MEASURING THE BIOECONOMY

RECOMMENDED REVISIONS TO THE NAICS AND NAPCS

EO 14081 - Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy

Interagency Technical Working Group: USDA, DOE, DOC, EPA, NSF, BLS, DOD, FDA, OMB.

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Measuring the Bioeconomy – Recommendations for Revisions to the North American Industry Classification System (NAICS) and the North American Product Classification System (NAPCS)

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Executive Summary

For more than two decades, there has been sustained growth and diversification in biotechnology, biomanufacturing and the use of biobased resources to supplant nonbiobased production. Broadly, these activities and processes comprise the bioeconomy (NASEM, 2020). Measuring the economic contributions of this growing sector has become critical for ensuring United States economic and technological leadership in the global market, guiding government policy and funding decisions, achieving national security and environmental goals, and improving the Nation's health and well-being.

While growth in this sector has made significant contributions to the overall U.S. economy, measuring its scope and value is challenging in several ways. Building on available Federal and private sector data, recent efforts to estimate the U.S. bioeconomy have been demonstrated; however, these efforts have also highlighted challenges and limitations associated with data collection for these important metrics (Carlson, 2016; NASEM, 2020).

The recommendations for revisions to the NAICS and NAPCS are guided by the National Institutes of Standards and Technology's *Bioeconomy Lexicon* (NIST, 2022), a study of the feasibility of measuring the bioeconomy by the Bureau of Economic Analysis (Highfill, Chambers 2023), and recommendations in the National Academies of Sciences, Engineering, and Medicine report *Safeguarding the Bioeconomy* (NASEM, 2020). This document will briefly review the extant literature on the bioeconomy; will consider justification, challenges, and benefits for revised classifications; and will offer potential revisions for tracking the growth of this sector over time.

Acronyms and Abbreviations

Abbreviation	Name
BEA	Bureau of Economic Activity
BLS	Bureau of Labor Statistics
DOC	Department of Commerce
DOD	Department of Defense
DOE	Department of Energy
ECPC	Economic Classification Policy Committee
EO	Executive Order
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FRN	Federal Register Notice
GDP	Gross Domestic Product
GMO	Genetically Modified Organism
ITWG	Interagency Technical Working Group
NAICS	North American Industry Classification System
NAPCS	North American Product Classification System
NSF	National Science Foundation
NIST	National Institute of Standards and Technology
OMB	Office of Management and Budget
RFI	Request for Information
SBA	Small Business Administration
USDA	U.S. Department of Agriculture

Introduction

On September 12, 2022, President Biden issued Executive Order No. 14081, titled "Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy." This EO directed the Chief Statistician of the United States to establish an Interagency Technical Working Group (ITWG), to develop recommendations for bioeconomy-related revisions to the North American Industry Classification System (NAICS) and the North American Product Classification System (NAPCS) to the Economic Classification Policy Committee. The Bioeconomy ITWG comprises 14 voting members from 8 Federal agencies and 2 nonvoting members from the Economic Classification Policy Committee and the Office of Management and Budget. Federal agencies represented on the ITWG are the National Science Foundation (NSF), Department of Energy (DOE), Small Business Administration (SBA), Bureau of Economic Analysis (BEA), Environmental Protection Agency (EPA), U.S. Department of Agriculture (USDA), Bureau of Labor Statistics (BLS), the Food and Drug Administration (FDA), and the U.S. Census Bureau.

In related tasks, EO 14081 also directed the BEA to assess the feasibility, scope, and cost of developing a national measurement of the economic contribution of the bioeconomy. Additionally, the EO directed the NIST to develop a lexicon for the bioeconomy, with (1) consideration of relevant domestic and international definitions and, (2) the goal of assisting in the development of measurement methods for the bioeconomy that support uses such as

economic measurement, risk assessments, and the application of machine learning and other artificial intelligence tools.

EO 14081 identified the importance of the bioeconomy to the environment, health, employment, and national security. It also underscored the need for accurate data to measure the scope of the bioeconomy, its economic impact, tracking changes over time, informing policy, and fostering growth in this segment of the economy.

Advances in the development of biotechnology and the expanded use of biobased products continue to reshape U.S. manufacturing. Biological processes and biobased products are increasingly utilized across multiple sectors including, but not limited to, agriculture, health and medicine, food, fuel, and industrial and chemical production. These processes and products also have stimulated growth in information technologies and related fields.

Measurement of the bioeconomy is complicated by varying definitions of what constitutes the bioeconomy, which activities and products to include or exclude in the tally, and data limitations (Carlson, 2016). Recent efforts to measure the contribution of bioeconomic activity to the U.S. economy have estimated it to be approximately 5 percent of the U.S. Gross Domestic Product (NASEM 2020, Hodgson, 2022, Daystar, et.al., 2019). Differences in definition also extend beyond the United States, complicating economic comparisons across borders for this sector of the economy.

The definition of the bioeconomy also affects the measurement of emerging technologies and processes. The bioeconomy can refer to manufacturing activities that utilize: (1) processes employing synthetic biology such as fermentation, using bioengineered organisms, biomanufacturing of vaccines, bioengineered small molecule/protein/nucleic acid pharmaceuticals, or gene therapy products, and agriculture using genetically engineered crops or genetically engineered biological fertilizers; (2) processes that convert biobased feedstock to generate fuels and chemicals; and, (3) products that are directly made from harvested biological material, such as clothing from wool, hemp and cotton, chairs from lumber, and broad use of existing and renewable natural resources. This broad view includes long established industry sectors such as agriculture and forestry. But the inclusion of long-established sectors such as agriculture and forestry would pose significant challenges for measurement of emerging or nascent industries. The size and output of well-established traditional industries may dwarf the contributions of new technologies, and changes to these traditional classifications can disrupt time series measures (Bugge, Markus & Hansen, Teis & Klitkou, Antje, 2016; Highfill, 2023).

Conceptualizing and Defining the Bioeconomy

Definitions of a bioeconomy identify specific activities, processes, and products that fit within a specific framework. Since there is no standard definition of the bioeconomy, international definitions may reflect a particular country's technical capacity, natural resource base, and economic and trade policies. These definitions are also formed by the priorities, outputs, and outcomes that different countries have for this developing segment of their economy. One

commonality is that all bioeconomy definitions span multiple industry sectors including agriculture, textiles, chemicals, energy, technology, and pharmaceuticals (Bugge, et. al, 2016).

Based on definitions from a number of countries, three distinct constructs for the bioeconomy have been identified. Each construct partitions the bioeconomy into specific but related activities, processes, and outcomes (Bugge et. al, 2016, and NASEM, 2020).

> "A biotechnology vision focuses on activities in the bioeconomy that center around generating scientific knowledge enabled by the purposeful manipulation of DNA, with production processes operating at the molecular level, the commercialization of such processes, and the development of new commercial products through biomanufacturing.
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> The bioresource vision involves the conversion of biomass and biological materials (e.g., crops, trees) into sources of power and/or new products, such as bioplastics or biofuels.
>
> The bioecology vision "highlights the importance of ecological processes that optimize the use of energy and nutrients, promote biodiversity, and avoid monocultures and soil degradation." (Bugge, et.al. 2016).

These three visions encompass innovation and a biotechnological element, a biobased process including biobased feedstock and biomanufacturing, and ecological or biobased outcomes. These overlapping elements, to varying degrees, are evident in the U.S. Government definitions of the bioeconomy, to which we now turn.

Efforts to define the U.S. bioeconomy initially focused on renewable resources for use in manufacturing of fuels and energy produced from renewable biomass material and wastes:

> "The global industrial transition of sustainably utilizing renewable aquatic and terrestrial biomass resources in energy, intermediate, and final products for economic, environmental, social, and national security benefits." This definition of the bioeconomy focuses on biofuels, bioproducts, and biopower produced from renewable biomass material and wastes." (DOE/EE, 2018)

Other definitions of the U.S. bioeconomy reflect similar perspectives but shift the focus to biotechnology. For example, the Office of Science and Technology Policy (OSTP) cites technological advances in the specific fields of health and agriculture:

> "The bioeconomy represents the infrastructure, innovation, products, technology, and data derived from biologically related processes and science that drive economic growth, improve public health, agricultural, and security benefits." (OSTP, 2019)

Similarly, the NASEM definition reflects a similar focus on research and innovation advances by life sciences and biotechnology:

> "The U.S. bioeconomy is economic activity that is driven by research and innovation in the life sciences and biotechnology, and that is enabled by technological advances in engineering and in computing and information sciences." (NASEM, 2020)

As noted in the NASEM report, how a bioeconomy is defined will decide what is selected to be included and measured in this sector of the economy (NASEM 2020). In 2022, directed by EO

14081, NIST drafted a current definition for the Bioeconomy Lexicon, emphasizing a biotechnology vision, specifically:

> "…the application of life sciences, in the areas of biotechnology and biomanufacturing, and including industries, products, services, and the workforce." (NIST, 2022)

This definition of the U.S. bioeconomy provides some context for the selection of activities and manufacturing processes that might be considered for classification; however, this definition of the bioeconomy, like other components of the economy, will necessarily evolve in response to the growth and application of technological innovations, the expanded use of sustainable biobased products and processes across manufacturing sectors, improved data, and enhanced data collection processes. The ITWG's interpretation of the NIST definition guided its discussions of the revisions to the NAICS and NAPCS and helped to fostered dialogue with bioeconomy advocates, industry representatives, and academics.

