Convening Framing Document

FEEDSTOCKS OF THE FUTURE FOR A CIRCULAR U.S. BIOECONOMY

This Convening is hosted by the Foundation for Food & Agriculture Research (FFAR) in partnership with Schmidt Futures. FFAR is a nonprofit that builds public-private partnerships to fund audacious research addressing the biggest challenges in food and agriculture. Schmidt Futures is a philanthropic initiative founded by Eric and Wendy Schmidt that bets early on exceptional people making world better. The overarching purpose of this Convening is to explore the challenges and opportunities of utilizing future circular and alternative feedstocks in biomanufacturing processes to advance the U.S. bioeconomy. This framing document serves as a primer to the Convening from March 28-29, 2023.

Background

Replacing petroleum feedstocks with renewable sources will be a key element of a successful circular bioeconomy. Considerable research has refined the use of starch- and sucrose-rich feedstocks (e.g., corn, sugarcane) for bioproduct development. However, sustainable bioproduct development will require biomass sources that (a) will not distort the food system with increased demand and (b) can yield a variety of carbon building blocks. Waste materials from the food and agriculture sector, as well as municipal waste, may serve as alternative biomass sources for future biomanufacturing processes. Identifying these circular and alternative feedstocks, which we will collectively refer to as *future feedstocks*, developing methods and technologies to use them, identifying pathways to desired products and possibly co-developing bespoke microbial production strains requires scientific and engineering research. Strategic partnerships and policies, in parallel with robust research, are needed to create an environment adequate for the adoption of future feedstocks.

Objectives

The overarching objective of this Convening is to identify three to four promising lines of inquiry in the categories described below (i.e. Focus 1-4) that (1) are currently unfunded or

underfunded, (2) could yield actionable results within a five-year timeframe, and (3) would require interdisciplinary collaboration.

Key areas of focus of this Convening are:

Focus 1: Circular Feedstocks – Identifying candidate feedstocks for additional research, considering their potential regional and temporal availability, utility for producing desired products, environmental and sustainability concerns and harvest and processing challenges.

Focus 2: Methods and Technologies – Identifying research gaps and unmet needs relating to methods and technologies that could increase the economic viability of valorizing biogenic waste through the use of circular and alternative feedstocks. This may include consideration of challenges related to heterogeneous feedstocks.

Focus 3: Products – Identifying potential avenues to develop desired products from circular and alternative feedstocks. This will include consideration of barriers to increasing use of circular and alternative biomass feedstocks to produce desired products on a local, regional, or national scale.

Focus 4: Enabling Environment – Identifying nontechnological barriers to the adoption of circular and alternative feedstocks for bioproduction, as well as candidate interventions to improve the enabling environment for their use. This will include consideration of the needs, concerns and capabilities of agricultural producers, industry, consumers, local and regional governments and other stakeholders.

Scope and Building Common Language

This section defines the scope of the Convening and builds common language within that scope. The scope is organized by overarching definitions and the four focus areas. These definitions will serve as a guide, build common understanding between, and enable synergies of participants.

Overarching

- **Circular bioeconomy** – An economy that forgoes the traditional linear economic model of "take-make-consume-throw away" for one that uses the power of biotechnology, design for bioproduction, and machine learning / artificial intelligence to create an economic system in which waste products serve as inputs to create highly valued products and materials, that are used as long as possible, and reused

without drawing down limited resources or generating wastes that are disposed into the atmosphere, landfills, or rivers, lakes and oceans.

Focus 1: Circular Feedstocks

In alignment with Focus 1 to identify circular feedstocks, this includes a focus on **"circular and alternative biomass feedstocks**." Related definitions and examples of feedstocks within the scope of this are below:

