Energy & Manufacturing Competitiveness Partnership

Accelerate.

Turbocharging the Manufacturing Renaissance in an Era of Energy Abundance

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Council on Competitiveness

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Meeting the grand challenges—and even grander opportunities—of the 21st century demands an innovation-driven economy powered by a secure, sustainable, affordable energy portfolio and a robust, agile, advanced manufacturing sector.

America's ability to compete in and lead the global economy through this era of transformation hinges on bold, collaborative policy solutions leveraging America's total innovation ecosystem—industry, academia, labor and the national laboratories—at the heart of the nation's productivity and prosperity.

Table of Contents

Foreword

Following the success of two major initiatives exploring the U.S. economic opportunity in the energy and manufacturing spaces, the Executive Committee of the Council on Competitiveness (Council) recommended a new project be undertaken to merge these two policy streams and identify a set of recommendations that could ensure U.S. leadership founded on access to a diverse energy portfolio and the potential of an advanced manufacturing renaissance. Rising to the challenge were a tremendous set of leaders from among the Council membership who championed this effort, starting with the co-chairs: the Honorable Rebecca Blank, chancellor of the University of Wisconsin, Madison; Mr. Christopher Crane, president & CEO of Exelon Corporation; Mr. Jeff Fettig, chairman of Whirlpool Corporation; Dr. William H. Goldstein, director of Lawrence Livermore National Laboratory; and the Honorable Subra Suresh, former president of Carnegie Mellon University.

Consistent with the Council's mission to strengthen U.S. productivity, raise the standard of living for all Americans and expand global markets, its members and staff seek to constantly push the policy envelope, asking what's new on the horizon that holds the potential to either grow or inhibit U.S. prosperity. *Accelerate* captures the disruptions across the energy and manufacturing sectors and puts forth a road map for policymakers to follow that will allow the United States to lead, to capture value from new technologies and to prepare its citizens to prosper long term. The policy underpinnings of this effort will be a critical springboard for the launch of the National Commission on Innovation and Competitiveness Frontiers later this year.

Our thanks go out to the Council's members, its staff and the hundreds of experts who generously contributed their time to ensuring this report is both substantive and impactful.

Sincerely,

Samuel R. Allen
Chairman and Chief Executive Officer
Deere & Company

Mehmood Khan
Vice Chairman and Chief Scientific Officer
of Global Research and Development
PepsiCo, Inc.

Michael M. Crow
President
Arizona State University

Charles O. Holliday, Jr.
Chairman
Royal Dutch Shell plc

Deborah L. Wince-Smith
President & CEO
Council on Competitiveness

Letter from the Co-Chairs

In 2004, the Council sparked a national movement to "Innovate America," resulting in passage of the America COMPETES Act and a renewed commitment to U.S. creativity, entrepreneurship and global leadership in emerging technologies. Five years later, we declared "Energy is Everything" and embraced a broad portfolio of energy resources to power America's innovation engine. In 2012, the Council galvanized an American manufacturing movement centered around the nascent advanced manufacturing renaissance and its critical role to the vitality of the entire U.S. economy.

Today, America has entered a new frontier shaped by the tremendous opportunity of low-cost domestic energy abundance, the proliferation of game-changing disruptive technologies and the availability of powerful tools from supercomputers to 3D printers to futuristic biomanufacturing processes. And the Council is leading once again.

In *Accelerate*, we are pleased to share with you the critical findings and recommendations of the Energy and Manufacturing Competitiveness Partnership (EMCP). Led by a C-suite Steering Committee comprising leaders from industry, academia, labor and the national laboratories, the EMCP brought together more than 300 experts and practitioners to assess the economic opportunity at the nexus of energy and manufacturing and define a national policy agenda to catalyze the U.S. manufacturing renaissance. Through the leadership of several Steering Committee members, the EMCP approached America's diverse industrial landscape not as a monolith, but as a network of distinct but interdependent sectors, each with its own challenges and opportunities.

Through six diverse regional sector studies encompassing bioscience, advanced materials, water, agriculture, energy and aerospace, the EMCP explored how cross-cutting factors play out within each sector, identified discrete factors shaping each sector and assessed common threads that span the economy. One such thread that wound itself inextricably throughout every sector was the promise and pitfall of cybersecurity. At the direction of the Steering Committee a related, but separate policy effort was undertaken to develop a national agenda for cybersecurity and a companion report accompanies this one.

Importantly, *Accelerate* presents a road map of concrete actions from investments in research to regulatory experimentation to educational innovation. And it calls upon all stakeholders in the economy to engage and leverage the seminal opportunity the current landscape has created and catalyze a new wave of productivity and prosperity.

