölitz and Blechhammer plants provided scrap iron. Three other plants in their zone, at Leuna, Böhlen, Zeitz, and the Sudetenland plant at Brüx (Möst), which the Russians gave to Czechoslovakia, continued with coal and tar hydrogenation, and after modification, refined petroleum into the early 1960s. Some dismantling and conversion to synthetic ammonia production for fertilizers occurred at the Leuna plant which, by 1947 the Russians had renamed the Leuna Chemical Works of the Soviet Company for Mineral Fertilizers. The last of the coal hydrogenation plants in the Soviet Zone at Lützkendorf did not resume production after the war. Three of the F-T plants continued operation after the war. Schwarzheide in the Soviet Zone, which had a labor force of 3,600, produced gasoline for Russian civilian and military construction. Gewerkschaft Victor in Castrop-Rauxel and Krupp Treibstoffwerk in Wanne-Eickel in the British zone, as of February 1946 were producing oils and waxes from fatty acids and using them to make soaps and margarine. The six other plants remained inoperative.

The German synthetic fuel industry succeeded technologically because in the 1920s Pier at IG Farben developed suitable catalysts for the hydrogenation of coal and divided the process into separate liquid and vapor phase hydorgenations, improving both economics and yield. A short time later Fischer and his co-workers at the KWI prepared the catalysts and established the reaction conditions that made the F-T synthesis a success. But neither coal-to-oil conversion process could produce a synthetic liquid fuel at a cost competitive with natural petroleum. Coal hydrogenation and the F-T synthesis persevered and survived because they provided the only path Germany could follow in its search for petroleum independence.

Dr. Stranges has been a faculty member at Texas A & M since 1977 where he teaches courses on the history of science. He is the author of ELECTRONS AND VALENCE and of articles on the history of synthetic fuels published in ISIS, TECHNOLOGY AND CULTURE, ANNALS OF SCIENCE, and other history of science journals. He received his Ph.D in history of science from the University of Wisconsin in1977.

EDITOR'S NOTE: The photos that accompany this article might seem slightly scewed to the Bergius process. A full description of the FT process (and the personalities behind it) can be found in a previous Energeia article by Burt Davis (volume 8(3)) and may be viewed at http://www.caer.uky.edu/energeia/PDF/vol8_3.pdf

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