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A Road Map for Sustainable Chemistry

In January 2021, Congress enacted the Sustainable Chemistry Research and Development Act to better coordinate federal and private sector investments in sustainable chemistry research and development, commercialization, and scaling. Since passage of the act, the federal landscape for sustainable chemistry has changed dramatically, providing important strategic opportunities to advance US leadership in the field. Notably, through legislation that includes the Inflation Reduction Act and the CHIPS and Science Act, the federal government has made massive investments in decarbonization, resilient domestic manufacturing, and job creation, and environmental justice has become a national priority. Additionally, new initiatives at global, state, and market levels are putting pressure on firms to find solutions that reduce both climate impacts and chemical pollution. Rapidly advancing sustainable chemistry can contribute substantially to all these goals, but it requires an ambitious, focused, and coordinated strategy at the federal level.

With little fanfare, the National Science and Technology Council's interagency Strategy Team on Sustainable Chemistry published its first report in August 2023, entitled *Sustainable Chemistry Report: Framing the Federal Landscape*. A two-year effort that engaged more than 14 federal agencies and was cochaired by the White House Office of Science and Technology Policy, the National Institute of Standards and Technology, and the National Science Foundation, the report is a laudable survey of the range of sustainable chemistry activities across the federal government. The interagency team is now beginning work on a federal strategic plan for advancing sustainable chemistry in the United States. This plan should provide an actionable road map with a clear and measurable direction for innovation, links to government priorities as well as business and societal needs, and incentives for adoption in the marketplace. Given that chemistry is a major driver of US gross domestic product and plays a central role in solving many of the country's most pressing environmental challenges, any federal strategy on sustainable chemistry will need clear leadership and coordination to be successful in achieving its goals.

As a starting point, a road map should give funding agencies, investors, businesses, and others clear ideas of how to direct their investments. Although aspirational, the 87-word definition of sustainable chemistry (see box) detailed in the Strategy Team on Sustainable Chemistry's report misses the mark. On the one hand, it is too restrictive in requiring the use of renewable feedstocks, renewable power, and "optimal" efficiency—a standard that few major chemical projects in the United States could meet today. On the other hand, it is too permissive in failing to exclude activities that create risks to human health and the environment, despite meeting climate-focused criteria. For example, benzene could be produced using renewable power and feedstocks operating at optimal efficiency, without regard for the fact that it is carcinogenic and harmful to the communities where it is produced. Despite its length, the definition is followed by the caveat that "advancement in one of these areas should not be at the detriment of another area," and provides some criteria for measuring sustainable chemistry. However, the definition is too complicated to utilize in a policy or investment context.

For comparison, the Expert Committee on Sustainable Chemistry proposed a much clearer, shorter, working definition: "Sustainable chemistry is the development and application of chemicals, chemical processes, and products that benefit current and future generations without harmful impacts to humans or ecosystems." More importantly, the definition ties to specific criteria for which metrics and tools can be used to guide investments that clearly advance sustainable chemistry and do not lead to regrettable solutions or shift impacts to communities that have previously been harmed. Businesses and investors require this type of clarity. Such definitions should be designed to interact with other efforts, such as the European Commission's criteria for "safe and sustainable by design" chemicals.

Secondly, sustainable chemistry investments must be tied to the ongoing priorities of the Biden administration and Congress, as well as those of voters and consumers. In addition to the passage of the Inflation Reduction and CHIPS and Science Acts, the Infrastructure Investment and Jobs Act and the Executive Order on Advancing Biotechnology and Biomanufacturing Innovation for a Sustainable, Safe, and Secure American Bioeconomy together represent a once-in-a-generation opportunity to invest in sustainable chemistry. Additional administration priorities related to environmental justice, supply chain resilience, and domestic manufacturing are also inextricably linked to chemistry and the chemical industry. The federal government must explicitly incorporate sustainable chemistry into implementation of these new laws and initiatives.

DEFINITION OF "SUSTAINABLE CHEMISTRY" FROM THE *SUSTAINABLE CHEMISTRY REPORT*

Sustainable chemistry is the chemistry that produces compounds or materials from building blocks, reagents, and catalysts that are readily available and renewable, operates at optimal efficiency, and employs renewable energy sources; this includes the intentional design, manufacture, use, and end-of-life management of chemicals, materials, and products across their life cycle that do not adversely impact human health and the environment, while promoting circularity, meeting societal needs, contributing to economic resilience, and aspiring to perpetually use elements, compounds, and materials without depletion of resources or accumulation of waste.

