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The revolt of the chemists: biofuels, agricultural overproduction, and the chemurgy movement in New Deal America

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ABSTRACT

This article proposes a new reading of the chemurgy movement in New Deal America. It shows that the quest for renewable energy was rooted in a vision of a new economy based on chemical knowledge. Rather than a goal in itself, fuel alcohol for automotive uses was meant to showcase the problem-solving power of chemists and the urgency to put chemists in charge on all levels. The article places this vision in the context of the existential crisis of capitalism in the 1930s and traces the movement's formation, its defining projects and their failures, and how the cause petered out in the post-war years. The chemurgy movement failed for three reasons. Its defining product, fuel alcohol, was not competitive on existing markets, the movement lacked political allies, particularly in the farming community, and faced vigorous resistance from the oil industry, and its vision of expert rule never gained momentum.

KEYWORDS

Renewable energy;
alternative fuels; alcohol;
expertocracy; chemurgy

Nature will not tolerate violators at her shrine; where she bids, the alert and discerning will do her reverence. No recalcitrant ever won a combat with Nature. Thus the teaching of the great chemical revolution should mould the thoughts and aspirations of all earnest men; theirs to do and act that self-containment shall strengthen social solidarity.

William J. Hale¹

Alcohol has powered cars since their earliest days. In the first decade of the twentieth century, when racing was the defining purpose of car use, a lively debate arose over the relative merits of alcohol-powered versus gasoline-powered automobiles.² However, the chemurgy movement brought it to a new level in New Deal America when it inaugurated the first attempt to produce automobile fuel from agricultural raw material on an industrial scale. As far as we know, it was the only attempt of its size and ambition until the Brazilian ethanol program in the 1970s.³ Chemurgy's fuel alcohol campaign emerged at the crossroads of three separate trends. First, the campaign took place against the backdrop of the world's only country that had embraced mass motorization in the 1920s, which assured a sizeable market for fuels. Second, fuel alcohol promised an outlet for agricultural commodities whose price had collapsed in the wake of surplus production. However, neither of these would have produced a significant movement for biofuels in the absence of a third factor: a burgeoning academic profession. The chemurgy

movement sought to empower chemists as the nation's supreme problem solvers, and at its core, chemurgy held a vision of expert rule for a society wrestling with an existential crisis of capitalism. This article proposes to view the quest for fuel alcohol in a new context that I call, with a bow to Edwin T. Layton, Jr., the revolt of the chemists.⁴

The chemurgy movement failed in dramatic fashion, and so did the fuel alcohol project. This has framed scholarly perspectives, and scholars have explored different narratives that revolved around the theme of an undeserved failure. Some twenty years ago, Randal Beeman published an adoring article about 'the forgotten promises of the chemurgy movement'.⁵ A 2010 book on the history of biofuels is dedicated to William Hale, a determined advocate of fuel alcohol 'who, in an era when oil was king, refused to keep pace with his companions'.⁶ However, a quest for precursors runs the risk of a decontextualized narrative where emphatic praise discourages inquiries into the heroes' motives. Against this backdrop, this essay serves as a call for caution in the emerging history of renewables. Chemurgy's crusade for fuel alcohol was about renewables, but for contemporaries, that was not the main frame of reference.

This article seeks to place chemurgy at the crossroads of energy history, agricultural history and the history of science and technology. Chemurgy's approach to renewables drew on a number of contemporary trends: agricultural overproduction, technological innovation, business opportunities, understandings of expertise and their institutional representation, and the emerging political framework of New Deal America. It should be stressed from the outset that chemurgy was about a broad range of commodities, but fuel alcohol was a genuine cause with special status. Mark Finlay has argued that 'as the Depression intensified and grain surpluses mounted in the Midwest, chemurgy's initial focal point became the power alcohol (bioethanol) movement'.⁷ One of the key figures, William Hale, declared in a letter of 1940 that the fuel alcohol industry 'is by far the most important factor in this movement. All else is important but of minor influence in the immediate future'.⁸ Fuel alcohol claimed a lot of the movement's intellectual and financial resources, and its failure was a key factor in the demise of chemurgy as a self-identified movement. While chemurgy was about more than fuel alcohol, one cannot understand its trajectory without the ill-fated biofuels project.

The first section of this paper provides the context by presenting some background information on the institutional development of the chemurgy movement. The second focuses more closely on the movement's understanding of chemical expertise. In a nutshell, chemurgy did not just seek to develop new knowledge but also sought to enhance the status of chemical expertise. It envisioned chemists as supreme economic coordinators, effectively tying chemurgy to a vision of a new economy centered on chemical knowledge. The following section discusses chemurgy's fierce clash with petroleum interests and the movement's failure to build a coalition with the New Deal administration or the farmers. The fourth section looks into the trope of an upcoming resource scarcity that underpinned chemurgy's promise. It shows that this trope grew out of a professional vision that was disconnected from market observations or any other real-world context: ideas about resource scarcity were essentially vehicles for expertocratic self-legitimation. The final section looks into the hapless career of the business ventures that chemurgy's fuel alcohol project begat. It is hard to avoid the impression that the company at the core of chemurgy's quest, the Atchison Agrol Company, was a preordained failure, to the point where its failure is less difficult to explain than why

people invested money into the endeavor. The Atchison plant closed in November 1938, and while the corporation continued to operate under a new name, the National Agrol Company survived only because William Hale ran and endowed it in the style of a sugar daddy.