Federal Classification Systems for Industries and Products

EO 14081 called for recommendations to revise NAICS and NAPCS to provide measures of the bioeconomy. The goal of this effort would be to enable more comprehensive measures of bioeconomic contributions to the U.S. economy.

These classifications provide a systematic organization of both industries (NAICS) and products (NAPCS). NAICS industries are defined by similarities in production processes. NAPCS products are defined based on use. As described by the Office of Management and Budget, and the U.S. Census (Federal Register Notice, 2021; U.S. Census Bureau 2021):

> "NAICS is a system for classifying establishments (individual business locations) by type of economic activity. Its purposes are: (1) To facilitate the collection, tabulation, presentation, and analysis of data relating to establishments, and (2) to promote uniformity and comparability in the presentation and analysis of statistical data describing the North American economy.
>
> NAICS is unique among industry classifications in that it is constructed within a single conceptual framework. Economic units that have similar production processes are classified in the same industry, and the lines drawn between industries demarcate, to the extent practicable, differences in production processes. This supply-based, or production-oriented, economic concept was adopted for NAICS because an industry classification system is a framework for collecting and publishing information on both inputs and outputs, for statistical uses that require that inputs and outputs be used together and be classified consistently.
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> In the design of NAICS, attention was given to developing production-oriented classifications for (a) new and emerging industries, (b) service industries in general, and (c) industries engaged in the production of advanced technologies… NAICS divides the economy into 20 sectors. Industries within these sectors are grouped according to the production criterion."

Federal statistical agencies use NAICS to collect and/or publish data by industry. NAICS is a classification of industries used, among other measures, to facilitate economic measurement including the Gross Domestic Product (GDP). GDP is 1 of 13 Principal Federal Economic Indicators and, as such, revisions to the NAICS are recommended by the Economic Classification Policy Committee (ECPC) and approved by OMB (OMB, SPD #8, Federal

Register/Vol. 86 No. 242). NAICS is widely used by State agencies, trade associations, private businesses, and other organizations.

Additionally, as described by the U.S. Census Bureau:

> "The North American Product Classification System (NAPCS) complements the NAICS industry system and provides an alternate way of classifying output. NAICS was developed to classify units according to their production function. NAICS results in industries that group units undertaking similar activities using similar resources but does not necessarily group all similar products or outputs.
>
> "NAPCS was developed to classify the outputs, products, or transactions of establishments, within a demand-based conceptual framework… Thus, in many cases, the need for specific statistical data is better addressed with product data crossing industries rather than with the creation of a new industry. This is particularly true with NAICS, which groups establishments into industries based on their production function."

Although complementary to NAICS, NAPCS is not a standard classification for Principal Federal Statistics. Revisions to the NAPCS, however, correspond to the NAICS 5-year revision cycle and are also used for various statistical and nonstatistical purposes.

Measurement Challenges

Although a clear definition can help specify the parameters for measuring the bioeconomy, there are limitations for measuring bioeconomic activity using current NAICS classifications. NAPCS offers more granular data at the product level and provides a more comprehensive set of measures. However, NAPCS currently only identifies a few categories of biobased products.

One challenge with the NAICS is that it initially classifies industries at the sector level. Within the manufacturing sector (31–33), this may encompass a broad range of activity. However, some classification codes do not make distinctions between traditional and biobased processes or the inclusion of biobased feedstock in the manufacturing process.

For instance, milk can be manufactured by precision fermentation using genetically engineered microorganisms instead of using dairy cows. The fermentation approach covers both environmental and health benefits, but the NAICS classification includes all milk, whether obtained from animals, plants, or microorganisms, in a single industry:

> "311511 - Fluid Milk Manufacturing. This U.S. Industry comprises establishments primarily engaged in (1) manufacturing processed milk products, such as pasteurized milk or cream and sour cream and/or (2) manufacturing fluid milk dairy substitutes from soybeans and other nondairy substances."

Similarly, biofuels other than ethyl alcohol that are not made in petroleum refineries and not blended with petroleum are solely identified as biobased products within the broader NAICS industry 325199. Biofuels blended with petroleum and not made in petroleum refineries are in NAICS Industry 324199, All Other Petroleum and Coal Products Manufacturing.

Another example of a broadly written NAICS classification that includes both biobased and nonbiobased production is:

> "325199 All Other Basic Organic Chemical Manufacturing - This U.S. industry comprises establishments primarily engaged in manufacturing basic organic chemical products (except aromatic petrochemicals, industrial gases, synthetic organic dyes and pigments, gum and wood chemicals, cyclic crudes and intermediates, and ethyl alcohol)."

As defined, this industry would include a large variety of chemicals which may be produced from biomass via traditional chemistry, or biomass via synthetic biology.

A second challenge is that NAICS codes are assigned to an establishment's primary production activity. Byproducts and secondary manufacturing processes are included but not accounted for under a single assigned NAICS code. For instance, an increasing number of farms produce biogas through anaerobic digestion. However, the primary activity of farming determines the industry code for the establishment in the Agriculture Sector (11). Developments in the generation and collection of biogases may involve agriculture to a large degree but accounting for this production activity at the industry level only occurs when ownership of the biogas production operation is separate from the farm operation.

A third challenge may be the accuracy of the assigned NAICS codes. NAICS codes are self-reported and may be incorrectly identified, omitted, or incorrectly entered on data collections. Inaccurate classification has implications for measurement of the components of the bioeconomy. The quality of the NAICS codes assignment is a factor of the quality controls in place for each statistical program.

A fourth challenge to revisions is that review and revisions of the NAICS is a deliberative process that adheres to statistical standards, including guidelines for protecting confidentiality, accuracy with regard to sector and industry, and maintaining consistency across time series measurement. New industries seeking a NAICS classification need to achieve a sufficient size threshold, so when reported in the aggregate, it would minimize or eliminate the ability to identify an enterprise, potentially preventing disclosure of propriety information.

Additionally, changes to current NAICS codes to classify specific segments of industries with unique bioeconomy codes, will change the trajectory of current industry measures over time. These factors carry considerable weight when determining revisions to the NAICS codes for new or emerging industries. As demonstrated in the Economic Classification Policy Committee (ECPC) recommendations for OMB decisions regarding 2022 related revisions to the 2017 NAICS:

> "Given the substantive comments received in opposition to the ECPC recommendations for biobased products manufacturing and renewable chemicals manufacturing, [Office of Management and Budget] OMB is providing more explanation for its decision to accept these ECPC recommendations. OMB understands the importance of these growing topic areas; however, evidence to date suggests that further delineating the relevant industries at this time would risk the ability of Federal statistical agencies to publish industry data at this granular level given the small size of the potential industries. Further delineation would also jeopardize existing time series' continuity." (OMB, FRN 2021-27536 2021)

A final consideration when revising the classifications is that the NAICS and the NAPCS classifications are harmonized through trilateral agreements with the Instituto Nacional de

Estadística y Geografía (INEGI Mexico), and Statistics Canada, to facilitate measurement, research, and trade policy (OMB, FRN 2021-27536 2021). Revisions to the NAICS may require new trilateral agreements, depending on the terms of the current trilateral agreements. Without such agreements, differences across these classifications will impact the ability to compile comparable statistical measures of production across the United States, Mexico, and Canada.

