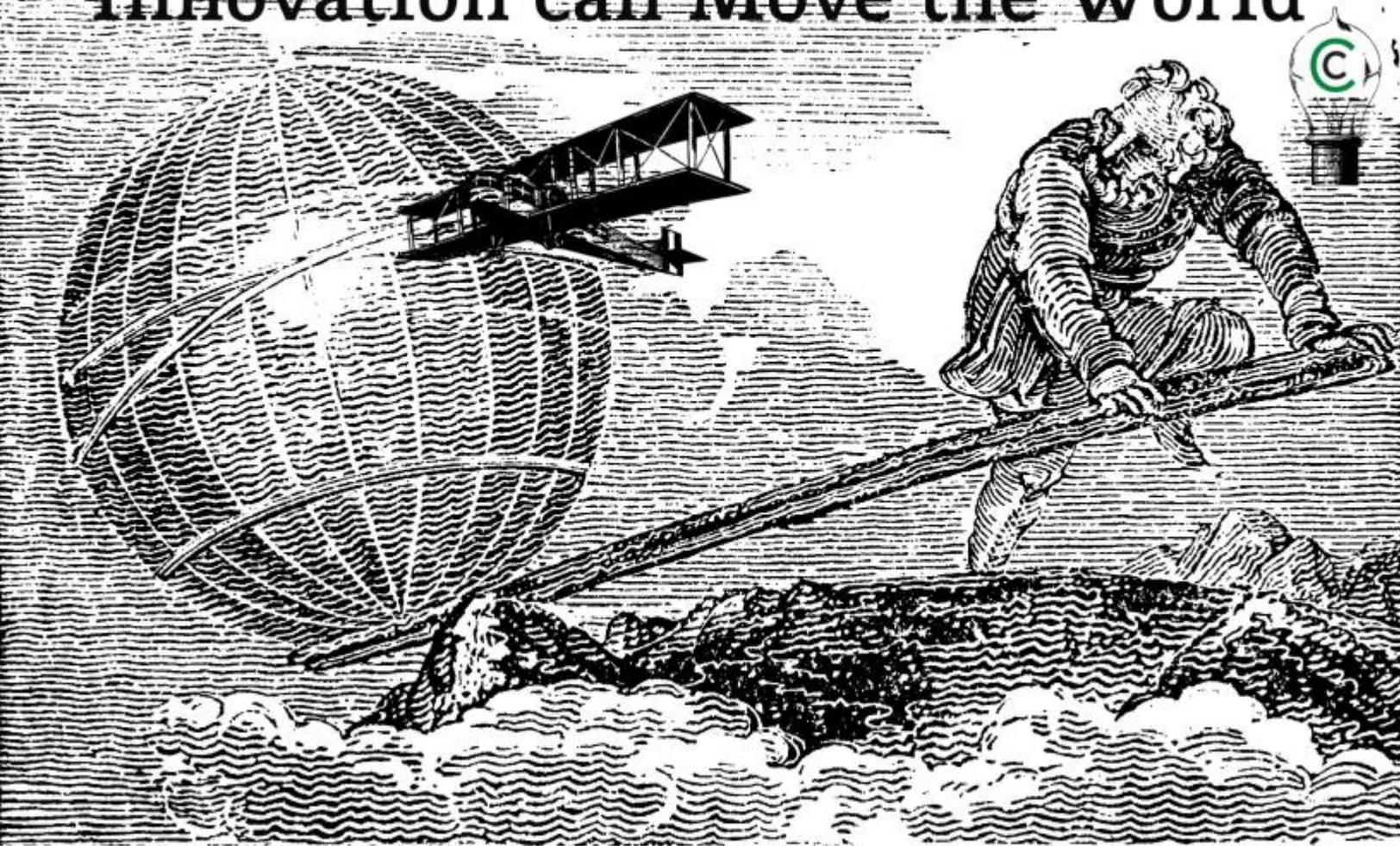


Innovation can Move the World



The Industrial Status of Biofuel Technologies

This report is on the commercial status of the biofuels industry, including ethanol, biobutanol, biodiesel, biogas, gasification, pyrolysis, torrefaction and other emerging biofuels, and exposes the pretensions of some biofuel developers.

