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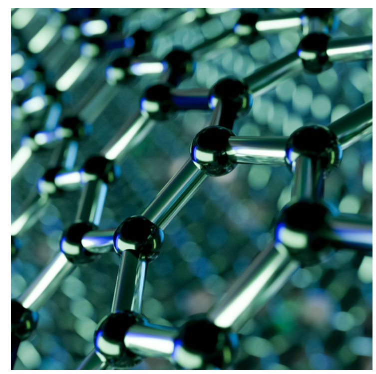
POLICY BRIEF

RECOMMENDATIONS FOR THE NEW ADMINISTRATION

Recommendations for Realizing the Full Potential of Nanotechnology and Carbon Nanotubes as the Energy Sector Transitions[1]

Rachel A. Meidl, LP.D., CHMM., Fellow in Energy and Environment

This brief is part of a series of policy recommendations for the administration of President Joe Biden. Focusing on a range of important issues facing the country, the briefs are intended to provide decision-makers with relevant and effective ideas for addressing domestic and foreign policy priorities. View the entire series at www.bakerinstitute.org/recommendations-2021.



INTRODUCTION

Nanotechnology is an emerging, rapidly growing, and promising field with advanced applications in industrial, commercial, and medical sectors and the ability to convey solutions that help the world meet global climate targets and sustainability goals. Carbon nanotubes (CNTs), a family of carbon-based hollow cylindrical structures with unique physicochemical properties, hold great promise for new materials with far fewer environmental and energy requirements. They have many potential use applications, including structural reinforcements that could displace or supplement steel, aluminum, and other metals, concrete, and plastics, decreasing the need for energy-intensive primary minerals and materials with high CO_2 footprints. CNTs are critical components for future decarbonization strategies. As society progresses toward a clean energy revolution, it will be imperative that the field of advanced nanomaterials have a clear and consistent path to commercialization shepherded by industry best practices, guided by informed life-cycle-based policies, and underpinned by a comprehensive, interdisciplinary research strategy. The distinctive electrical, thermal, and mechanical properties of CNTs will advance American leadership in innovation, energy, and environment, but there is a need to standardize, define, and communicate policy-driving information on their safe manufacturing, handling, use, and disposal; expedite commercialization of nanotechnology-enabled applications; support a skilled workforce; and ensure responsible development from lab to market and reuse.

CNTS, KNOWLEDGE GAPS, AND SUSTAINABILITY

Despite tremendous advancements in the field of nanotechnology and progress made in developing and implementing environmental, health, and safety (EHS) research-based protocols for addressing nano-safety issues, challenges remain. These include investigating health and toxicity effects given the many different

Nano-related EHS efforts should be a priority flagship theme for the NNI, with dedicated support and prolonged stable funding around this competency to begin closing the existing EHS knowledge and data gaps and to accelerate technology transfer to markets.

Appropriate investments in policy, safety, and standards that support nanotechnology EHS research and the transition to a lower-emissions future while meeting growing energy needs are vital to reestablishing climate leadership, attaining the global targets of the UN SDGs, and contributing to U.S. national security interests.

nanomaterial types and potential routes of exposure, nanomaterial classification issues, and limitations in research methodologies.[2]

Prior to full market integration and to attain public acceptance of CNTs, it will be imperative to consider critical components in order to achieve sustainability—the interaction of social, environmental, and economic elements. A clear set of guidelines, best practices, and standard operating procedures, formulated with input from academia, industry, and regulatory bodies, will greatly improve the public understanding and acceptance of CNTs and thus increase their commercial viability and sustainability.

U.S. INNOVATION AND COMPETITIVENESS IN NANO-RELATED EHS: REVISED AGENDA, REFOCUSED STRATEGY

China is significantly outperforming the U.S. in the number of scientific publications during the last decade. It is the largest contributor to the top 1% of most-cited papers related to nanoscience and nanotechnology,[3] and surpassed the U.S. in the total number of nanotechnology patents.[4] Further, basic nanoscience advances occurring in the U.S. are being translated into societal and economic benefits outside the nation, detracting from U.S. competitiveness and placing U.S. national security at risk.[5]

The National Nanotechnology Initiative (NNI) is a U.S. federal government program that serves as the central point of cooperation and collaboration for federal agencies engaged in the science, engineering, and technology of nanoscale research and development.[6] One of the main pillars of the NNI strategic plan is "[t]o support the responsible development of nanotechnology,"[7] with a program focus in "Environmental Health and Safety." EHS nanotechnology research is not keeping pace with product development, and policies are not keeping pace with technology and product improvements. Despite the criticality of EHS information, only a fraction of the NNI budget is dedicated to this category, and funding has been decreasing.[8]

The new administration should refocus the NNI and refine its scope to energy and environment initiatives, in line with national priorities. Nano-related EHS efforts should be a priority flagship theme for the NNI, with dedicated support and prolonged stable funding around this competency to begin closing the existing EHS knowledge and data gaps and to accelerate technology transfer to markets. Additionally, integrated R&D efforts that are interdisciplinary and coordinated (i.e., energy, environment, economics, social science, public policy, etc.) are another distinguishing feature shown to be effective in the nanotechnology framework of other leading countries. This multidisciplinary strategy will allow national capacity-building training and education to form a diverse, new generation of scientists and engineers who are cognitively adaptable in interdisciplinary fields.