Chemurgy: the institutional setting

The roots of chemurgy lay in the American farm crisis of the interwar years. Before the First World War, American farmers had enjoyed the golden years of American agriculture. The advancing frontier brought new land into cultivation, and producers of grain and meat found willing buyers domestically and abroad. Market conditions became even more favorable during World War One, but the boom years ended with a dramatic plunge of commodity prices in 1920/21. Throughout the 1920s, growing yields per acre and weak international markets made for chronic overproduction, which kept prices down. The crisis grew even more dramatic with the onset of the Great Depression.⁹

The basic idea of chemurgy was that scientific innovation could create the new markets that farmers were so desperately seeking. The discussion began in 1926 when two articles proposed the idea independent of each other. Wheeler McMillen, an agricultural journalist, published an editorial in *Farm and Fireside* that asked for more research on nonfood uses for crops.¹⁰ Writing in Henry Ford's weekly *The Dearborn Independent*, otherwise known for its anti-Semitic content, William Hale made a similar case from the chemists' point of view.¹¹ Hale also provided the name for the movement with his 1934 book *The Farm Chemurgic*: 'Chemurgy, from the Greek χημεία (black art of Egypt, or chemistry) (chêmi = Egypt) and ἐργον (work) is that science concerned in the working with and for chemical compounds'.¹²

By that time, chemurgy was advancing from a mere idea towards formal structures. One of the pioneering steps came from Henry Ford who, in addition to his well-known penchant for the soybean, created a lab for chemurgic research in 1929.¹³ The Chemical Foundation, owner of the German chemical patents that the US had confiscated during World War One, supported the publication of Hale's *Farm Chemurgic*.¹⁴ The community found an institutional hub with the foundation of the Farm Chemurgic Council in 1935 when more than 300 delegates met for a conference in Dearborn, Michigan. The association, which soon changed its name to National Farm Chemurgic Council in order to avoid confusion with regional associations, continued to work into the post-World War Two era, but it was a somewhat shadowy existence after the movement's heydays in New Deal America. The Council disbanded just as Americans were showing a renewed interest in recycling and alternatives to fossil resources in the wake of the 1973 oil price shock.¹⁵

The Council's birth in Dearborn mirrors the important role of Henry Ford in the institutionalization of chemurgy. The 1935 conference culminated in a melodramatic ceremony in Henry Ford's replica of Independence Hall where delegates signed a 'Declaration of Dependence Upon the Soil and the Right of Self-Maintenance'.¹⁶ Ford did not provide financial support to the Council itself, but the organization won another sponsor with deep pockets.¹⁷ The Chemical Foundation generously endowed the work of the Farm Chemurgic Council during its early years, and the head of the Foundation, Francis Patrick Garvan, served as president of the Council until his death in November 1937. The timing of his death was particularly unfortunate for chemurgy's ambitions in

that it coincided with the expiration of the Foundation's profitable patents. Garvan's successor, Wheeler McMillen, steered the Council into calmer waters and thus assured its survival, but that came at the expense of a diminished role. As we will see, one of the first things that he threw overboard was fuel alcohol.¹⁸

Chemurgy dealt with a wide range of topics from its inception. Hale's article of 1926 discussed issues as diverse as soybeans, corn hulls, peanut oil, and forestry.¹⁹ When the Council's Board of Governors and Committee Members met in January 1937, the minutes recorded discussions on soybeans, insecticides, fertilizers, plastics, tung oil, cotton in road construction, paper from Southern pine, Jerusalem Artichokes, hemp, flax, and organo-phosphates.²⁰ Chemurgists had no qualms about incorporating George Washington Carver's work on the many uses of peanuts even though it predated the 1926 articles: it had become an American national myth since Carver lectured on peanuts in a congressional hearing in 1921.²¹ In essence, chemurgy was a collective imaginary, nourished by a community of like-minded chemists but aimed for a mass audience that never materialized. Revealingly, the word remained confined to the active vocabulary of a single generation.²²

In defining the movement's scope, it seems best to focus on means rather than issues. Chemurgy was flexible when it came to the materials in play. It cared little whether American farmers were already producing a commodity in large quantities or not at all, and it looked at by-products and wastes as well. However, chemurgy was adamant about employing chemical means to create new uses or expand an existing range of uses for plants that farmers could produce on American soil. Nothing was safe from chemistry's transformative powers: 'Substitution is the battle-cry of the chemical age', William Hale noted in a speech of 1949.²³ Riding on the back of the boom of the American chemical industry after World War One, it stressed how chemistry opened new opportunities for agriculture as a producer of raw materials. Traditional patterns of resource use were now subject to science-based improvement, and the miraculous powers of chemistry would open new opportunities for farmers, industry, and society at large.

One would assume that in its quest for science-based improvement, the chemurgy movement was a natural ally of the federal government, which had a long-standing record of supporting agricultural research through land grant colleges, agricultural experiment stations and extension services.²⁴ However, chemurgy's relationship with the federal government was fraught with conflicts, and it profited only marginally from the expansion of the federal bureaucracy in New Deal America. It was not until 1938 that the U.S. Department of Agriculture began to set up regional laboratories for chemurgic research in Peoria, New Orleans, Philadelphia, and San Francisco.²⁵ The flamboyant William Hale, whose rhetoric was embarrassing even to his fellow chemurgists at times, wrote in a letter of 1935: 'The Department of Agriculture, as at present constituted, stands as the greatest derelict afloat in these United States. We must use every effort to break down this unscientific organization for the good of our country'.²⁶ After all, chemurgy was aiming for a kind of expertise that was different from what the U.S. Department of Agriculture had traditionally embraced.