NAICS does classify industries conducting Scientific Research and Development Services in physical, engineering, and life sciences, such as agriculture, electronics, environmental, biology, botany, computers, chemistry, food, fisheries, forests, geology, health, mathematics, medicine, oceanography, pharmacy, physics, veterinary, and other allied subjects. This classification is a component of the Professional, Scientific, and Technical Services Sector (54) and captures some research and development in biotechnological innovations 54174:

> "541714 Research and Development in Biotechnology (except Nanobiotechnology). This U.S. industry comprises establishments primarily engaged in conducting biotechnology (except nanobiotechnology) research and experimental development. Biotechnology (except nanobiotechnology) research and experimental development involves the study of the use of microorganisms and cellular and biomolecular processes to develop or alter living or nonliving materials."

This research and development in biotechnology (except nanobiotechnology) may result in development of new biotechnology (except nanobiotechnology) processes or in prototypes of new or genetically altered products that may be reproduced, utilized, or implemented by various industries."

However, research and development activities are also likely to be carried out by entities that are classified under other NAICS codes, such as manufacturing. Currently, there are no specific sector categories classifying bioeconomic industrial activities, while several sectors classify some biobased manufacturing and industrial activity adjacent to or combined with traditional industrial processes.

Acknowledging the limitations and potential restrictions of NAICS, a number of studies have suggested that NAPCS would be a more appropriate and feasible classification for assessing the economic contributions of the U.S. bioeconomy. (Carlson, 2016, NASEM 2020)

> "Finally, although it would be useful to have high-quality, fine-grained data elucidating exactly which chemicals are produced, and with which organisms and processes, the NAICS may not be the ideal mechanism to gather all such information. Instead, the NAPCS, which is intended to classify products by use in the market, may be a more appropriate means to distinguish between biotechnological products intended for increasingly varied markets. For example, it could be argued that nonpotable ethyl alcohol produced by fermentation should not be segmented by NAICS codes into fuel and nonfuel uses, as long as the codes make it distinguishable from the same molecule produced by synthetic chemistry. Rather, the different uses of ethyl alcohol as a fungible molecule may best be accounted for at the point of use via the NAPCS. Similar market-level differentiation among biological products may be a better means to characterize the bioeconomy. The NAPCS appears to be underutilized for this purpose, save for a fine graining of "scientific research and development services" into many flavors of biological science and engineering." (Carlson, 2016)

Although the NAPCS may provide more granularity than NAICS for classifying bioeconomic activity at the product level, as previously indicated with NAICS, the NAPCS lacks specific categories or flags for identifying biobased products. In addition, revisions to the NAPCS raise similar concerns regarding confidentiality, accuracy, size, time series, and trilateral agreement implications.

Summary of Comments, Feedback, and Consultations

To inform its recommended revisions to the NAICS and NAPCS, the ITWG solicited comments and recommendation from two sources, (1) a Request for Information (RFI) published in the Federal Register, and (2) five listening sessions with industry experts, advocates and industry representatives.

The ITWG received 24 public comments from the RFI. Many respondents recommended adding specific industry and product categories including expanding and creating specific NAICS codes to identify biomanufacturing processes as well as specific NAPCS codes for distinct biobased manufactured products. To collect and organize comments for input to the report, the ITWG generated a tracking table of comments citing potential industries for consideration primarily within the NAICS Manufacturing Sector. This tracker served as a preliminary template for developing and informing the final set of recommended revisions. (See Attachment #1 ITWG and Public Comments Tracking Sheet).

Comments regarding new NAICS/NAPCS codes primarily reflected the majority view that the revisions need to establish specific categories and markers to more accurately identify biobased manufacturing and biobased products.

These comments highlight three response categories; (1) recommendations and rationale for assigning NAICS and NAPCS codes to both specific sectors and specific industries and products; (2) feasibility studies and economic impact analyses to assess and inform revisions to the NAICS and NAPCS, and (3) recommendations for changes to the classifications and potential outcomes from improved measurement.

(1) Recommendations for new or different classifications that account for biobased manufacturing processes and products:

- "Biomanufacturing, biotechnology, and products such as bioplastics and biofuels should be considered for unique classification. Doing so would enable a more accurate measurement of their economic contribution and help identify emerging and growing sectors of the economy, aligning with the principles of NAICS and NAPCS.

  Assigning bioplastics their own six-digit NAICS code in order for the data collected to enable industry and the government to quantify the percentage of bioplastics within the two industries in which they currently fall – the plastics industry and biobased products industry…Cellulose Acetate manufacturing and Soybean plastic manufacturing are bioplastic industries that are currently found under NAICS 325211 but should be designated under a bioplastic classification." (OMB 2023-0012-0001)

- "Improvements in the NAICS codes are needed to distinguish biobased products, including establishing a new subsector category within the Manufacturing (Sector 31-33) for "Biobased Product Manufacturing."

Such improvements can account for the fact that the manufacturing process for many biobased products is often much different than their traditional counterparts…

Another example is the difference between the production processes of many biobased plastic resins and traditional fossil fuel-derived plastic resins, both of which are currently listed under the 2022 NAICS Plastics Material and Resin Manufacturing code 325211. Many biobased plastics can be manufactured via the fermentation of agricultural feedstocks such as corn or sugarcane, during which novel microbes digest these crops in order to biosynthesize bio-based plastic resin. This is notably different than the processes by which many traditional plastic resins are derived, during which fossil fuels are processed into pre-polymer materials that then undergo a polymerization process that is not assisted by novel microbes…While changes to the North American Product Classification System (NAPCS) codes can contribute to a better understanding of the scope of the biobased product industry, this alone is not the answer to facilitating more accurate analyses of the industry. Instead, revisions to both NAICS and NAPCS are necessary to unlock the full economic and statistical reporting benefits." (OMB-2023-0012-0021)

- "Biobased product manufacturers and industries further down the supply chain such as biobased chemicals manufacturers must be included in the next iteration of NAICS. Common NAICS codes have parallels in biobased products such as "plastic and rubber products manufacturing (NAICS 326) and "nondurable goods including chemicals and chemical products, drugs, textiles, apparel, petroleum, and petroleum products" (NAICS 422)." (OMB-2023-0012-0016).

- Recommend "both medical and nonmedical biomanufacturing tracked as parts of the bioeconomy…the industry is distinct from traditional chemical manufacturing and refining in the use of biological organisms and enzyme-based processes to replace synthetic chemistry processes and the use of biomass alternative (non-petroleum) carbon sources." (OMB-2023-0012-0006)

- "No NAICS code accurately represents our industry. Creating a set of NAICS codes for biomanufactured chemicals may enable more effective tracking of our nascent industry. NAPCS codes for biomanufacturing products would let buyers know the source of the ingredients they are purchasing, so they can choose between the petroleum products that currently dominate the market and more environmentally friendly biobased alternatives." (OMB-2023-0012-0006)

Similarly, other comments recommended:

- "(1) The addition of new U.S. bioeconomy sector within NAICS which include biomanufacturing, and (2) Addition of a designator within NAPCS for products sustainably manufactured using bioprocessing and/or biotechnology (indicating low carbon-intensity bioprocesses such as gas fermentation)." (OMB-2023-0012-0017)

- Establishing NAPCS codes that distinguish biobased products from traditional petrochemical products may improve measurement of both the size and impact of the biomanufacturing. Biobased product specific codes would greatly enhance the ability to track and report on the biobased products industry. …the requirement for the development of standardized NAICS codes for renewable chemicals, biofuels and biobased products will provide a unique opportunity for reporting (OMB-2023-0012-0014).

Commenters also echoed shortcomings with the utility and lack of specificity of the NAICS:

- "The primary challenge in revising the NAICS and NAPCS codes will lie in devising a mechanism for classifying bioeconomic activity that produces existing products and services with new bio-based methods. The overlap between the products and services in the bioeconomy and the broader economy suggest that the existing structure and categorization of the NAICS and NAPCS can remain, while an additional level of detail is required to distinguish bio-produced products and processes from their traditional counterparts. Moreover, our research into the current state of the US bioeconomy has shown that it is not possible to

cleanly divide companies and organizations into bioeconomy and nonbioeconomy bins. In many cases, legacy players in each industry are adopting biological processes to update, enhance, and modify their current production systems and produce new products. This is most evident in the pharmaceutical and agrochemical industries in which existing chemical products (small molecule drugs and conventional pesticides) remain key revenue drivers for companies like Merck, Bayer, and Corteva, even as significant research and development and commercialization resources are being allocated to new biologics and biopesticides.

