

Biomanufacturing: Opportunities to Contribute to Climate Change Mitigation

Discussion document for BU-ISE/ITIF workshop on February 10, 2021

The Challenge

Since the invention of recombinant DNA technology in the 1970s, scientific knowledge of molecular and cellular biological processes has exploded, aided by revolutionary advances in tools to manipulate them. The “century of biology” shows no signs of slowing. If anything, it is accelerating thanks to gene editing.

Progress in biomanufacturing has been far less rapid than in bioscience. Its commercial successes have largely been limited to high-value, low-volume specialty niches, such as pharmaceuticals. Biomanufacturers will need to transcend these limits if they are to make significant contributions to tackling climate change. Whether and how they can do so – and how the federal government can best contribute – is the primary focus of this workshop.

There is no doubt about biomanufacturing’s potential contributions. Livestock and manure are responsible for about 6 percent of global greenhouse gas emissions.¹ As incomes rise globally, demand for meat and dairy products is expected to rise, driving up emissions further. Proteins made by fermentation as well as meat grown *in vitro* could replace agricultural production if costs can be reduced and consumers are willing.²

The chemical industry, too, accounts for about 6 percent of global emissions and rising.³ Bioengineers express confidence that they can build systems to produce virtually any organic molecule at the bench level. If biomanufacturing systems for major commodity chemicals can be scaled cost-effectively without requiring carbon-intensive inputs, they could radically disrupt this industry while slashing its emissions.⁴

The barriers that limit biomanufacturing’s contributions to climate change mitigation include:

- Lack of focus on and support for this objective among bioscientists and -engineers
- Mismatch between organisms used in laboratories and those best-suited to biomanufacturing
- Difficulty and cost of using the most abundant and sustainable feedstocks
- Inefficiency of scaled-up processes and mismatch between R&D and scale-up
- Inability to predict results of scaling-up, leading to variation in output
- Insufficient systems for data analysis and integration
- Lack of medium- to large-scale pilot facilities for process development and optimization
- Lack of funding for demonstration and early commercial production facilities
- Poor technology transfer and lack of standardized process recipe tools
- Weakness of end-use markets to stimulate sufficient private investments in innovation
- Potential conflicts over the future of agriculture

¹ WRI, “World Greenhouse Gas Emissions: 2016,” <https://www.wri.org/resources/data-visualizations/world-greenhouse-gas-emissions-2016>

² Good Food Institute, “Fermentation: An Introduction” (2020) and “Cultivated Meat” (2019), <https://www.gfi.org/industry>.

³ WRI, “Emissions.”

⁴ Rob Carlson, “Seeing the End of Oil,” *Bioeconomy Capital*, October 4, 2019, <http://www.bioeconomycapital.com/posts>

Although the United States has the strongest base of bioscience research in the world, other countries and regions have moved more rapidly into biomanufacturing. Biomanufacturing start-ups spun out of U.S. research institutions frequently go abroad to scale up production. These private decisions are the result of strategic planning and investment by foreign governments, especially in Europe, that have not yet been matched by the U.S. federal government. The nascent state of the industry, however, suggests that the United States still has a window to establish a competitive position in emerging climate-responsive biomanufacturing markets.

Issues for Discussion

What are the most promising opportunities to reduce GHG through biomanufacturing?

- From the food and agriculture industry?
- From the chemicals industry?

What federal RD&D investments are most likely to realize these opportunities?

- Cost-shared commercial-scale demonstration projects carried out by manufacturers?
- Cost-shared pilot-scale facilities run by public agencies?
- Publicly-supported equipment development programs carried out by vendors or trade organizations?
- Publicly-funded, targeted applied research programs carried out at academic and government laboratories?
- Publicly-funded, individual investigator-initiated basic research programs?

How should a federal RD&D strategy balance:

- Upstream basic and applied research with downstream scale-up and process development?
- Research on conversion and separations with feedstock production and preparation?
- Science and technology push with efforts to facilitate adoption and public acceptance?

What other federal policies would be most important to enhance the payoffs of these investments (setting aside economy-wide carbon pricing or regulation)?

- Tax incentives for manufacturers or investors?
- Loans or loan guarantees for manufacturers?
- Regulatory reform?
- Standards and certifications?
- Workforce development?
- Government procurement of end products?
- Stakeholder engagement?
- Labeling and public outreach?
- Reorganization of DOE and/or USDA?
- Creation/expansion of focused programs at other agencies (DOD, NIH, NSF, NIST)?
- New DOE national laboratory or laboratory consortium?
- Inter-agency coordination?

What is a plausible range of emissions reductions that could be achieved by 2050?

Workshop Agenda (draft)

Each session will begin with brief presentations from the speakers listed below. The majority of the time in each session will be devoted to discussion.

- 10:00 **Objectives, agenda, processes**
[Charles DeLisi, Boston University](#) (chair)
[David Hart, George Mason University/ITIF](#) (co-organizer)
- 10:10 **Biomanufacturing opportunities to cut agricultural GHG emissions**
[Dan Nocera, Harvard University](#)
[Liz Specht, Good Food Institute](#)
[Brian Sylvester, Covington & Burling](#)
- 11:20 **Break**
- 11:30 **Biomanufacturing opportunities to cut chemical industry GHG emissions**
[Tim Gardner, Riffyn](#)
[Karim Cassimjee, EnginZyme](#)
[Aindrila Mukhopadhyay, Lawrence Berkeley National Laboratory](#)
- 12:40 **Federal funding agenda for the 2020s & next steps**
[Dan Drell, DOE \(retired\)](#)
[Henry Kelly, Boston University](#) (co-organizer)