Progress in sustainable chemistry has already been identified as key to addressing climate change, because the chemical sector is the largest domestic industrial source of greenhouse gases. The recent report from a Department of Energy cross-sectoral roundtable (cohosted by Change Chemistry) notes sustainable chemistry investments can simultaneously support decarbonization of chemical production as well as environmental justice through "detoxification" of chemistry. Similarly, the administration's high-profile *Bold Goals for US Technology and Biomanufacturing* report calls for the United States to produce at least 30% of its chemical demand, as well as 90% of recyclable-by-design polymers, via sustainable and cost-effective biomanufacturing pathways within 20 years—which will be nearly impossible to achieve without massive investments in sustainable chemistry. Sustainable chemistry investments can also play a role in ending and remedying the disproportionate impacts of pollution on marginalized communities, as outlined in the administration's Justice40 Initiative, while creating new economic opportunities for them.

Achieving these goals by transitioning to a safer and more sustainable chemical sector will require coordinated action across agencies and clear integration into priority administration programs. Specifically, the Qualifying Advanced Energy Project Credit (also known as 48C), the Department of Energy's Loan Programs Office, the $6 billion Industrial Demonstrations Program, and the Greenhouse Gas Reduction Fund are programs that could support commercial-scale sustainable chemistry manufacturing projects.

Considering chemistry's large footprint—which spans many federal agencies—and a decades-long transition timeline, a dedicated champion is needed to coordinate government action across agencies, the private sector, investors, research and education institutions, workers' organizations, and advocates. While the creation of the interagency strategy team is a good first step, it is insufficient given the range of agencies involved and the small number of people who have the broad cross-agency and cross-sectoral knowledge required. Only a comprehensive and highly coordinated approach across agencies and industrial sectors can simultaneously identify needs for safer and more sustainable alternatives; communicate with researchers, investors, and manufacturers; evaluate hazards from potential alternatives; and target funding, research, recognition, and incentive efforts to promote safer, more sustainable chemistries.

The National Nanotechnology Coordination Office provides an example of how a strong coordinating body can bring together federal and industry stakeholders to speed investment and advance broader societal goals while shaping an emerging sector. Similar strong federal coordination strategies have also been used in semiconductors and with the so-called climate czars who have coordinated climate change actions under the Obama and Biden administrations.

Importantly, a federal coordinating body could assimilate the emerging state and European policies, as well as market and investor demands for eliminating chemicals of concern and finding safer and more sustainable alternatives. For example, it is necessary to address scientific, market, and administration concern about contamination from PFAS, or "forever chemicals," with a coordinated response. Simply cleaning up PFAS contamination is not enough; these high-performing chemistries—which are now used for many essential purposes, from electronics to health care—must be quickly replaced with safer alternatives. Coordinating a rational substitution strategy while considering the evolving global regulatory landscape will take a deliberate, concerted effort; it cannot be left to chance or managed as a purely "environmental" issue. An executive branch coordinating body will be able to bring stakeholders and resources to bear on the complex challenges posed by a chemical transition and carry that work on across multiple presidential administrations.

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Finally, the sustainable chemistry strategy cannot rely entirely on voluntary commitments. Commercialization, adoption, and scale of sustainable chemistry solutions faces significant incumbency barriers as existing chemistry is optimized, capitalized, and integrated into complex supply chains. According to the International Monetary Fund, fossil fuels are directly subsidized at more than $1.3 trillion per year globally (or $7 trillion, if external costs are included), putting sustainable chemistry at a disadvantage. To be competitive, investments need to be linked to subsidies and incentives that accelerate pathways to market, adoption, and scale as well as policies that disincentivize business as usual.

For example, successes in decarbonizing US electricity production and electrifying the transportation sector over the past decade were driven primarily by federal tax credits that reduced the cost difference between new, cleaner technologies and incumbent technologies, as well as procurement guidelines that drove demand. A coordinated approach for sustainable chemistry that includes production or investment tax credits; incentives for adoption that ensure faster market approvals, recognition for demonstrated safety, or both; more sustainable chemicals and products; and federal procurement requirements would help drive investment in and adoption of safe and sustainable chemicals and materials.

Given innovation and capital cycles, transforming the chemical sector toward sustainable chemistry will require a clear and compelling strategic road map and coordination to pace actions over the decades needed to transition the industry. This road map must not be a purely aspirational document, but should outline a federal commitment to ambitious goals, establish strong market signals, and align finance, regulatory policy, and industrial strategies.

This sounds audacious, but today's generation of chemistries was launched in part by a similar program over the course of a few years during World War II. Just as rubber became increasingly necessary for the war effort, the United States lost access to 90% of its rubber suppliers in Southeast Asia. In response, President Roosevelt established the Rubber Reserve Program in 1940. As it became clear that stockpiling rubber supplies was insufficient, the program incentivized the creation of synthetic rubber and engaged the four largest rubber companies in the quest. By creating coordinating bodies to manage research and development across academia, industry, and government, the collaboration produced synthetic rubber—as well as what we now know as the petrochemical industry—within a few years. A similarly expedited all-of-government technology approach today could guide the development of a new generation of more resilient, equitable, and sustainable chemicals that addresses some of the nation's most pressing needs while launching new industries.

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