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Bio of the Author:

Dr. Kutney, Ph.D. in chemistry, has participated in all aspects of innovation and technology commercialization - especially related to torrefaction, pyrolysis, biochar, and biomass gasification - from the research laboratory to patents to marketing to the executive suite. With two decades of executive experience in technology commercialization with global corporations and entrepreneurial enterprises, he brings the innovation of research and technology development, the financial discipline of big business, and the spirit of entrepreneurship to start-ups and early-stage companies. He has extensive C-level experience, including strategic, operational, business development, and administration leadership, business and financial planning and analysis, financing strategies, techno-commercial evaluations and feasibility studies.

Bioenergy and Biofuels

- Director of Emerging Technologies and lead consultant in forestry bioenergy for the world's largest renewable fuels consulting group ([Lee Enterprises Consulting](#))
- Director of Biochar Ontario
- Founded the LinkedIn group, *Bioenergy Projects & Ventures*
- Executive of a biorefining group (bark boiler and CHP/IPP facilities; the largest cellulosic ethanol business in North America; and bioproducts business with operations in Canada and France) of a major forest products company
- Executive of a biomass processing business in Canada
- Executive of a pyrolysis venture with pilot facilities in Canada and South Africa
- Authored over a dozen papers on pyrolysis presented at major bioenergy conferences (including the IEA Bioenergy, International Bioenergy Conference, and CanBio)
- Authored technical papers: [Biomass Pyrolysis Spectrum](#) and [The State of Pyrolysis in Canada](#)
- Authored a study on the commercial status of over seven hundred and fifty pyrolysis firms
- Authored a study on the global pyrolysis industry for the National Research Council Canada
- Authored a study on the commercial status of wood-to-(drop-in) fuels for a European client
- Mentored and edited the business plans for a biomass pellet venture in the U.S.
- Mentored and edited the business/financial plans for a First Nation's forestry venture in Canada
- Audited the commercial preparedness of a pyrolysis venture for an IPO in Canada
- Audited the commercial preparedness of a bioproducts venture for an international corporation in the U.S.
- Member of the expert panel on international standards for solid biofuels (wood/biomass pellets, torrefied pellets and biochar briquettes) for ISO ([TC 238](#))
- Member of the expert panel on Canadian standards for solid biofuels for CSA

Climate Change and Policy Development

- Authored the peer-reviewed book [Carbon Politics and the Failure of the Kyoto Protocol](#), which examines the policy challenges for addressing climate change
- Adjunct Professor & Part-time Instructor on fourth-year/graduate course on Climate Change, University of Northern British Columbia – Environmental Science

Entrepreneurship and New Ventures

- Managing Director of own consulting venture
- President of an emerging-technology venture
- Chief Operating Officer with a new-technology venture
- Approved consultant with the Business Development Bank of Canada ([BDC, Entrepreneurs first](#))
- [MBA mentor](#) & [Start-up Garage](#) mentor at the University of Ottawa
- Entrepreneur mentor with [Invest Ottawa](#)

The Industrial Status of Biofuel Technologies

A myriad of biofuel technologies exist, but which ones are truly industrial processes? The question is not always easy to answer. And one must define what is meant by an industrial process. To facilitate this task, three classifications of industrial status are utilized:

- I. *Established* – modern facilities are numerous, geographically wide-spread, and operational for a decade or more;
- II. *Developing* – a handful of modern industrial-scale facilities with a proven commercial track record for a number of years, but their geographic scope is limited;
- III. *Demonstration* – the first modern full-scale facilities have been constructed and operated on a continuous basis (at capacity) long enough to demonstrate their reliability, operating costs, and profitability.

Using this classification system, biofuel technologies can be categorized as shown in the following table.