The revolt of the chemists

In his pioneering article of 1926, Hale did not leave it at describing how chemistry would open new outlets for farm products. He also called for a reorganization of farm production in 'some large establishment which we shall term "an agricultural supply center" or,

more briefly, “an *agricenter*”. He described it as follows: ‘There must be brought together under a single head a vast number of farms covering in extent thousands of square miles’. These *agricenters* would allow what he saw as the crucial factor in the improvement of production methods, namely ‘the employment of men of talent who shall direct the researches, economics and finances necessary for successful farming’. Farmers would receive seeds and fertilizer for free and focus on working the land: ‘His entire duty is to cultivate the crops and his profits accrue from the sale of harvested products after the deduction of initial and operating expenses’. Farmers may also hold ownership in these *agricenters*, but Hale showed scant interest in property issues. When it came to the farmers, the crucial issue was that they ‘abide by the decision of those in authority’.²⁷

Hale’s vision preceded forced collectivization in the Soviet Union, to which it has an obvious similarity, but it was also a difficult sell on its own terms. Hale claimed to know ‘the real needs of the farmer’, but it does not seem like he spent a lot of time talking with farmers.²⁸ It did not occur to Hale that his proposal ran against the farmers’ interests. Why should farmers surrender command over their land – if not the land itself – and turn themselves into dependent workers? The idea of *agricenters* never got anywhere, but it sheds light on Hale’s understanding of expertise. He envisioned *agricenters* to operate under the guidance of lawyers, botanists, and biologists, but in the end, it was chemists who were supposed to call the shots. ‘When we contemplate the science of agriculture we are forced to define an agriculturalist simply as an organic chemical manufacturer’, Hale declared after depicting all other views of agriculture as reactionary: ‘Everyone seems to view the situation through the haze of bygone days’.²⁹

Hale’s enthusiasm had its roots in the great advances of contemporary chemistry. In Hale’s reading, chemistry’s track record of innovations, and particularly the Haber-Bosch process for the production of synthetic nitrogen, came down to a new chapter in human history. In fact, Hale felt so confident about this new epoch that he wrote about it in a prospectus for the Securities and Exchange Commission: ‘Happily at this stage the civilized world finds itself ushered into the Chemical Age, – an age brought on by great organic chemical discoveries but peculiarly initiated and based upon the synthesis of ammonia (Haber Process) from the elements of the atmosphere’.³⁰ Chemistry was poised to solve many problems, and thus ‘great nations must become chemically minded and chemically disciplined to direct nature’s biochemical processes to universal use’.³¹ It was no coincidence that the subtitle of Hale’s *Farm Chemurgic* – ‘Farmward the Star of Destiny Lights Our Way’ – alluded to ‘Westward the Course of Empire Takes its Way’, an icon of America’s Manifest Destiny.³²

Such an understanding of expertise had parallels with the contemporary technocracy movement.³³ In fact, Hale wrote an article in response to the technocracy movement in 1933 that found the rule of scientists preferable to the rule of engineers and thus called for ‘epistemocracy’ rather than technocracy.³⁴ These disagreements notwithstanding, both movements mirrored a feeling among their members that their traditional realm of expertise did no longer do justice to their ambitions: their expertise called not just for new solutions to existing problems but for a new political order. In a letter to Republican Senator John W. Bricker, Hale declared that chemurgy ‘opens a new world’, that he was living ‘in a period that can be no other than chemurgic’, and that younger generations would be ‘born with verve and zest sufficient to set this world in chemurgic order’.³⁵ It was a choice between ‘chemurgy or chaos’, the title of a speech of 1949 in which Hale gave

the following diagnoses of the woes of his age: 'Today we are confronted with misfortunes and misgivings rising out of disregard for scientific advance in the field of organic chemistry'.³⁶ Chemurgy was a new vision of society's progress, and problems such as the farm crisis or the supply of industrial raw materials were merely indicative of a much broader point: 'In chemurgy lies the hope of the world'.³⁷

This mindset shaped chemurgy's stance on fuel alcohol. The campaign was not just about alcohol as a fuel additive on the contemporary gasoline market. The issue at stake was something akin to a chemical Categorical Imperative. 'No other organic chemical can ever approach the magnificence that is chemurgic ethyl alcohol', a typical statement ran.³⁸ 'In no other compound is there such multiplicity of potential reactions capable of involving countless new combinations', the aforementioned prospectus declared.³⁹ And that was more than rhetoric. The business plan was exuberant in that it aimed for 'the construction of nearly a thousand fermentation plants of eight to ten thousand gallons daily output'. It would have been 'the greatest experiment destined to eliminate all unemployment': 'A million men in plant and on farm will directly be involved and another two million men in allied industries will come into steady work'.⁴⁰ And that was just the strategy for the immediate future. In the long run, much greater horizons were waiting to be explored: 'Its use as blend with gasoline is only the first step in the inauguration of the greatest industry man is destined to know for a century'.⁴¹

According to the prospectus, fuel alcohol was a matter of 'common sense', but the federal government thought otherwise.⁴² Previous scholarship has stressed the rift between chemurgy and the agricultural policies of the New Deal which aimed to boost farm income by buying abundant products with depressed prices and paying farmers to reserve land. While chemurgists sought to find new uses for overproduction, the New Dealers wanted to curb it through market controls.⁴³ However, this divergence of approaches mirrored a more fundamental clash of economic philosophies. Chemurgists had their own bespoke ideas on how markets worked. Their argument for economic nationalism and self-sufficiency was essentially chemical: 'Anyone who knows anything about chemistry knows that [export of agricultural products] is forever forbidden. International trade in agriculture must cease in a modern world', William Hale declared in a Senate hearing.⁴⁴ Even prices should no longer be a matter of supply and demand. Hale called for an 'awakening, when chemical valuation shall be the criterion in a world of commerce – agricultural and industrial. Never again should prices be allowed to transcend chemical values'.⁴⁵

The New Dealers were certainly not averse to science and engineering, but they could not accommodate this kind of expertise. With the presidential election of 1940 approaching, Hale hoped for a Republican candidate who embraced chemurgy.⁴⁶ When Roosevelt was elected to a third term, he put his hopes in Charles Lindbergh. In a letter of April 1941 to Hans Kühne of Germany's I.G. Farben Company, he called him 'the exponent of the best thought in America'.⁴⁷ Kühne replied with anti-Semitic comments, which did not keep Hale from continuing the conversation after World War Two.⁴⁸ When post-war politics equally failed to live up to his expectations, he put his hopes in 'a revitalized scientific government'.⁴⁹ Writing to the Assistant Secretary of the Department of Agriculture, J. Earl Coke, ten months before his death in August 1955, Hale envisioned nothing short of a chemurgic revolt in the upcoming presidential election: 'If the next two years do not bring forth a plant or two delivering chemurgic alcohol for fuel, based on

unrestricted output on farm under contract to such end, then you may expect in the Presidential election of 1956, a revolutionary leadership promising to spend a billion dollars or more on chemurgic research with all petroleum corporations safely under control by the Government'.⁵⁰