In summary, the revisions to NAICS and NAPCS should preserve the existing structure of the classification systems while adding additional codes for new biobased products and services and additional levels of detail for the implementation of new biobased methods to produce existing goods. This ensures compatibility with historical record-keeping strategies in which bioprocesses and conventional processes were combined within a single code, while also providing a scalable solution to indicate existing industries that have adopted biological processes. As new biotechnologies are developed and implemented across a wide set of industries, bioeconomy products can be classified easily without requiring extensive reconsideration of the existing structure. Revisions to the NAICS and NAPCS will facilitate measurement of the Bio Revolution within industries while enabling accurate quantification of the bioeconomy as a whole…

In its current form, the NAICS does not facilitate characterization of the bioeconomy or quantification of its economic value, as biobased products and production methods remain largely uncaptured. Using the current NAICS, many biotechnology companies are indistinguishable from their traditional manufacturing counterparts, thus impeding a characterization of the bioeconomy or quantification of its economic value. Sustainable aviation fuel, for example, is a bioproduced replacement for traditional aviation fuels and is increasingly utilized by commercial airlines to meet emissions and sustainability goals. Yet, companies developing and producing sustainable aviation fuels would be categorized in jet fuels manufacturing (NAICS 324110 – Petroleum Refineries) or in some cases as research and development companies (NAICS 541715 – Research and Development in the Physical, Engineering, and Life Sciences). Many other biobased products meet similar challenges with classifications." (OMB-2023-0012-0018)

(2) Respondents suggested continued research, feasibility studies and economic impact analyses to inform and assess revisions to the NAICS and NAPCS and others stressed the need for clarity and consistency when classifying biobased products. The underlying concern is that these complementary characteristics are needed for a classification process that has utility. Another respondent suggested testing bioeconomy processes from current manufacturing processes to differentiate these from non-biobased production methods to enable accurate measurement.

- "When it comes to biobased materials, the economic impacts of the bioproducts sector will be tracked more effectively if there is a designated NAPCS associated with the biobased industry and a NAICS associated with verified biobased products.…recommends applying standardized biobased testing requirements using ASTM D6866 method B to help identify, classify, and measure biobased industries (NAICS) within the bioeconomy. Biobased testing is suitable for biobased industries such as energy, waste, agriculture, and manufacturing sectors." (OMB-2023-0012-0015)

Another respondent submitted a research proposal to use modeling to estimate the percent of the industry that is biobased.

- "We propose conducting a more detailed market analysis to understand the true growth potential of different sectors of the bioeconomy, using surveys, market intelligence studies, and consumer marketing analyses to develop a better understanding and more refined estimate of the potential growth of these

markets in the private sector. The analysis would also comprise an understanding of the key performance factors that will determine the successful commercialization of bioproducts in these sectors…

…Develop a Bioproducts academic-industry consortium that would include governmental partners and NGOs focused on BioProducts related research that would aid in the development of scientifically based results that can be used in the marketing of BioProducts. This could include such things as Life Cycle Inventory databases, Life Cycle Assessment, and linkages to industry-specific Product Category Rules (PCRs), Environmental Product Declarations (EPDs) as well as industry-wide supply chain assessment tools based on LCA such as the Higg Index." (OMB-2023-0012-0004)

(3) Respondents highlighted themes and potential outcomes from the adoption of classifications specifically for biobased manufacturing and products:

- "Federal Government efforts should include generating annual indicator reports for the use of the renewable feedstock and the products generated from it, and not the process by which the renewable feedstock is converted to either renewable chemical or biofuel. The product produced from renewable resources should be included in NAICS." (OMB-2023-0012-0010).

- "Across the pharmaceutical industry, research and development has shifted to focus on the development of biologics. Biologics are biobased therapeutics such as proteins or nucleic acids that have the same goal as traditional small molecule compounds—treating disease. As this industry and its products have grown in prominence, these bioeconomy contributors are a success story of the existing framework given the addition of the "Biological Product Manufacturing" (325414) NAICS code and the related "Biological products" (71201010101) NAPCS code…When considering revisions to the North American Industry Classification System (NAICS) and North American Product Classification System (NAPCS), the changes must accommodate the measurement and classification of both kinds of activities within the bioeconomy. Fortunately, both classification systems have existing mechanisms for the inclusion of new products and services as industries grow and technology advances. Both systems have the capacity to assign new codes to distinct industries and products, for example, the addition of 325315 for Compost Manufacturing in the 2022 NAICS code revisions. The existing mechanisms for adding NAICS and NAPCS codes will be useful for new industries such as cultivated meat and bioplastics." (OMB-2023-0012-0018)

Lastly, one commentor offered some insight to NAICS as it pertains to accuracy:

- "Self-assigned NAICS codes often do not accurately reflect the nature of the business. Some of this seems to be due to unfamiliarity with the NAICS, but some of this seems to be because the production process-focused classification causes problems when a business has more than one process—for example, an entity which both develops and manufactures vaccines could potentially fall in two different industry sectors. I suspect an entity which produces genetically modified crop seeds should only fall into agriculture or manufacturing, not both, but I am not sure which one…I am somewhat skeptical that revising the NAICS will result in quality statistics on the bioeconomy—better than are possible now, yes, at least if that level of detail is collected, but not what you could call good. The NAICS as a system is not suited to describing a group based on foundational principles rather than production details." (OMB-2023-0012-0002)

The unifying theme of these comments is that the validity of economic data rests on the capacity of the classifications to comprehensively and accurately identify the full range of industries and products and to differentiate between those processes and products generated from the application of life sciences (biotechnology and biomanufacturing), from those that are not.

Summary of Comments from the Listening Sessions

The ITWG hosted five listening sessions with academics and researchers, bioindustry advocates, and industry representatives. The dialogues provide opportunities for the ITWG to receive information on the data shortcomings, structural impediments and flexibilities of NAICS and NAPCS and potential areas for revisions.

Several presenters focused on the ITWG's end goal, stressing that the questions and the definitions we employ are important to our effort. Although there are multiple uses for industry and product classifications, the primary reason for NAICS and NAPCS revisions is to adapt and enable measurement of economic output of new and existing industries and products. Speakers did point out however that current data were insufficient for accurately measuring bioeconomic activity across different segments of the economy.

Presenters encouraged the ITWG to take a broad view and to exercise caution when recommending revisions to the classification system, as these would probably impact the NAICS structure and current measurement.

Additionally, many presenters encouraged the ITWG to consider "emerging" products/industries that may grow over the next decade. By the time updates are made to the next NAICS vintage (2027) and surveys implement the new codes, these products/industries will no longer be emerging.

Several listed some industries and products that the ITWG might consider for revisions, and also pointed out the difficulty of classifying blended biobased and traditional industrial manufacturing and feedstocks. Prominent among these were biofuels, biogases, food, biochemicals and bioplastics.

Although the task of recommending revisions may be difficult, given that the most recent effort to comprehensively revise the 2017 NAICS to reflect the bioeconomy was not successful (i.e., resulting in the diversion of selected revision proposals to NAPCS rather than NAICS), presenters stressed this will be a slow and evolving process and encouraged the ITWG to offer recommendations.

Revision Process and Recommendations

Reviewing the RFI comments and the Listening Session feedback, there are a few recurring requests. Multiple comments discuss the desire to incorporate in some way biomanufacturing, biogas, and renewable natural gas production into the existing NAICS structure. These categories may merit inclusion, but the concerns expressed by this working group as well as previous iterations of ECPC and OMB review should inform both recommendations and incorporation of new codes into the existing structure of NAICS.

Following are the guidelines the ITWG used to develop its recommendations.

(1) Ability to identify desired statistical units (establishments).

The extent to which bio-related activities are the "primary economic activity" conducted by establishments influenced the Working Group's recommendations. When discussing biofuels with experts in the field, they indicate that biofuels are often a secondary product of establishments that traditionally focused on petroleum-based production. Consequently, even if these production activities are becoming increasingly common, they still may not be captured by statistical surveys that only capture an establishment's primary NAICS. As pointed out by many researchers and commenters (Carlson, 2016; NASEM 2020), this difficulty suggests NAPCS could be a more effective avenue for identifying activity related to the bioeconomy.

There appears to be a significant challenge when considering primary vs. secondary economic activity as a rationale for choosing whether to include certain NAICS codes. In most cases, data are not available on the fraction of establishments that may consider bio-related economy activity as the "primary economic activity". With the exception of NAPCS product data, the only way to know about the lack of data would be to rely on private third-party data to justify creating the new codes that can identify these activities.

To address this challenge, members of the ITWG formed a subgroup to identify NAICS industries with production processes that are partially or fully biobased, to considered revisions consistent with these guidelines. These selections drew from existing NAICS Sectors as well as the public comments. (See Attachment #2 - Proposed Bioeconomy NAICS revisions)

The industries recommended by the ITWG subgroup provide a starting point for discussing potential revisions to the NAICS based on enhance identification of wholly or in part biobased processes.