Table. Biofuel Technologies by Stage of Industrial Development

<i>Established</i>	<i>Developing</i>	<i>Demonstration</i>
Wood pellets	Biogas/AD	Slow Pyrolysis (biochar)
Fermentation Ethanol	Cellulosic Ethanol	Fast Pyrolysis (pyrolysis oil)
Biodiesel	Renewable Diesel/HEFA	Torrefaction (biocoal)
Biomass Gasification		Butanol
		Steam Explosion (black pellets)

In addition, there are a host of popular biofuel technologies, not included in the table, that are approaching the *demonstration* stage of industrial development, including: biomass-syngas-FT, hydrothermal liquefaction, tire pyrolysis, MSW plasma gasification, and algae biofuels.

Established Biofuel Industries

Biofuel is the oldest fuels industry, far pre-dating that of fossil fuel.¹ However, during the 20th century, oil, coal and natural gas took over the fuel industry. In the latter quarter of the century, biofuels started making their comeback; the return of the biofuels was first inspired by oil crises and the drive for energy independence, and only more recently by incentives to combat climate change.

A thriving new market for grains, corn, soybeans, and other agricultural crops now exists in the ethanol and biodiesel industries; in 2015, for the U.S., alone, the consumption of such biofuels are: ethanol = 1.14 quadrillion Btu, biodiesel = 0.26 quadrillion Btu,² and capacities are: ethanol = 15 billion gallons, biodiesel = 2 billion gallons. An even larger (based on energy production) biofuel industry exists using forestry biomass - including wood pellets, hog fuel and wood chips - which is utilized for electricity and heat production; in the U.S., wood biomass consumption = 2.04 quadrillion Btu and wood pellet capacity = 11 million tons.

Much of this bioenergy production utilizes incineration, but biomass gasification is also employed to a lesser extent. The designation of biomass gasification as an *established* industry is debatable. While larger scale biomass gasification projects have had limited success compared to incineration,³ the market penetration of the former technology has been lack luster. But smaller scale biomass gasification units have had some success, and the technology has been established for a long time.⁴

Developing Biofuel Industries

In the past decade or so, biogas/anaerobic digester technologies appear to have evolved beyond the *demonstration* stage into the *developing* category. As with biomass gasification, this sector has been around for a long time. After struggling, the biogas sector appears to be gaining momentum, and if it continues, will join the *established* industries in the future.⁵

A similar situation has arisen with cellulosic ethanol, with some major corporate players being involved. However, the recent bankruptcy filing of Abengoa has raised some questions as to the

¹ Kutney, Gerald 2016. [Where did biofuels technologies come from?](#), *Biofuels Digest*, June 1.

² U.S. EIA 2016. [Renewable and Alternative Fuels, Overview, Recent Data](#), accessed December 1, 2016.

³ For an overview, see [IEA Bioenergy Task 32](#).

⁴ For an overview, see [IEA Bioenergy Task 33](#).

⁵ For an overview, see [IEA Bioenergy Task 37](#).

future of this sector.⁶ While a case can be made for the designation of cellulosic ethanol from agricultural biomass as being in the *developing* category, the same cannot be said for cellulosic ethanol from forestry biomass, which still has not passed into the *demonstration* stage.⁷

Cellulosic ethanol is often referred to as second-generation biofuels. Included in this category is renewable diesel, including hydroprocessed esters and fatty acids (HEFA).⁸ This biofuel is also part of the *developing* category.

Demonstration Biofuel Industries

There are a series of biofuel technologies that have been under development for a number of years but have failed to crack into the industrial-scale *developing* category, though not from a lack of effort and ingenuity. Two of the most active are related to pyrolysis. Slow pyrolysis has a long history and is best known for the traditional technology for producing charcoal, but new industrial-scale facilities have not been built. A new era of technology development was spurred on by the issue of climate change and the emergence of the biochar market.⁹ Fast pyrolysis, which can also produce biochar, has had mixed success but new demonstration facilities have recently come on stream. These latest developments may take this demonstration technology¹⁰ to the *developing* category soon. Other demonstration technologies include torrefaction,¹¹ biobutanol,¹² and steam explosion.