Hale's plans had an otherworldly touch, but he was not far removed from the world of business: his father-in-law was Herbert Henry Dow, the founder of Dow Chemical. Hale received degrees from Miami University of Ohio and Harvard University, held fellowships at the Technische Hochschule Berlin and Göttingen University in Germany and joined the University of Michigan after a term at the University of Chicago. One of his students was Herbert Dow's daughter Helen. They married in 1917, and Hale built an organic research laboratory at the company of his father-in-law. (Helen died from the Spanish flu in October 1918.) But in the end, being the son of a Presbyterian minister probably left a deeper impression than Herbert Henry Dow.⁵¹ Hale preached his own gospel, that of chemurgy, and sold it as a panacea to society's woes: 'No longer need we fear famine and pestilence or strife and turmoil when once we have adjusted our economy to the chemurgic way under Divine law'.⁵² However, faith does not count for much if you fail to attract an audience.

Vested interests

The New Deal had a different solution to the problem of agricultural overproduction, but it was not averse to chemurgy from the outset. In the spring of 1933, chemurgists met with officials from the U.S. Department of Agriculture and agreed on draft legislation in support of fuel alcohol. The plan was to tax gasoline blended with alcohol with one cent per gallon whereas unblended gasoline would receive a tax of two cents per gallon, increasing to three cents per gallon from 1935 on. On 28 April 1933 Agricultural Secretary Henry Wallace sent a letter to President Roosevelt that envisioned a large power alcohol industry in the nation's major grain regions.⁵³ However, the collaboration came to a quick and permanent end when the plan ran into vigorous opposition from petroleum interests, and the New Deal was henceforth cautious in its dealings with chemurgy. In the words of David E. Wright, alcohol had wrecked the marriage.⁵⁴

The project had aimed for the use of alcohol as a fuel additive, and that market was firmly in the hands of the Ethyl Gasoline Corporation, a subsidiary of General Motors and Standard Oil. The Ethyl Corporation had survived a bitter controversy in the mid-1920s when its product, tetraethyl lead, came under fire as a threat to public health. A number of gruesome workplace accidents raised awareness of the dangers of the substance, but the company eventually prevailed and established tetraethyl lead as America's favorite anti-knock additive.⁵⁵ The petroleum industry was not in the mood for another controversy when fuel alcohol advanced on the agenda in 1933, and its campaign included some sinister tactics. Distributors of alcohol blends received visits from mysterious experts who demonstrated that alcohol and gasoline would separate when shaken. The trick worked because the experts carefully washed their test tube by way of preparation and left a few drops of water inside. Water mixes with alcohol but not with gasoline, and phase separation set in immediately.⁵⁶

Petroleum was a powerful industry, and much has been made of its determination to stamp out the competition.⁵⁷ But at the same time, it bears recognition that chemurgy was, as corporate challengers go, an easy target. Chemurgy knew that fuel alcohol hinged on government support, and that allowed the petroleum industry, not exactly a herald of free markets by tradition, to lambast discriminatory regulation. Furthermore, chemurgy entered the fight somewhat light-heartedly, cheerfully assuming that for a movement challenging the fundamentals of America's economy, a powerful enemy offered prospects for a spectacular victory. In his memoirs, Wheeler McMillen described how Francis Garvan, as president of the Farm Chemurgic Council, 'cheerfully fanned the fires of conflict, all the happier because the foe was rich and powerful. He built the scrap into magnificent proportions'.⁵⁸ McMillen, who succeeded Garvan after his death and had to deal with his political legacy, stressed the contrast between Garvan as 'a great battling Irishman' and himself as 'a cautious Scotchman without Garvan's talents and resources', but as so often, popular ethnography was probably camouflage for a lack of understanding.⁵⁹ McMillen was one of the few people in the chemurgic camp who hailed from an agricultural background. He perhaps never understood that Garvan, Hale and others were in for a crusade. At its core, chemurgy was not about fuel alcohol or any other product, let alone about the advantages of renewable over nonrenewable energy sources. It was not even about monetary interests, except in the sense that chemurgists viewed them as notoriously overrated. Chemurgy was essentially about a professional creed, and any opposition, no matter how powerful, only revealed that people had failed to understand the commandments of the new age.

From a political standpoint, the campaign for fuel alcohol might have fared better if chemurgy had built a coalition. The commodity chain for fuel alcohol was exceedingly complicated in that it comprised farmers, processors, and retailers, and chemurgy never engaged with any of these parties. The farmers in particular were a strangely passive agent in the chemurgic literature: their single purpose was to produce the raw material that chemurgists would engage with. The literature was silent on agricultural issues such as crop rotations or soil erosion measures, and chemurgists never understood that their economic calculus was deeply flawed from an agricultural point of view. They hoped for cheap raw material in order to strengthen their competitive edge, but low commodity prices were the underlying cause of the farm crisis.

At the end of the day, chemurgists had little to show beyond their professional creed, and as few shared their enthusiasm, their demands were easily brushed aside. The chemurgy movement never came closer to preferential legislation from Washington than in the Spring of 1933, and on the state level, their only achievement was a law in Nebraska that supported alcohol blends through a state gasoline tax refund.⁶⁰ It would have been a meager result for any movement, but for a group of people who saw themselves as the priests of a new epoch, it was devastating.