(2) NAICS self-reporting and misclassification.

While some NAICS misclassification is always present, it seems likely this misclassification will be more prominent if there are very similar industry categories or industry distinctions with unclear definitions.

In the case of chemicals, bio-based production is not necessarily binary. That is, production processes can comprise a mix of new bio-related applications of life science as well as more traditional non-biobased methods. An establishment may not know how to categorize itself if it is using such a mix.

(3) NAICS and data disclosure concerns.

Another issue that concerns measurement and was a factor in the Working Group's recommendations, is perhaps a byproduct of the lack of precision in identifying statistical units. The primary concern is whether there will be sufficient data available to produce publicly released statistics on specific categories related to the bioeconomy.

For example, a very small number of establishments may classify themselves under newly proposed NAICS categories, and consequently, aggregations of these new categories may be publicly suppressed due to data disclosure concerns. However, this may not necessarily be prohibitive. Evidence Act (PL 115-435, 2019) requirements are advancing secure tiered access

data sharing through a National Secure Data Service. Though not released publicly, researchers will still be able to apply for and be granted access to restricted versions of the data for use in approved projects. Moreover, government entities with access to the underlying data can still conduct internal analyses that involve data which is publicly suppressed.

(4) NAICS intended purpose.

The recommendations proposed by the ITWG need to be consistent with the intended purpose of NAICS. NAICS is meant to capture differences in production. This guideline raises two issues. First, the ITWG should make its NAICS recommendations concise. In this context, concise means only creating a separate biobased NAICS category if the production process truly differs from production processes already captured by NAICS categories. As an example, there appears to be little utility in having separate "Biobased Plastic Bottle" and "Petroleum Based Plastic Bottle" NAICS categories, as the production of the bottle is very similar despite differences in the underlying plastic. Instead, there should be separate categories for bioplastics and petroleum plastics production since those processes will be quite different.

Second, the working group was skeptical of any suggestions/recommendations related to terms that are not easily defined. For example, "sustainability" does not have a standard definition and is therefore not suited for NAICS industry descriptions despite its importance in unlocking a prosperous economic future. It makes more sense to identify industries and products and then separately discuss their sustainability.

There are two primary reasons for the approach mentioned above. One reason is that sustainability is often difficult to measure. An expert from one of the listening sessions walked the working group through the nuances of what it means for something to be truly sustainable, and the level of technical detail needed to make determinations about sustainability. It's unlikely and perhaps cost prohibitive for establishments to perform the prerequisite analyses to determine whether their production processes are sustainable. It seems more likely that establishments will simply decide whether they think their processes are sustainable on the spot.

The second point, related to the first, is that it's not clear that sustainability will be the same across establishments. That is, establishments A and B may be sustainable, but it could be that establishment B is much more sustainable than A or that A disputes B's claim that B is sustainable.

In summary, the lack of a clear definition of "sustainability" along with the difficulties of measuring sustainability even if there were a clear definition, suggest excluding it from NAICS and NAPCS code recommendations.

The working group should identify the industries and let economists, statisticians, government agencies, etc. define sustainability and apply it to the identified industries using methods they develop for their individual projects. Caution also applies when using other terms that have multiple possible definitions.

(5) Time Series (In)Consistency.

Perhaps the foremost concern associated with substantial changes to the NAICS codes is time-series (in)consistency. Significant changes and/or rearrangement of NAICS codes have the potential to severely hinder research related to industry trends over time. Simply put, consideration of this issue should have a large impact on what the ITWG recommends as it will play a significant role in what the ECPC ultimately accepts or rejects.

Recommendations regarding additional codes and structure would likely differ significantly from the structure if NAICS was created from scratch; however, NAICS has been in use for 25 years, so creating it from scratch is not feasible. To the extent possible, changes should be limited to six-digit level additions with the acknowledgement that future iterations of NAICS could then reorganize these additions under their own subhierarchy. Doing so would allow the working group to (1) introduce new NAICS codes to measure new applications of life science, (2) allow researchers and data users to more easily understand how the new codes relate to the older classification system, and (3) would lay the foundation for the future creation of broader hierarchies (five-, four-, three-digit biobased codes) should they become needed.

Guiding Principle for Proposed Revisions

Based on the concerns and thought expressed above in combination with information gathered from the RFI comments and listening sessions, the ITWG followed these broad principles:

(1) Six-digit NAICS industry breakouts and additions only, with rare exceptions. Consider that these exceptions will be driven primarily by the existing NAICS coding structure.
(2) Consider alternatives to NAICS changes, by adding specific products to NAPCS.
(3) Leave aside "sustainability" and other difficult-to-define terms as metrics or classification terms for NAICS and NAPCS.
(4) Consider disclosure concerns and potential protections when weighing the value of comprehensive data.
(5) Recommend revisions to the NAICS that are concise and advance efforts to identify bioeconomy related activities and products.

Recommended Revisions to NAICS

The table below lists the ITWG's recommendations to the ECPC for revisions to NAICS. It also displays the vote tallies for each revision. The table records votes in favor, opposed, abstained, and absent and records what will be recommended to the Chief Statistician. The ITWG also made three additional recommendations that it believes will strengthen and improve data collection and deliberation.

Table 1. ITWG Recommended Revisions

	Description	Yes	No	Abstain	Absent/ Vote Not Recorded	Recommend To Chief Statistician?
(1)	Differentiate biobased component of 325211 "Plastics Material and Resin Manufacturing" [1] 325211a "Plastics Materials and Resin Manufacturing, Petroleum Based" 325211b "Plastics Materials and Resin Manufacturing, (Biobased)"	12	0	0	2	Yes
(2)	Differentiating biobased 313110 "Fiber, Yarn, and Thread Mills" and 325220 "Artificial and Synthetic Fibers and Filaments Manufacturing" 313110b "Fiber, Yarn, and Thread Mills (Biobased)" 325220b "Artificial and Synthetic Fibers and Filaments Manufacturing (Biobased)"	12	0	0	2	Yes
(3)	Breakout/rename 32512 "Industrial Gas Manufacturing" 325121 "Industrial Gas Refineries, (Excluding Biogas)" 325122 "Industrial Gas Refineries, (Biogas)" Electricity generation from biogas and RNG production from biogas are included elsewhere.	9	2	0	3	Yes
(4)	Differentiate Lab-Created Dairy, Meat and Seafood Product Add 311515 "Lab-Created Dairy Products" Add 31199b "Lab-Created Meat" Add 311710b "Seafood Product Preparation and Packaging, Lab-Created"	12	0	0	2	Yes
(5)	Breakout Biomedical Technology: 541714b "Research and Development in Biomedical Technology (excluding Nanobiotech)"	0	10	2	2	No

[1] Could include polylactic acid (PLA), polyhydroxy alkenoate (PHA), polybutylene succinate (PMS), polybutylene adipate-co-terephthalate (PBAT), polybutylene adipate-co-succinate (PBAS), etc. Also move soybean plastic manufacturing and cellulose acetate manufacturing to this specific part of the breakout.

(6)	Split 221112 "Fossil Fuel Electric Power Generation" and 221117 "Biomass Electric Power Generation" into: Coal Electric Power Generation (includes electric generators that use biomass in combination with coal) Natural Gas Electric Power Generation (includes electric generators that use renewable natural gas in combination with fossil natural gas) Petroleum Electric Power Generation (includes electric generators that use biofuels in combination with petroleum products) Biogas Electric Power Generation (for electric generators that mainly use biogas from anaerobic digestion of organic material. Biogas may be obtained from landfills, water treatment, agricultural digesters, or other sources.) Wood Electric Power Generation (for electric generators that mainly use wood products)	9	0	3	2	Yes
(7)	Tissue Manufacturing for Human and Animal Use Add 325414b "Human Tissue Engineering Manufacturing" - organic, lab-grown, medical implements such as skin grafts, cartilage, etc.	12	0	0	2	Yes
(8)	Add 325316 "Biogas/Microbial and Biologics Solid Waste Fertilizer Manufacturing" [2]	0	10	0	4	No
(9)	Plant aquaculture, sea plant agriculture, and seaweed farming Add 112513 "Plant aquaculture, sea plant agriculture, and seaweed farming" (with future consideration for splitting out seaweed farming)	11	0	1	2	Yes

[2] We have concerns about this addition for this iteration of NAICS. One concern is the lack of a market that seems to exist currently. Based on information from the listening sessions and the RFI, we believe this is going to be a sizeable industry in the future that merits a breakout. Additionally, one listening session commentator suggested that we need to think long term given the pace of change for the NAICS Codes. Consider this revision for future additions? We also suggest using "Microbial and Biologics" instead of "Biogas." This might be better as there appears to be other kinds of microbial fertilizer production (see Gryphon Scientific RFI comments) and it seems prudent to also allow for the possibility of more general biologic processes. We also think microbial is a more precise description of the production process.