- **Biomass** – Any organic matter that is available on a renewable or recurring basis, including agricultural crops and trees, wood and wood residues, plants, algae, grasses, animal manure, municipal residues and other residue materials.
    - **Sustainable biomass** – Biomass that does not affect food production for domestic consumption or export, does not lead to deforestation or land degradation and maintains environmental quality.
- **Feedstock** – A product used as the basis for manufacture of another product.
    - **Circular feedstocks** – Feedstocks derived from waste materials, such as agricultural residues or forest slash; as such, renewable waste from one economic activity becomes the source material for new economic activity.
    - **Alternative feedstocks** – Renewable biomass feedstocks that are not currently in use.
    - **Crop residue** – The portion of the crop remaining after the primary product is harvested or processed. Examples include corn stover (stalks and husks), rice straw and nut husks and shells.
    - **Animal byproduct** – Discarded or underutilized material from industries directly associated with the raising and processing of animals and animal products. These include byproducts of animal agriculture (manure, eggshells, used bedding, spoiled milk and milk coproducts, etc.), and meat processing and animal testing (carcasses, bones, feathers, etc.)
    - **Forestry residues** – Woody biomass left over from wildfire management and timber operations (branches, stumps, treetops, bark, sawdust, etc.), or byproducts and coproducts of industrial wood-processing operation (bark, sawmill slabs, saw dust, wood chips etc.).
    - **Municipal solid waste (MSW)** – Wastes (garbage) collected from municipalities consisting mainly of yard trimmings, paper products and other organic matter such as food waste.

- **Processing residues** – The byproducts and waste streams produced when biomaterials are processed. For example, sawdust at timber mills, sugar cane bagasse, etc. These materials aggregate at the point of processing.

Focus 2: Methods and Technologies

In alignment with Focus 2 to identify methods and technologies, this Convening includes a focus on **transformational technologies**. All types of technologies are considered within scope within the context of circular and alternative feedstocks (as defined above). Examples include but are not limited to industrial fermentation, pyrolysis, computational modeling, bioprocessing, enzyme design, etc.

Focus 3: Products

In alignment with Focus 3 to identify products, related definitions and examples are below:

- **Products** – Intermediates and end-use products with a material reduction in greenhouse gas emissions and/or a material improvement in functional performance with environmental benefits.
- **Platform chemicals** – Chemicals with one to six carbon atoms (C1-C6) or aliphatic long chain hydrocarbons that can be produced from circular biomass that serve as important precursors to a wide range of solvents, resins, flavors, fragrances, adhesives, plastics, etc. Examples include methanol, ethanol, benzene, toluene, xylene, BDO, ethylene, 2,5 furandicarboxylic acid, organic acids (e.g. lactic, succinic, levulinic), etc.
- **Specialty chemicals** – End use functional molecules made directly from biomass and manufactured to purpose, used as solvents, resins, flavors, fragrances, food ingredients and additives, enzymes, etc. This includes renewable fine chemicals. These tend to have low volume and high value with margins of 30% or higher.
- **Commodity chemicals** – Molecules generally used as intermediates, manufactured, sold and traded on a global basis whose price is quoted on commodity exchanges such as ICIS. These tend to have high volume and low value, with lower margins.

Focus 4: Enabling Environment

In alignment with Focus 4 to identify nontechnological barriers and opportunities, all related barriers are within scope and should be considered throughout this Convening. Examples of nontechnological barriers include but are not limited to regulatory definitions, available

infrastructure, policies, etc. Examples of opportunities include policy interventions such as subsidies and regional public procurement policies.

Suggested Pre-read Documents

In 2022, Schmidt Futures' Task Force on Synthetic Biology and the Bioeconomy developed recommendations and a strategy to help realize the potential of the U.S. bioeconomy for maximum public benefit. This report is key to the context of this Convening:

- Hodgson, A., Alper, J., Maxon, M.E. 2022. The U.S. Bioeconomy: Charting a Course for a Resilient and Competitive Future. New York, New York: Schmidt Futures. https://doi.org/10.55879/d2hrs7zwc

Additional related readings that will help inform the Convening discussions:

- Schulte, L.A., Dale, B.E., Bozzetto, S. et al. Meeting global challenges with regenerative agriculture producing food and energy. Nat Sustain 5, 384–388 (2022). https://doi.org/10.1038/s41893-021-00827-y
- UIDP. 2021. World Without Waste: A Circular Bioeconomy Workshop Report. https://uidp.org/custom-type/innovation-in-the-bioeconomy-world-without-waste/
- U.S. Department of Energy. 2016. 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1: Economic Availability of Feedstocks. M. H. Langholtz, B. J. Stokes, and L. M. Eaton (Leads), ORNL/TM-2016/160. Oak Ridge National Laboratory, Oak Ridge, TN. 448p. doi: 10.2172/1271651. http://energy.gov/eere/bioenergy/2016-billion-ton-report