The great upcoming resource scarcity

One of chemurgy's arguments deserves closer scrutiny for scholars who seek to historicize renewables. Chemurgists bolstered their case for fuel alcohol with references to 'our dwindling supply of all mineral fuels'.⁶¹ They even put it into numbers: 'For this country the best authorities estimate our petroleum reserves as sufficient for 12 to

15 years and our shale oil reserves sufficient for twice that time'.⁶² Similar arguments about resource exhaustion run through modern history from William Stanley Jevons' *The Coal Question* of 1865 to the Club of Rome's *Limits to Growth* of 1972, but chemurgy's timing was unfortunate.⁶³ In the early 1920s, concerns over dwindling petroleum reserves were strong, but by the end of the decade, these gloomy predictions 'had been washed away by the flood of oil that seemed to flow unendingly out of the earth'.⁶⁴ Even after 1945, when demand grew rapidly in Western society, the key problem of the oil business was the petroleum *surplus*.⁶⁵ While chemurgists were warning of an upcoming scarcity, the point of prospective exhaustion was moving farther and farther into the distant future.

However, it is doubtful whether the upcoming resource scarcity was really a result of market observation. Chemurgists never claimed independent studies on the subject. In fact, it is striking that they invoked the prospect even when it was not in sync with their overall argument. In a report, Leo Christensen, a chemist from Iowa State University who had entered the fuel alcohol business in 1935, stressed that the issue at stake was nothing more than a fuel additive: 'In this use alcohol is not a substitute for gasoline but instead serves as a high quality antiknock agent, gum solvent and combustion clarifier. It is of the utmost importance that this fundamental truth be kept clearly in mind'.⁶⁶ But then Christensen added in the same breath 'that someday, when petroleum resources are depleted, power alcohol may become a replacement fuel of superior quality'.⁶⁷ It is not clear how that enhanced Christensen's argument. In fact, the point ultimately weakened the case for fuel alcohol in that it tied the topic to a situation that would not materialize for some time.⁶⁸ Chemurgy's professional pride obviously called for a long view irrespective of whether others cared about the great upcoming resource scarcity.

The long view was particularly noteworthy because chemurgy was not sure whether contemporary means allowed for the full replacement of fossil fuels. In his *Farm Chemurgic*, Hale published an estimate with astronomic figures. He calculated that America would need an annual supply of 10 billion gallons of alcohol for a 50 percent gasoline blend. That production would require four billion bushels of corn – twice the contemporary American harvest. With an average yield per acre of 25 bushels, production would claim 160 million acres, which was roughly all the American land where corn cultivation made sense. 160 million acres were also close to 50 percent of America's total farmland. But then, scientific progress could easily push these boundaries: 'Today a mere 25 bushels of corn constitutes an average yield per acre; tomorrow we know how to bring this yield up to 200 bushels per acre'.⁶⁹ In other words, Hale sought to respond to an upcoming scarcity crisis with means that were not yet at his disposal, and the gamble about future technological advances did not strike him as particularly risky. The progress of American agriculture failed to honor Hale's expectations, though, as the average yield of American corn farmers stood at 171.7 bushels per acre in 2014.⁷⁰

The great upcoming resource scarcity was more about the gospel of chemurgy than about emerging markets. The blueprints with thousands of fuel alcohol plants were a daring proposition if the point of exhaustion was still a decade away, but chemurgy was not interested in a more circumspect approach that would have focused on experiment stations and improving efficiency: market realities and chemurgic visions were and remained separate intellectual worlds. The resource scarcity trope was ultimately an act

of wishful thinking that the age of chemurgy would lead to a new economy. It is hardly surprising that when chemurgy moved from plans to action, the endeavor ended in resounding failure.

Sugar daddy's folly

For a movement that claimed to inaugurate a new era, the hapless struggle against petroleum interests and New Deal policies was a frustrating experience. Chemurgists were not shy in offering visions of dramatic political change, be it in the form of a successful Republican, Charles Lindbergh, or a revolutionary scientific government. But by virtue of their training, chemists were used to action, and that made pipedreams about upcoming events a less than satisfying business. Soon after the creation of the Farm Chemurgic Council in 1935, Garvan used funds from the Chemical Foundation to set up the Atchison Agrol Company for the production of fuel alcohol. The company bought an old plant in Atchison, Kansas and went to the task of turning it into a model plant. In short, Garvan wanted to 'prove his case'.⁷¹ Located on the banks of the Missouri River north of Kansas City, Atchison offered good access to grain markets. However, the project was less fortunate in other respects.

The project faced a host of technical problems that were only resolved over time. Furthermore, the plant ran into trouble with regulators. Alcohol production was a closely controlled business even after the repeal of prohibition, and the tax authorities harbored a suspicion that the real goal of the Atchison project, so obviously lacking a sound economic rationale, was to produce alcohol for human consumption. It took long negotiations and expensive concessions to appease the tax collectors.⁷² The project also suffered from the hesitancy of farmers to sell raw material because there was speculation for higher prices elsewhere. This problem reflects chemurgy's fraught relationship with the farming community, as does the response of Leo Christensen, the general manager of the Atchison project: future projects should buy some land and take production into their own hands.⁷³ Where more circumspect managers would have talked with the producers and offered them a better deal, chemurgists found it preferable to eliminate the unreliable farmer from the commodity chain.