	Note: Algae farming would remain under 112519					
(10)	5415 "Computer Systems Design and Related Services" Breakout for custom software that facilitates genomic data analysis and interpretation 541511b	11	0	0	3	Yes
(11)	Agricultural seeds manufactured with genetic editing [3] Retain GMO seed production in the Agriculture Sector (11)	11	0	0	3	Yes
(12)	Establish five new industries under 325199 "All Other Basic Organic Chemical Manufacturing" Production of Basic Organic Chemicals Using Synthetic Biology (Split out of 325199) Production of Basic Organic Chemicals Using Biobased Feedstocks (Split out of 325199) [4] Fatty Acid Ester Production from Biobased Feedstocks. (Includes fatty acid esters for non-fuel use and fuel use (biodiesel). Split out of 325199) Production of RNG from biogas. (Includes establishments whose primary output is pipeline-grade natural gas produced from biogas. Split out of 325199) Hydrotreatment of Esters and Fatty Acids (Production of hydrocarbon fuels from vegetable oils or animal fats. Includes production of renewable diesel, renewable jet fuel, renewable naphtha, and renewable propane/butane. Split out of 325199. Does not include biodiesel, since biodiesel is chemically distinct from hydrocarbon fuels.)	12		2		Yes

[3] The ITWG discussed the significant presence of GMO in agriculture. Products are patented and manufactured under stringent criteria and marketed for crop production.

[4] The ITWG raised a concern that there is the potential for confusion between biobased chemicals and chemicals produced by synthetic biology. Companies manufacturing biobased chemicals may not know which code to select. The ITWG recommends that the ECPC be cognizant of this potential confusion and add greater clarity to these distinct manufacturing processes.

(13)	Split one new industry out from 324191 "Petroleum Lubricating Oil and Grease Manufacturing" Biobased Lubricating Oil and Grease Manufacturing	12		2		
	The Working Group also recommends that the three emerging technologies listed below are monitored by the ITWG for potential revisions to the 2022 NAICS:					
(14)	Cellular metabolic engineering and chassis organism development (CRISPR) – Potential NAICS codes: 31–33 Manufacturing (3251 Basic Chemical Manufacturing; 3252 Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing; many others potentially including 3253; 3254; 3255; 3256; 3259; 3261; 3262; 3273; 3332; 3345; 3399)					Pending Further Discussion
(15)	DNA Sequencing and Synthesis technology – Consider Potential NAICS codes: 51 Information (5112 Software publishers; 5182 Data Processing, Hosting, and Related Services)					Pending Further Discussion
(16)	Computational analysis and AI/ML-guided design – Potential NAICS codes: 54 Professional Scientific and Technical Services (5415 Computer Systems Design and Related Services; 5416 Management, Scientific and Technical Consulting Services; 5417 Scientific Research and Development Services [and items therein]; 5419 Other Professional Scientific and Technical					Pending Further Discussion

Additional Recommendations

(1) Consider expanding data collection for NAICS and NAPCS

Currently the Census of Agriculture and other statistical programs conducted by the Department of Agriculture's National Agricultural Statistics Service (NASS) do not collect data using NAICS and NAPCS industries and products. Addressing this limitation may provide additional

data and information to complement the data collected by the Economic Census and other agencies' statistical programs. The Chief Statistician of the United States may consider discussing with NASS this expanded data collection and the agency's capacity and needs to include NAICS and NAPCS through existing statistical data collection activities of the Department of Agriculture.

ITWG Vote: 11 Yes 0 No 3 Absent

(2) Consider making NAPCS a standard classification for Principal Federal Statistics.

Neither NAICS nor NAPCS includes a Bioeconomy Sector for classification; these activities are dispersed throughout the classifications. Comprehensive measurement of bioeconomic activity requires the use of both NAICS and NAPCS; NAPCS also offers the advantage of much greater granularity compared to NAICS. However, NAPCS is implemented through the use of a collection structure that is coded and organized differently than the NAICS classification structure. Although concordances are available between the two structures, direct use of NAPCS, with flexibility for additional detailed products within trilateral NAPCS products, would provide a single, more robust classification model for use by statistical programs.

Given the widely acknowledged utility of the NAPCS for identifying and tracking bioeconomic activity, and its potential for improving measurement and data quality, the Chief Statistician may consider appointing an Interagency Technical Working Group to assess the feasibility and value of making NAPCS a standard classification for Principal Federal Statistics. Considerations for the ITWG may include any potential impact on data accuracy and utility, comparability with other countries, and the capacity of Federal Agencies to meet these standards (budget, staffing).

ITWG Vote: 10 Yes 2 No 2 Absent

(3) Expand and continue the efforts of the Bioeconomy ITWG to improve data collection to support the work of Federal Agencies to measure the Bioeconomy.

The Bioeconomy Interagency Technical Working Group will continue to fulfill its Charter and to:

- Advocate for expanded and enhanced measurement of new and existing biobased products and new or existing biobased manufacturing processes (e.g., see recommendations 1, 2 and 12, 13 and 14 above).
- Examine the application of different definitions for the bioeconomy as these include or exclude bioeconomy products, industrial processes, components, or technologies.
- Track and link biobased products and industries that require new NAPCS codes or differentiated NAICS codes to support data collection and measurement for the bioeconomy, including the development of a satellite account under various definitions of the bioeconomy.
- Act as a sounding board in support of the work of the Economic Classification Policy Committee (ECPC).

ITWG Vote: 11 Yes 0 No 3 Absent

Summary of the Votes

All revisions were voted on and the decisions to either recommend or not recommend a revision to the Office of the Chief Statistician were substantial majorities. Of the 14 members voting on the 13 revisions and 3 recommendations, a majority counted as 9 to 12 Yes or No votes. Members who abstained indicated that they were unsure or did not have sufficient knowledge to offer an informed vote. Members who were counted as absent were not able to attend all or part of the meetings.

Concluding remarks

Acknowledging the potential scope and breadth of the U.S. bioeconomy, these proposed revisions reflect a limited selection of this economic activity and are consistent with the ITWG's interpretation of the bioeconomy as defined in the NIST Lexicon (NIST, 2022). As future revisions are considered, the ITWG suggests that the Economic Classification Policy Committee (ECPC) consult with stakeholders and consider future revision proposals to separately identify other aspects of this activity as the bioeconomy evolves.

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(2) OMB 2023-0012-0021
(3) OMB 2023-0012-0016
(4) OMB 2023-0012-0006
(5) OMB 2023-2012-0017
(6) OMB 2023-0012-0014
(7) OMB 2023-0012-0018
(8) OMB 2023-0012-0015
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Attachment #1. ITWG and Public Comments Input Tracking Sheet

Code	Description	Notes	Def'n in NIST Lexicon	RFI References	ITWG
3b	Biomanufacturing	Production through biotechnological processes from biologically derived feedstocks (food waste, nonfood crops, and cellulosic or algal biomass) or biological processing	The use of biological systems to produce goods and services at commercial scale	OMB-2023-0012-0009: new biomanufacturing platforms OMB-2023-0012-0010: The Department of Energy growth trajectory with its loan guarantee program is collecting data on biomanufacturing and biotechnology OMB-2023-0012-0006: medical and non-medical biomanufacturing - use of biological organisms and enzyme-based processes to replace synthetic chemistry processes and the use of biomass alternative (non-petroleum) carbon sources. Biomanufacturing can produce chemical goods that are functionally indistinguishable from existing products. It can also produce alternatives with improved properties. See comments for three processes. OMB-2023-0012-0015: Recommends requiring biobased content testing using the ASTM D6866 standard (Carbon-14) for biobased industries and biobased products in NAICS and	May need a new code for Biomanufacturing (based on advances in Life Sciences) and/or subcodes under various existing Manufacturing codes. Cellular metabolic engineering and chassis organism development. The discovery and development of gene editing systems (i.e., CRISPR) combined with advanced computational systems and laboratory automation will greatly accelerate the field of biotechnology and biomanufacturing, particularly now in the age of genome-enabled biology. Advances in life sciences will produce whole new kinds of products and services developed from a deeper, more mechanistic understanding of biology. CRISPR-based technologies combined with optimized chassis organism development will accelerate the industrial production of numerous new products and processes. Whole new biomanufacturing processes, biomolecules, biomaterials, chemicals, fuels,

				NAPCS OMB-2023-0012-0014: Biomanufacturing, biotechnology, and products such as bioplastics and biofuels should be considered for unique classification. OMB-2023-0012-0016: Biobased product manufacturers and industries further down the supply chain such as biobased chemicals manufacturers must be included in the next iteration of NAICS. Common NAICS codes have parallels in biobased products such as "plastic and rubber products manufacturing" (NAICS 326) and "nondurable goods including chemicals and chemical products, drugs, textiles, apparel, petroleum, and petroleum products" (NAICS 422).	and bio-hybrid machines and/or information storage devices are but a small sampling of what may come that will require new NAICS codes to capture progress in these new industries. Such new industries are distinct from other more traditional biobased processes that existed before the broad advent of genome sequencing. Likewise traditional biobased industries that have transitioned to newer genome-based technologies might warrant a distinguishable NAICS code to reflect this change.

