Introduction

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Robbin Johnson is senior advisor, Global Policy Studies, University of Minnesota Institute of Public Affairs. He retired from Cargill, Incorporated in January, 2007, after 36 years at the company. He held a number of positions over his career, finishing as Senior Vice President, Corporate Affairs. Elected to that position in 2000, he worked with senior management on

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communications and external relations issues, serving on the Corporate Center and the Corporate Affairs committees. He continues as President of the Cargill Foundation. Johnson graduated from Yale University in 1968, attended Oxford University as a Rhodes Scholar from 1968 through 1970 and Yale Law School from 1970 through 1971.

The essays in this volume result from a conference held at the Joyce Foundation in Chicago in September, 2008. Those attending included experts who analysed the continuing questions surrounding biofuels and their impacts on the economy of the US Midwest, where most of US ethanol and biodiesel is produced.

From 1990 to 2000, global biofuel production (ethanol and biodiesel) grew slowly, reaching 17.5 billion litres in 2000. In the new century, however, significant mandates and other incentives for commercial biofuel production (produced thus far only from crops) were enacted in the United States (US) and the European Union (EU). As the Brazilian sugarcane-based ethanol industry also matured, global production of biofuel rose rapidly, diverting crops away from food and feed uses and putting upward pressure on prices (OECD, 2008a). Global biofuel production reached over 77 billion litres in 2008, over four times its 2000 level (OECD, 2008b). In the three years from 2005 to 2008, the quantities of corn (maize) used for ethanol production in the USA grew from 14.3% of available supplies to an estimated 30% or more in 2008–2009, according to the USDA (Baker et al., 2008).

The purpose of the invited papers was to assess the technical, economic and environmental impacts of biofuels. The papers covered a wide range, and included many insights beyond the conventional understanding of biofuels and their potential. The first paper, 'Opportunities and challenges of transitioning to sustainable next-generation transportation biofuels', by Jason Hill of the University of Minnesota, focused on the challenges facing a transition from conventional biofuels based almost entirely on maize and soybeans, to 'next generation' fuels based on a variety of 'cellulosic' alternatives. While daunting, Hill's assessment is that these challenges could be met with new technical approaches and changes in cropping patterns.

The second paper, 'Effects of biofuels vs. other new vehicle technologies on air pollution, global warming, land use and water', by Mark Z. Jacobson of Stanford University, offered a detailed assessment of claims that biofuels offer a more carbon-friendly alternative to fossil fuels, and that they are less polluting to local environments relative to alternatives such as electric or hydrogen fuel-cell vehicles. Jacobson's findings were largely negative: both maize-based and cellulosic fuels blended with gasoline at an 85/15 percent ratio (E-85) degrade air quality, climate, land and water supply more than any of the alternatives studied. Air pollution from cellulosic E-85 may actually cause more harm than the same fuel blend derived from maize. The land footprint required to produce either maize or cellulose for biofuels exceeds that required for a wind-powered battery electric vehicle by a factor 500,000 to 1 million to one. Jacobson concludes that either maize or cellulose-based biofuels will, relative to other options, damage human health, climate, land and water.

The third paper was 'Nitrous oxide's impact on net greenhouse gas savings from biofuels: life-cycle analysis comparison', by Arvin R. Mosier, Paul J. Crutzen, Keith A. Smith and Wilfried Winiwarter. The authors are, respectively, former research chemist with USDA, geoscientist at the Max Planck Institute, faculty member of the School of Geosciences at the University of Edinburgh, and researcher at the International Institute of Applied Systems Analysis (IIASA). Their paper analyses the links from the heavy applications of nitrogen (N) needed to grow maize and other feedstocks for biofuels, and resulting nitrous oxide (N_2O) releases into the atmosphere. N_2O is a greenhouse gas 296 times more damaging to the atmosphere than CO_2. Lifecycle assessments of the Greenhouse Gas (GHG) emissions resulting indicate that emissions from an average Midwest maize-ethanol plant do not meet the requirement for a 20% reduction for new-facility renewable fuels plants in the Energy Independence and Security Act of 2007 using two-of-three methodologies (although a third methodology does allow the requirement to be met in the case of maize). The result, concluded the authors, is that US biofuel production may trigger a net increase in global warming.

The fourth essay was 'Current and future ethanol production technologies: costs of production and Rates of Return on invested capital', by Douglas G. Tiffany and Steven J. Taff of the University of Minnesota. Tiffany and Taff compared the costs of production and returns for two current and three proposed ethanol technologies subsidised under 2007 energy legislation and the 2008 Farm Bill. Two simulations use maize as feedstock; three use cellulosic materials: corn stover, switchgrass and woodchips. Monte Carlo techniques were used to assess rates of return on each option. The overriding conclusion was that profitability is heavily reliant on the existing structure of subsidies. And, even acknowledging these subsidies, the variations in profits depending on the prices of feedstocks and substitutes such as maize and oil make biofuels a high-risk industry.

The fifth paper, by Doug Koplow, head of Earth Track, an environmental consulting firm based in Cambridge, Massachusetts, was 'State and federal subsidies to biofuels: magnitude and options for redirection'. Koplow, among the most careful students of subsidies to the energy sector, analysed more than 200 state and federal US subsidies to biofuels, predicting that cumulative costs under some mandate proposals might exceed one *trillion* dollars by 2030. Present subsidies account for half or more of the retail price of biofuels in the USA. Even using the most favourable assumptions on biofuels' carbon footprint, these subsidies make biofuels one of the most expensive ways of reducing CO_2 emissions – comparable to the cost of building and maintaining nuclear reactors. Koplow concludes that reduced GHG emissions from biofuels are 'largely illusory', and that a fuel neutral set of policies should be implemented in which all alternatives to conventional fuels compete against each other for market share.

The sixth paper was by Timothy Searchinger and Ralph Heimlich. Searchinger, for many years counsel to Environmental Defense and now at Princeton University, and Heimlich, formerly at USDA and now at Agricultural Conservation Economics, developed a model to analyse the land use changes driven by expanded US biofuels production in the USA and globally. They offer a sobering assessment of the likely negative environmental impacts, and call for a variety of policy innovations to avoid biofuels' land use from distorting other land uses in the USA and abroad.

The final essay in this volume is by Otto C. Doering III and Wallace E. Tyner, 'US and International policies affecting liquid biofuels' expansion and profitability'. Doering and Tyner, two seasoned analysts of US agricultural policy at Purdue University,

offer a full assessment of the global implications of US commitments to biofuels. Noting that biofuels policy is enmeshed in a larger policy matrix, they conclude that requirements to blend ethanol with other fuels at certain levels (the 'blending wall') and life-cycle requirements for biofuels, will affect their impact on fuel use and energy policy.

These papers were among the most forward-looking analyses of the biofuels sector at the time, and remain fresh and relevant today. Indeed, if past and current policymakers had considered them carefully, these papers might have occasioned a more judicious approach to biofuels as an energy alternative.

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