Wishful thinking had been part of the project from the outset, both in terms of the overall vision and in the details. When a project manager reported to the Board of Governors of the Farm Chemurgic Council in January 1937, he spoke about a huge demand: 'Orders for 12 million gallon of Agrol have been received at Atchison, although the plant capacity is only 3 million gallons annually'.⁷⁴ Two years on, Leo Christensen painted an altogether different picture: the Atchison project 'has never had control of sufficient outlets to absorb its production of Agrol Fluid [i.e. fuel alcohol]'.⁷⁵ By that time, Christensen had abandoned the moribund project: he wrote the report from his new home in Miller, Nebraska, which he soon left for jobs at the University of Idaho and the University of Nebraska.⁷⁶ When the Chemical Foundation finally killed the project, estimates of the loss ran between \$300,000 and \$600,000.⁷⁷

The vision of chemurgy had met the world of business, but the outcome was open to debate from chemurgy's point of view. Sure, the plant had never produced alcohol at competitive prices, but maybe scientific and technological progress would drive down costs? A sustained effort at creative accounting, opaque in procedure but clear in

outcome, brought future alcohol projects into the realm of the possible, if only in chemurgic rhetoric. In the end, chemurgy promised alcohol production for free: the prospectus for the Securities and Exchange Commission declared that 'given an unlimited amount of organic waste and a receptacle for its controlled decomposition, there is every possibility that the spirit of ethyl alcohol that distils therefrom [sic] may record a cost approaching nothing'.⁷⁸ However, when McMillen succeeded Garvan at the helm of the Farm Chemurgic Council, he was unwilling to commit his organization to these kind of hopes. 'We realize keenly that no effort can succeed unless it is entirely sound in its economic basis', he declared at the Council's annual dinner in 1941. For those who failed to get the message, he spelled out what was on his mind: 'For instance, the chemurgic program has been hampered by the unfortunate controversy which was aroused a few years ago over power alcohol'.⁷⁹

McMillen's stance brought him fierce criticism from the likes of William Hale who declared that the new course would 'wreck the chemurgic program'.⁸⁰ And Hale did not leave it at words. In 1939, he bought Atchison Agrol from the Chemical Foundation, renamed it National Agrol Company, and turned it into a somewhat farcical enterprise. As a platform for bold ideas, the National Agrol Company served Hale well. But as a business proposition, it failed miserably. The company hinged on Hale's readiness to devote his own time and resources to the cause, something that he bragged about in his presidential report in 1942: 'your President bent every effort to secure more and more patent applications, paying for the necessary research out of his own pocket'.⁸¹ The National Agrol Company did not report a profit until the sixth annual meeting of stockholders in April 1947, and that profit came to a grand total of \$1,328.50.⁸² (In 1941, the company had been authorized to issue shares with a par value of \$5,100,000.⁸³) If the National Agrol Company had been a normal corporation, a shareholders' revolt would have been natural, but this business was more reminiscent of a family adventure. In a letter to the American Research and Development Corporation of 1947, Hale described the company's ownership base as follows: 'National Agrol Company comprises a group of inventors, together with friends, numbering all told about two hundred stockholders'.⁸⁴

Insofar as the National Agrol Company had a core business, it was 'research, patent holding, plant design, plant management and consultation on chemurgic processes'.⁸⁵ During the World War Two, agriculture supplied more alcohol to the synthetic rubber project than the petroleum industry, but the company failed to profit.⁸⁶ Instead of cashing in on the temporary demand, the National Agrol Company started construction on a new 'demonstration and research plant and laboratory' for alcohol in Lincoln, Nebraska in late 1946. It showed an impeccable sense for bad timing because the post-war oil glut had just set in.⁸⁷ However, Hale's enterprising spirit had already seized on another product by that time. His April 1947 report to shareholders gave only scant attention to the Lincoln plant and focused on Vita Green, a chlorophyll-laced chewing gum. His enthusiasm did not show in the corporation's figures. The balance sheet as of 31 December 1946 recorded a chewing gum supplies inventory worth \$1,533.95 and income from gum sales in the amount of \$18.⁸⁸ Hale maintained an infatuation with chlorophyll for the rest of this life and built another company, the Verdurin Company, around its promise. Verdurin's first annual report dealt with chlorophyll-impregnated cigarette filters (also known as Hale cigarettes) and chlorophyllized coffee ('Chlorophyll serves

to oxidize away much of this bitter poison, and hence the finished product is sweeter and more palatable. It will probably carry the name 'oxi-coffee'⁸⁹). The second annual report of the Verdurin Company also discussed experiments with chocolate.⁹⁰

Apart from the culinary unknowns, the great mystery of the National Agrol Company is why people put money into the corporation. There certainly was no lack of warnings. When Hale approached W. B. Bell of the American Cynamide Company as a potential investor in 1939, Bell sent a polite decline: 'even with the best of goodwill, it is hard to come to a favorable decision'. But being a friend of Hale's, he sent some fatherly advice. Bell made no bones of his amazement: 'I find you and some of your associates on your side completely convinced that not only are we on the threshold of the creation of a new industry, but that this industry will revitalize our farms and farmers, will find jobs for the unemployed and bring into balance industry and agriculture'. It reminded Bell of what he perceived as the thinking of the New Deal, and that was obviously not a compliment from the mouth of a corporate leader: 'one thing in our presentation somewhat dismays me and that is your indication that costs, even when they contain every known order of expenditure, may create a complete illusion because these costs do not contain the unknown and uncertain costs brought about by the dislocation of the economy'. In sum, Bell found that the entire endeavor looked more like 'an Altruistic experiment', and that was probably an adequate description not only of National Agrol but of chemurgy as such.⁹¹ Chemurgy was about far more than personal gains: 'In Agrol lies the hope of America' was the closing sentence in the company's prospectus.⁹² In light of that vision, a worthless share was a small price indeed.

Hale continued to search for opportunities to sell chemurgy and its crowning jewel, fuel alcohol, but his efforts increasingly had an air of desperation. One of his forays was about the fight against photochemical smog in Los Angeles, where he argued that the exhaust gases from gasoline engines caused cancer. It failed to make an impression even among those who were otherwise sympathetic to his cause. 'Dr. Hale's advocacy of alcohol has sound practical support', a letter to Dow Chemical's public relations department declared. 'But when Dr. Hale becomes emotional over the effects of the exhaust gas from gasoline engines on cancer of the lungs, I must disagree with him'.⁹³ However, Hale stuck to the point: 'years will pass and many will die of cancer of the lung', he wrote to a colleague at the School of Engineering of the University of Southern California and suggested the following approach: 'Do you suppose you could get a few scientific men together and hit hard at this crux?'⁹⁴ That was how chemurgy sought to solve problems: assemble a number of able men and get them to work. But the fight against Los Angeles smog was entering its second decade at that time, and the hard-working men were long at work on other and more promising approaches against the urban menace.⁹⁵ In the post-war years, fuel alcohol was a solution in search of a problem.