311b	Bioengineered food manufacturing	Also includes food derived from bioengineering	Bioengineered food: certain food produced with biotechnology and subject to labeling under the National Bioengineered Food Disclosure Standard. As noted therein, a food is bioengineered if it contains detectable genetic material that has been modified through in vitro recombinant DNA techniques, and for which the modification could not otherwise be obtained through conventional breeding or found in nature. Bioengineering: the application of engineering principles and practices (including from chemical, mechanical, and electrical engineering disciplines) to the life sciences; see	OMB-2023-0012-0004: Biorefining - 311221, 311313, 311311/2, 311222/3, 311225 OMB-2023-0012-0010: cell-cultured food ingredients OMB-2023-0012-0023: Concurs with -0004; Figure 3-2 of the Safeguarding the Bioeconomy report - Biorefining (food) - 311210, 311221, 311224, 311225, 311300	Add 311515 “Lab-Created Dairy Products” Add 311616 “Lab-Created Meat” Split 311710 into: i. 311711 “Seafood Product Preparation and Packaging, Not Lab-Created” ii. 311712 “Seafood Product Preparation and Packaging, Lab-Created”

			also "biological engineering"		
312b	Bioengineered beverages manufacturing	Also includes beverages derived from bioengineering			
313b	Biotextiles manufacturing	Excludes fibers/filaments (see line20)		OMB-2023-0012-0004: Textiles - products in 31 OMB-2023-0012-0023: Concurs with -0004	313110b “Biobased (organic?) Fiber, Yarn, and Thread Mills”
314b	Biotextile products manufacturing (except apparel)				
315b	Biotextile apparel manufacturing				

325b	Biochemicals and biochemical products manufacturing (except bioplastics products and biorubber products)			OMB-2023-0012-0004: Biobased chemicals - codes in 325 and 326 Enzymes - 32519, 325414 OMB-2023-0012-0010: renewable chemicals OMB-2023-0012-0006: biomanufactured chemicals OMB-2023-0012-0023: Concurs with -0004	
3251b	Basic biochemicals manufacturing				Track how NAICS 32519 is impacted by the use of biofeedstocks. "…primarily engaged in manufacturing basic organic chemicals from renewable substrates using traditional chemistry"
32513b	Biodyes and biopigments manufacturing				
32517b	Other basic biochemicals manufacturing	32512, 32518, 32519			
325171b	Industrial bioenzymes and biocatalysts manufacturing		Biocatalyst: a biomolecule, such as an enzyme, that increases the rate of a chemical reaction	OMB-2023-0012-0004: Enzymes - 32519, 325414 OMB-2023-0012-0010: enzymes, single cell protein for food and feed OMB-2023-0012-0023: Concurs with -0004; Figure 3-2 of the Safeguarding the Bioeconomy report -Other enzymes 32519pt	

325172b	Biofuels, liquid and solid, manufacturing	325193 PT (ethanol); 325199 PT	Fuel produced from biomass or through biomanufacturing (with scope notes; biofuels def'n also includes gaseous fuels)	OMB-2023-0012-0010: bioethanol, biodiesel, biofuels, alternative fuels, sustainable aviation fuels (SAF) OMB-2023-0012-0023: Figure 3-2 of the Safeguarding the Bioeconomy report - Biofuels (ethanol) - 324110pt	
325173b	Biogas manufacturing	32512 PT		OMB-2023-0012-0019: create an industry for the activity of recycling various forms of organic waste into several products including biogas and digestate. Biogas is the precursor for many other products derived from natural gas such as fertilizers, plastics, fuels (RNG, hydrogen, sustainable aviation fuel) etc.	325122 “Industrial Gas Refineries, (Biogas RNG)” Note: For biogas to be pipeline-compatible, it requires some clean-up steps and then is called renewable natural gas (RNG).
325174b	RNG (biomethane) manufacturing			OMB-2023-0012-0022: there should either be one new NAICS industry code for all RNG production facilities, regardless of the feedstock and regardless of the specific technology deployed, or separate codes could be created that identify the particular feedstock (landfill, wastewater, food waste, livestock, or agricultural waste, etc.) and specific technology (anaerobic digestion, gasification, non-combustion thermal	

				conversion, Power-to-Gas, etc.).	
325179b	Other basic biochemicals manufacturing, not elsewhere classified			OMB-2023-0012-0023: Figure 3-2 of the Safeguarding the Bioeconomy report - Biobased petrochemicals 32511; Other biobased chemicals - long list of NAICS including 32519 and beyond	
3252b	Bioplastics materials, biorubber materials, biofibers, and biofilaments manufacturing	Except bioplastics products and biorubber products			
32521b	Bioplastics and biorubber materials manufacturing				

325211b	Bioplastics materials manufacturing		Plastics, in whole or in significant part, derived from and/or composed of biomass (any material of biological origin that is available on a renewable or recurring basis); see also "biobased polymer"	OMB-2023-0012-0007: Bio-Based Filler Powders OMB-2023-0012-0010: bioplastics OMB-2023-0012-0014: The globally accepted definition developed by the industry of "bioplastics" is "biobased and/or in some way biodegradable." Consider classifying biodegradable monomers (oxo-, marine-, and soil-degradable) and certified compostable resins separately. To avoid revealing sensitive company information, a new NAICS code should compile the full suite of bioplastic resins.	325211b "Plastics Materials and Resin Manufacturing, Biobased (Organic?)" i. Could include polylactic acid (PLA), polyhydroxy alkenoate (PHA), polybutylene succinate (PMS), polybutylene adipate-co-terephthalate (PBAT), polybutylene adipate-co-succinate (PBAS), etc. ii. Also move soybean plastic manufacturing and cellulose acetate manufacturing to this specific part of the breakout
325212b	Biorubber materials manufacturing				
32522b	Biofibers and biofilaments manufacturing				Current language (cellulosic and noncellulosic) for NAICS 32522 may not be practical as the bioeconomy evolves.
3253b	Biopesticides, biofertilizers, and other agricultural biochemicals manufacturing			OMB-2023-0012-0007: Biochar Soil Amendments OMB-2023-0012-0023: Biopesticides, plant incorporated protectants, and biostimulant production OMB-2023-0012-0020: compost and biochar; the compost and soil amendent's portion of the bioeconomy is	Add 325316 "Biogas/Microbial and Biologics Solid Waste Fertilizer Manufacturing" or "Microbial and Biologics" instead of "Biogas" might be better

				inadequately grouped with fertilizers	
32541b	Biopharmaceuticals and biomedicines manufacturing		Biological product (human medical use): a virus, therapeutic serum, toxin, antitoxin, vaccine, blood, blood component or derivative, allergenic product, protein, or analogous product, or arsphenamine or derivative of arsphenamine (or any other trivalent organic arsenic compound), applicable to the prevention, treatment, or cure of a disease or condition of human beings. Biological product (veterinary medical use): all viruses,	OMB-2023-0012-0023: continue to capture the contribution of biologics and other forms of biopharmaceutical production; Figure 3-2 of the Safeguarding the Bioeconomy report - Biopharmaceuticals 325412pt; Biologics 325414; Other pharmaceuticals 325412 pt	Add 325415 “Microbial and Biologics Manufacturing” Alter 325414 “Biological Product (except Diagnostic, Microbial, and Biologics) Manufacturing