Compounding the need for further clarity in nanotechnology is the recent decision in the European Union (EU) to place CNTs on a proposed list for consideration of banning.[9] The U.S. needs to reengage on the global stage to negotiate on the assessment of EHS factors and to help with the standardization and harmonization of classification and research methodologies that will guide safe and informed commercial developments of manufactured nanomaterials.

NANOTECHNOLOGY: PRIORITIZE ENERGY AND ENVIRONMENT

The transition to low-CO_2 or zero-CO_2 energy technologies is hampered by the fact that there are few suitable alternatives at scale for fossil fuels in the industrial or transportation sectors, which in 2017 accounted for nearly 60% of total energy consumption (representing 44% of global CO_2 emissions).[10] Unconventional processes that entirely eliminate the production of CO_2, such as the direct conversion of methane in natural gas to hydrogen and value-added carbon materials such as CNTs (otherwise known as methane pyrolysis), may be a path toward reducing emission sources and meeting rising energy demand without resulting in a complete overhaul of these sectors.[11]

If energy leadership, sustainability, and environmental stewardship are priorities for this administration, and governments and industry are being held accountable to United Nations (UN) Sustainable Development Goals (SDGs), any new energy technologies and innovations must require life-cycle obligations for nanomaterials that identify and quantify EHS, social, and economic impacts from cradle to grave. Current strategies do not account for sustainability outside of U.S. borders—they simply shift the risk to another part of the value chain, leaving those impacts unrealized. The U.S. should build policies that capture and quantify these impacts to understand the trade-offs and how a technology that is being sold as a solution behaves throughout its life, so that our actions do not reinforce weak governance and exacerbate local tensions and grievances beyond U.S. borders.

ESTABLISHMENT OF NNI CENTER OF EXCELLENCE "POLICY LAB"

The U.S. federal government, via the NNI, can serve as a clearinghouse and central repository of open-source scientific information, risks, benefits, and uncertainties related to EHS nanotechnology and devise new strategies for coordinating and communicating the tools, data, and information that will help shepherd the scientific community through expedient technology transfer and alleviate regulatory barriers to international trade and commerce. The new administration should establish a dedicated "policy lab" within the NNI that unites multidisciplinary experts from the social, political, and natural sciences with policymakers, public policy scholars, economists, business leaders, and other stakeholders to ground actions and policies in the best available science. The policy lab will bridge the gap between the realm of EHS nanomaterial science, technology, and theory and the world of action through policy and economics. Without addressing the many facets of policy, CNTs and other nanomaterials cannot reach their full potential.

CONCLUSION

The development of advanced CNT solutions and their resultant EHS and sustainability profiles must be a national and global priority in order to stimulate and support research and growth and for the U.S. to regain nanotechnology leadership. Appropriate investments in policy, safety, and standards that support nanotechnology EHS research and the transition to a lower-emissions future while meeting growing energy needs are vital to reestablishing climate leadership, attaining the global targets of the UN SDGs, and contributing to U.S. national security interests.

"Building back better" in America requires access to domestic sources of clean, affordable, and reliable energy. Unleashing these abundant domestic energy resources will require investment in next-generation nano-enabled technologies that will improve the resiliency and sustainability of the nation.

ENDNOTES

1. This policy brief is part of an expanded Baker Institute report. Meidl, Rachel A. 2021. *Recommendations for Realizing the Full Potential of Nanotechnology and Carbon Nanotubes in the Energy Transition.* Baker Institute Report no. 02.01.21. Rice University's Baker Institute for Public Policy, Houston, Texas.

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AUTHOR

Rachel A. Meidl, LP.D., CHMM, is the fellow in energy and environment at the Baker Institute. She was previously appointed deputy associate administrator for the Pipeline and Hazardous Materials Safety Administration, an agency of the U.S. Department of Transportation. Her research focuses on the intersection between domestic and international policy and law as it relates to the transboundary movement of hazardous wastes; upstream and end-of-life management of byproducts and wastes; and alternative and renewable energy, among other issues.

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