Conclusion: cascades of failure

On the surface, fuel alcohol failed in the market for not being competitive at existing prices, but that was only one of several ways in which the chemurgy movement lost out. It failed politically because it ran into opposition from the New Deal and petroleum interests. It failed as a business proposition with its most cherished product, fuel alcohol. It even failed intellectually in that it never generated much excitement beyond its own

sphere of experts. Even the farming community, perceived by the chemurgy movement as a natural ally, was hesitant to support chemurgy, suspecting that others, most notably industry, would reap the benefits.⁹⁶ The one success that Hale achieved was that he managed to sustain his crusade to his death, and that was arguably a tribute to the strength of his personal contacts and his wealth. His intellectual journey would have faced limits earlier if he had not been the son-in-law of the founder of Dow Chemical. It is difficult to understand the strange career of the National Agrol Company without acknowledging the existence of a strong network of men who were willing to risk money on a commercial folly in exchange for access to a network. In sum, failure was multifaceted, and scholars have found it easy to offer explanations. A quarter-century ago, economist Vernon Ruttan observed that chemurgy ‘lost both scientific and political credibility because it promised more than it could deliver’.⁹⁷

But retrospective assessments of failure miss an important point. Chemurgy’s fuel alcohol project did not seek success under the rules of a capitalist economy. Quite the contrary, it sought to supersede capitalism with an economy guided by chemical thinking. Such a vision was arguably more plausible in the crisis years of global capitalism in the 1930s, where visions such as technocracy found an audience. But having an audience is different from having a following, which in turn is different from having a political coalition, and it seems that chemurgy’s fuel alcohol project was essentially a vehicle for a grand expertocratic vision with some technological work attached. When New Deal America showed no inclination to fall for the intellectual promise of chemurgy, any hope for success, corporate or other, melted into thin air.

Notes

1. Hale, *Prosperity Beckons*, i.
2. Bernton et al., *Forbidden Fuel*, p. 9. For early proposals to subsidize fuel alcohol production see Giebelhaus, “Farming for Fuel,” 174.
3. Cf. the essay by Jeffrey Manuel in this issue.
4. Cf. Layton, *Revolt*.
5. Beeman, “‘Chemivisions’,” 23–45.
6. Bernton et al., *Forbidden Fuel*, xl.
7. Finlay, “Old Efforts,” 36.
8. Michigan State University Archives and Historical Collections, East Lansing, USA (MSUA), LC 176 (William J. Hale Papers) Box 2 Folder 12, William J. Hale to Wheeler McMillen, 19 June 1940, 2.
9. Hurt, *American Agriculture*, 221 n.
10. Effland, “New Riches,” 292.
11. Hale, “Farming Must Become A Chemical Industry.”
12. Hale, *The Farm Chemurgic*, ii.
13. Watts, *People’s Tycoon*, 483.
14. MSUA LC 176 Box 1 Folder 26, Agreement between Dr. William J. Hale and The Stratford Company, 29 August 1934, 1.
15. Finlay, “Old Efforts,” 37, 42; Olson, *Chemurgy and Agriculture*, 1–3.
16. Pursell, “Farm Chemurgic Council,” 309.
17. MSUA LC 176 Box 2 Folder 16, Wheeler McMillen to William J. Hale, 17 January 1946.
18. McMillen, *New Riches*, 38–40.
19. Hale, “Farming Must Become A Chemical Industry,” 25.

20. MSUA LC 177 (Farm Chemurgic Council Records) Box 32 Folder 20, Farm Chemurgic Council, Minutes of Semi-Annual Meeting, Board of Governors and Committee Members, 22 January 1937.
21. Hersey, *My Work*, 164.
22. For a rare recent use of the term see [anonymous], "Better Living through Chemurgy."
23. MSUA LC 176 Box 2 Folder 51, William J. Hale, Chemurgy or Chaos. Address before Goodwyn Institute, Memphis, Tenn., 15 November 1949, 3.
24. Cf. Busch and Lacy, *The Agricultural Scientific Enterprise*.
25. Furnas, "The Farm Problem," 27.
26. MSUA LC 176 Box 2 Folder 12, William J. Hale to Wheeler McMillen, December 17, 1935.
27. Hale, "Farming Must Become a Chemical Industry," 24.
28. Hale, "When Agriculture Enters," 1311.
29. See note 27 above., 4.
30. MSUA LC 176 Box 3 Folder 52, Agrol Supreme. A Prospectus. Undated attachment to a letter from the National Agrol Company, 9 July 1941, 3.
31. *Ibid.*, 9.
32. MSUA LC 176 Box 2 Folder 12, William J. Hale to Wheeler McMillen, 17 May 1934.
33. Layton, *Revolt*, pp. 226–28; Akin, *Technocracy*.
34. Hale, "Epistemocracy."
35. MSUA LC 176 Box 1 Folder 45, William J. Hale to Hon. John W. Bricker, 5 December 1949.
36. MSUA LC 176 Box 2 Folder 51, William J. Hale, Chemurgy or Chaos. Address before Goodwyn Institute, Memphis, Tenn., 15 November 1949, 3.
37. *Ibid.*, 1.
38. MSUA LC 176 Box 2 Folder 53, William J. Hale, Out of Chaos into Chemurgy. Address before Renewable Resources Symposium, Philadelphia Engineers' Club, 21 November 1950, 17.
39. MSUA LC 176 Box 3 Folder 52, Agrol Supreme. A Prospectus, 9.
40. *Ibid.*, 8.
41. *Ibid.*, 9.
42. *Ibid.*, 8.
43. Gardner, *American Agriculture*, 216.
44. *Use of Alcohol*, 131.
45. Hale, "Epistemocracy," 29.
46. MSUA LC 176 Box 2 Folder 12, William J. Hale to Wheeler McMillen, 19 June 1940, 2.
47. MSUA LC 176 Box 2 Folder 5, William J. Hale to Hans Kühne, 30 April 1941.
48. Cf. the correspondence in MSUA LC 176 Box 2 Folder 5. For another I.G. Farben contact, see *ibid.* Box 1 Folder 36.
49. MSUA LC 176 Box 1 Folder 45, William J. Hale to Earl Ubell, 23 March 1955.
50. MSUA LC 176 Box 1 Folder 38, William J. Hale to J. Earl Coke, 15 October 1954.
51. Cf. the biographical sketch in the finding aid for LC 176 (William J. Hale Papers), Michigan State University Archives and Historical Collection, and Whitehead, *The Dow Story*, 95.
52. MSUA LC 176 Box 2 Folder 51, William J. Hale, Chemurgy or Chaos. Address before Goodwyn Institute, Memphis, Tenn., 15 November 1949 1, 3.
53. Wright, "Alcohol Wrecks a Marriage," 56 n.
54. *Ibid.*
55. Warren, *Brush with Death*, 116–33; Uekötter, "The Merits of the Precautionary Principle."
56. Bernton et al., *Forbidden Fuel*, 25.
57. Wright, "Alcohol Wrecks a Marriage," 61; Carolan, "A Sociological Look," 96 n.
58. McMillen, *New Riches*, 37.
59. *Ibid.*, 40.
60. Haynes, *American Chemical Industry*, 142. For the debate about an Iowa state law see Manuel, "Iowa's Original Ethanol Debate."
61. MSUA LC 176 Box 2 Folder 51, William J. Hale, Chemurgy or Chaos. Address before Goodwyn Institute, Memphis, Tenn., 15 November 1949, 11.
62. *Ibid.*