			serums, toxins (excluding substances that are selectively toxic to microorganisms, such as antibiotics), or analogous products at any stage of production, shipment, distribution, or sale which are intended for use in the treatment of animals and which act primarily through the direct stimulation, supplementation, enhancement, or modulation of the immune system or immune response		
32542b	Cells, tissues, organs, and other biological constructs manufacturing				Add 339117 “Human Tissue Engineering Manufacturing”
3255b	Biocoatings, biopaints, and bioadhesives manufacturing			OMB-2023-0012-0007: convert Biomass Sorghum into a coating, which protects military vehicles from chemical warfare	
3256b	Biocleaning compounds and personal use				

	biopreparations manufacturing				
32561b	Biodetergents and biocleaning compounds manufacturing				
32562b	Biocosmetics, biofragrances, and other personal use biopreparations manufacturing				
3259b	Other biochemical products manufacturing (except bioplastics products and biorubber products)				
326b	Bioplastics products and biorubber products manufacturing				
3263b	Bioplastics products manufacturing	3261		OMB-2023-0012-0023: Figure 3-2 of the Safeguarding the Bioeconomy report - Biobased plastic products 326	
32631b	Bioplastics packaging manufacturing	326111, 326112, 326140 pt, 326150 pt		OMB-2023-0012-0004: Biobased Plastic Bottles and Packaging - 32619, 32611, 326160, 326121	
32632b	Bioplastics bottles manufacturing	32616		OMB-2023-0012-0004: Biobased Plastic Bottles and Packaging - 32619, 32611, 326160, 326121	

32639b	Other bioplastics products manufacturing			OMB-2023-0012-0007: Shipping Pallet Made From Bio-Based Filler Powder and Plastic Waste	
3264b	Biorubber products manufacturing	3262			
32641b	Biorubber tires manufacturing	32621			
32642b	Biorubber hosing and belting manufacturing	32622			
32649b	Other biorubber products manufacturing	32629			
327b	Bioproducts manufacturing for building/construction				
3271b	Biocements, bioconcretes, and biocement/bioconcrete products manufacturing	3273			
3279b	Other bioproducts manufacturing for building/construction				
				Other:	Other:

				OMB-2023-0012-0010 Feedstock cultivation/production - e.g., hemp - separate NAICS code for each type; wood pellets OMB-2023-0012-0023 Carbon capture technologies that are associated with biotechnology; Figure 3-2 of the Safeguarding the Bioeconomy report - Crop products, Electromedical instruments, Surgical and medical instruments, Bioeconomy R&D services, Intangible investments, Public and nonprofit R&D and software and data-related analytic services	Agricultural seeds manufactured with genetic editing Growing and sustainably harvesting crops Plant transformation technologies. A broader more biobased economy will require a deeper understanding of plant-based feedstocks that serve as a source of biobased products and materials on which to build a broader bioeconomy. Technologies to more efficiently and cost effectively transform plants to engineer new functional properties and/or desirable traits into a broad variety of nonfood bioeconomy/bioenergy crops will be needed to take full advantage of the diverse metabolic potential of plants. New ways to introduce DNA into plants cells will be key to developing new products from plant biomass or utilizing plants as “factories” themselves for growing a wide range of products (lots of caveats here with genetically modified crops). Potential NAICS codes: 11 Agriculture, Forestry, Fishing

					and Hunting (1111 Oilseed and Grain Farming; 1119 Other Crop Farming; 1125 Aquaculture [ex. algae]; 1151 Support Activities for Crop Production) i. Add 112513 “Plant aquaculture, sea plant agriculture, and seaweed farming” OR ii. Plant aquaculture seems out of place in the animal production category: 1. Add 111993 “Plant aquaculture, sea plant agriculture, and seaweed farming” 2. Rename 1125 “Animal Aquaculture” and 112519 “Other Animal Aquaculture” a. Note, Algae farming would remain under 112519

					221112b “Fossil Fuel Generation (Natural Gas)” 1. Broke out natural gas because it might make sense to group biogas and natural gas together in a broader group and then list them separately within that group 2. Note: Consider not putting RNG under 21 but instead somewhere in manufacturing (consider under 32512) Add 221119 “Biogas/Microbial and Biologics Gas Electric Power Generation”

					Industries that provide genomic analysis products may warrant a separate and/or distinguishable NAICS (or NAPCS) code. Potential NAICS codes: 51 Information (5112 Software publishers; 5182 Data Processing, Hosting ,and Related Services) 541714b “Research and Development in Biomedical Technology (excluding Nanobiotech)” Laboratories and new corporations using principles of genomic design will be creating whole new biological testing and design systems to produce numerous products rooted in advances in life sciences. Potential NAICS codes: 54 Professional Scientific and Technical Services (5415 Computer Systems Design and Related Services; 5416 Management, Scientific and Technical Consulting Services; 5417 Scientific Research and Development Services [and items therein]; 5419 Other Professional Scientific and Technical Services)

Attachment #2. Proposed Bioeconomy NAICS Revisions

Recommendation Number	New NAICS Industry Description	Comments	Existing NAICS Industry, if any	Industry Group for New NAICS Industry
1	Plastics materials and resin manufacturing, petroleum based		325211 "Plastics Material and Resin Manufacturing"	3252 "Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing"
	Plastics materials and resin manufacturing, biobased	Includes but not limited to Polylactic Acid (PLA), Polyhydroxy Alkanoate (PHA), Polybutylene Succinate (PBS), Polybutylene Adipate-Co-Terephthalate (PBAT), Polybutylene Adipate-Co-Succinate (PBAS), and cellulose acetate		
	Plastics materials and resin manufacturing, all other			
2	Synthetic fiber, yarn, and thread mills	Uses fibers produced primarily from first-use or recycled fossil or mineral resources	313110 "Fiber, Yarn, and Thread Mills"	3131 "Fiber, Yarn, and Thread Mills"
	Biobased fiber, yarn, and thread mills	Uses fibers produced directly from plants and animals (e.g., cotton and wool) or biobased synthetic fibers (e.g., biobased polypropylene)		
3	Lab-created dairy products			3115 "Dairy Product Manufacturing"
4	Lab-created meat			3116 "Animal Slaughtering and Processing"
5	Seafood product preparation and packaging, not lab-created	For production using farmed or wild-caught finfish and shellfish	311710 "Seafood Product Preparation and Packaging"	3117 "Seafood Product Preparation and Packaging"
	Seafood product preparation and packaging, lab-created	For cultured finfish or shellfish meats		

Recommendation number	New NAICS industry description	Comments	Existing NAICS industry, if any	Industry Group for new NAICS industry
6	Research and Development in Biotechnology (excluding Nanobiotechnology and Biomedical Technology)		541714 "Research and Development in Biotechnology (except Nanobiotechnology)"	5417 "Scientific Research and Development Services"
	Research and Development in Biomedical Technology (excluding Nanobiotechnology)			
7	Coal electric power generation	Includes electric generators that use biomass in combination with coal	221112 "Fossil Fuel Electric Power Generation" 221117 "Biomass Electric Power Generation" 221118 "Other Electric Power Generation"	2211 "Electric Power Generation, Transmission, and Distribution"
	Natural gas electric power generation	Includes electric generators that use renewable natural gas in combination with fossil natural gas		
	Petroleum electric power generation	Includes electric generators that use biofuels in combination with petroleum products		
	Biogas electric power generation	For electric generators that mainly use biogas from anaerobic digestion of organic material. Biogas may be obtained landfills, water treatment, agricultural digesters, or other sources.		
	Municipal solid waste power electric generation	For electric generators that mainly use municipal solid waste via direct combustion		
	Wood electric power generation	For electric generators that mainly use wood products		
8	Development and maintenance of genomic information databases			5416 "Management, Scientific, and Technical Consulting Services" OR 5417 "Scientific Research and Development Services"

Recommendation number	New NAICS industry description	Comments	Existing NAICS industry, if any	Industry Group for new NAICS industry
9	Computational analysis and design in support of biological system development			5417 “Scientific Research and Development Services”
10	Metabolic engineering of organisms			5417 “Scientific Research and Development Services”
11	Production of chemicals using synthetic biology		32519 “Other Basic Organic Chemical Manufacturing”	3251 “Basic Chemical Manufacturing”
	Production of chemicals using biobased feedstocks			
12	Biobased synthetic fibers and filaments manufacturing	Includes traditional cellulosic fibers such as rayon and acetate as well as recently developed biobased fibers	325220 “Artificial and Synthetic Fibers and Filaments Manufacturing”	3252 “Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing”
	Synthetic fibers and filaments manufacturing, not biobased	Includes fibers produced from traditional petrochemical raw materials		