⁶ Fitzgerald, Patrick 2016. [Spain's Abengoa Wins U.S. Bankruptcy Court Protection](#), *Wall Street Journal*, April 27.
Planck, Jacquelin 2016. [Abengoa Lines Up Buyers for U.S. Ethanol Plants](#), *Wall Street Journal*, June 13.

⁷ For an overview, see [IEA Bioenergy Task 39](#).

⁸ For an overview, see Brown, Bill and Radich, Tony 2015. [New Biofuels Eliminate Need for Blending with Petroleum Fuels](#), U.S. EIA *Today in Energy*, November 9; also see U.S. Department of Energy, Alternate Fuels Data Center, [Renewable Hydrocarbon Biofuels](#); accessed December 1, 2016.

⁹ For an overview, see Lehmann, J., and Joseph, S. 2012, *Biochar for Environmental Management: Science and Technology*, Routledge, pp. 3-5 (also see 2nd edition, 2015).

¹⁰ For an overview, see [IEA Bioenergy Task 34](#).

¹¹ For an overview, see Cremers, Marcel, et al. 2015. [Status Overview of Torrefaction Technologies](#), IEA Bioenergy Task 32.

¹² For an overview, see U.S. Department of Energy, Alternate Fuels Data Center, [Biobutanol](#); accessed December 1, 2016.

Emperor's New Biofuels – A Commentary

Complicating the issue of the industrial status of biofuel technologies is that there are many hyperboles about the stage of commercial development made by enthusiastic project developers. At times, when I read about the industrial status of emerging biofuels on websites, blogs and social media, a certain fairy tale comes to mind: *The Emperor's New Clothes* by Hans Christian Andersen (1805-75):¹³

Many years ago there was an Emperor so exceedingly fond of new clothes that he spent all his money on being well dressed. He cared nothing about reviewing his soldiers, going to the theatre, or going for a ride in his carriage, except to show off his new clothes...

In the great city where he lived, life was always gay. Every day many strangers came to town, and among them one day came two swindlers. They let it be known they were weavers, and they said they could weave the most magnificent fabrics imaginable. Not only were their colors and patterns uncommonly fine, but clothes made of this cloth had a wonderful way of becoming invisible to anyone who was unfit for his office, or who was unusually stupid...

"But he hasn't got anything on!" the whole town cried out at last.

The Emperor shivered, for he suspected they were right. But he thought, "This procession has got to go on." So he walked more proudly than ever, as his noblemen held high the train that wasn't there at all.

In the world of biofuels, the “weavers” are those overly zealous (or financially desperate) project developers who promote technologies as *established*, when in fact these *Emperor's new biofuels* are in a much earlier stage of development. Nevertheless, the “whole town” should not judge the credibility of the biofuels sector on the basis of these few “invisible” industries for, as discussed above, there are many biofuel technologies that are commercially proven.



¹³ Hersholt, J. 2016. [The Emperor's New Clothes](#), SDU H.C. Andersen Centret; accessed December 1, 2016.

Sixth Element Sustainable Management is a "boutique" consulting firm specializing in **commercializing innovation**, and evaluating the business preparedness and commercial potential of technology developers and their projects. We provide executive management services for inventors, entrepreneurs, investors, and public sector agencies in new technology, start-ups and early-stage ventures. Services are directly provided by the Managing Director of Sixth Element Sustainable Management, Gerald Kutney, Ph.D. in chemistry.

Venture success depends more on management than the technology itself. Dr. Kutney has participated in all aspects of innovation and technology commercialization, from the research laboratory to patents to marketing to the executive suite. With two decades of executive experience in technology commercialization with global corporations and entrepreneurial enterprises, he brings the innovation of research and technology development, the financial discipline of big business, and the spirit of entrepreneurship to start-ups and early-stage companies.

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