63. Jevons, "The Coal Question"; Meadows et al., *Limits to Growth*.
64. Yergin, *The Prize*, 223.
65. *Ibid.*, 430.
66. MSUA LC 174 (Leo M. Christensen Papers) Box 16 Folder 49, Leo M. Christensen, The Agrol Opportunity, 26 June 1939, 1.
67. *Ibid.*
68. In other nations, World War Two would create such a shortages of fossil fuels that, in turn, spurred innovation in biomass energy technologies, see Arne Kaijser in this issue.
69. Hale, *The Farm Chemurgic*, 163–64, 168 (quotation).
70. <http://cornandsoybeandigest.com/blog/usda-projects-record-2014-crop-production> (retrieved 13 February 2015).
71. McMillen, *New Riches*, 270.
72. Haynes, *American Chemical Industry*, 25.
73. MSUA LC 174 Box 16 Folder 49, Leo M. Christensen, The Agrol Opportunity, 26 June 1939, 22.
74. MSUA LC 177 Box 32 Folder 20, Farm Chemurgic Council, Minutes of Semi-Annual Meeting, Board of Governors and Committee Members, 22 January 1937, 16.
75. See note 73 above, 43.
76. Cf. the biography of Leo M. Christensen in the finding aid for LC 174 (Leo M. Christensen Papers), Michigan State University Archives and Historical Collection.
77. Haynes, *American Chemical Industry*, p. 143; Bernton et al., *Forbidden Fuel*, 25; Giebelhaus, "Farming for Fuel," 182.
78. See note 39 above, 4.
79. MSUA LC 176 Box 2 Folder 12, Excerpts from remarks by Wheeler McMillen, President, National Farm Chemurgic Council, at the annual dinner, 27 March 1941, 1–2.
80. MSUA LC 176 Box 2 Folder 12, Wheeler McMillen to William J. Hale, 22 April 1941, 1.
81. MSUA LC 176 Box 3 Folder 54, Corporate Record Book, Report of the President at the Annual Meeting, 9 March 1942, 1.
82. MSUA LC 176 Box 3 Folder 55, Corporate Record Book, Report of the President, Sixth Annual Meeting of the Stockholders of National Agrol Company, 30 April 1947, 3.
83. MSUA LC 176 Box 3 Folder 52, letter of the National Agrol Company, 9 July 1941, 1.
84. MSUA LC 176 Box 3 Folder 56, William J. Hale to Georges F. Doriot, 19 May 1947, 1.
85. MSUA LC 176 Box 4 Folder 9, The Chemurgic Outlook for National Agrol Company. William J. Hale, President, April 1947, 1. Cf. MSUA LC 176 Box 3 Folder 52, letter of the National Agrol Company, 9 July 1941 2, and *ibid.* Folder 54, Corporate Record Book for 1938–1946.
86. Finlay, *Growing American Rubber*, 193.
87. MSUA LC 176 Box 4 Folder 9, The Chemurgic Outlook for National Agrol Company. William J. Hale, President, April 1947, 1.
88. MSUA LC 176 Box 3 Folder 55, Corporate Record Book, Report of the President, Sixth Annual Meeting of the Stockholders of National Agrol Company, 30 April 1947.
89. MSUA LC 176 Box 4 Folder 14, 1952 Report. Annual Meeting of the Stockholders of Verdurin Company, 9 April 1953, 2.
90. *Ibid.*, 1953 Report. Second Annual Meeting of the Stockholders of Verdurin Company, 12 February 1954, 1.
91. MSUA LC 176 Box 3 Folder 60, W. B. Bell to William J. Hale, 24 July 1939.
92. See note 39 above, 9.
93. MSUA LC 176 Box 1 Folder 45, P. E. Biggar to Public Relations, Dow Chemical Company, 14 February 1952.
94. MSUA LC 176 Box 1 Folder 38, William J. Hale to Harry L. Fisher, 24 November 1954.
95. Cf. Uekötter, *Age of Smoke*, 198–07, and Dewey, *Don't Breathe the Air*, 37–110.
96. Finlay, "The Failure of Chemurgy," 99.
97. Ruttan, "Constraints," 211.

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