Looking forward, the work of the EMCP provides an important foundation upon which the Council's National Commission on Innovation & Competitiveness Frontiers can build. Formally launching later this year, the Commission will continue the Council's thought leadership, pushing the policy envelope to capture the economic potential of emerging technologies and America's ever evolving innovation ecosystem.

We thank the private and public sector leaders and experts for their support and contributions and look forward to working together to build a more prosperous, productive and secure America.

Sincerely,

Christopher Crane
President & CEO
Exelon Corporation

Rebecca Blank
Chancellor
University of Wisconsin—Madison

William H. Goldstein
Director
Lawrence Livermore National Laboratory

Executive Summary

For more than two centuries, American industry has harnessed the nation's abundance of natural resources, energy, talent and ingenuity to power and unleash the most productive economy in the world.

Dramatic shifts spurred by globalization, recession, regulatory and tax trends, ascendant and increasingly advanced industrial activity across Europe and Asia and accelerating changes in consumer demand have buffeted America's industrial and manufacturing enterprises, threatening America's place as a global superpower. Yet today, America finds itself facing a new, promising frontier shaped by two powerful transformations working in tandem:

- The generational re-emergence of advanced and highly productive manufacturing capacity in the United States; and
- The increasing abundance of innovative, sustainable, affordable and domestically-sourced energy.

To capitalize on this convergence, the Council on Competitiveness (Council) launched the Energy and Manufacturing Competitiveness Partnership (EMCP) in 2015, which leveraged more than a decade of leadership in the energy and manufacturing fields that began with the seminal National Innovation Initiative (NII) in 2003 and continued most recently with the Energy Security, Innovation and Sustainability Initiative (ESIS, 2007–2009), the U.S. Manufacturing Competitiveness Initiative (USMCI, 2010–2011) and the American Energy and Manufacturing Competitiveness Partnership (2012–2016). The EMCP, a C-suite-directed initiative, focused on the shifting global energy and manufacturing landscape and how energy transformation and demand are shaping industries critical to America's prosperity and security.

Over a span of three years, the Council executed an ambitious roadmap to focus national attention on the intersection of the energy and manufacturing transformations. Recognizing the tremendous innovation and changing landscape across the manufacturing sector, from 3D printing to the proliferation of sensing devices and the use of advanced modeling and simulation tools, the EMCP was designed to approach the country's diverse industrial landscape as a network of distinct but interdependent productive sectors, each with its own challenges and opportunities. Through a series of sector studies hosted around the nation by members of the Steering Committee, the EMCP identified the salient questions and challenges facing the energy-manufacturing nexus within key sectors of the economy. Seeking input from leaders throughout the private sector, academia, the research and scientific community, NGOs and government, each of the six sector studies looked at how decision-makers can bolster the critical pillars of competitiveness-technology, talent, investment and infrastructure.

The picture painted by these sector studies is, from one perspective, bleak.

- The United States is plagued by outdated regulatory and physical infrastructure that is failing to keep pace with innovation in sectors from materials to aerospace and beyond.

- The absence of a coordinated, defined research agenda to guide insufficiently-funded research and development is limiting the potential for advancement in key sectors such as bioscience.
- Science has a perception problem that can only be combatted through increased scientific literacy.
- The skills gap is growing, and will continue to get worse as workforce demographics shift.
- And, while all this is happening at home in the United States, global competition is ramping up as countries around the world realize the advantages of investing in a strong innovation ecosystem.

Yet, the United States is not without its strengths. American innovators—icons of industry, brilliant scientists and engineers, and everyday geniuses—continue the nation's 150-year legacy of reshaping entire industries, the marketplace and the world with breakthrough technologies, products and services. Hundreds of renowned research institutions and national laboratories keep the United States at the forefront of knowledge creation and on the cutting edge of game-changing technologies. The nation's culture of entrepreneurship, risk-taking and creativity—stoked by venture capital—is unmatched around the globe. Additionally, America's transition from energy dependence to energy abundance is of unparalleled promise.

Wise policies and practices, in many cases, could unleash these American strengths, boost manufacturing engines and raise technology commercialization to new heights, driving U.S. economic growth and job creation. Developing next-generation physical and regulatory infrastructure to support the nation's advanced energy and manufacturing enterprise will build the foundation upon which America's economy can thrive and compete. Fueling the innovation and production economy from idea to implementation will allow for increased industrial productivity as the United States reaffirms its leadership in new knowledge creation and its end-use application. Moreover, catalyzing the power and potential of the American worker to thrive in an advanced manufacturing economy will enable the advanced technology-based economy of the next decade to provide higher-paying jobs for American families.

"The United States stands at an economic inflection point where we can either seize the opportunity in front of us or watch others take the lead in critical sectors from AI to big data to additive manufacturing."

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness

These key challenges, opportunities and recommendations discussed throughout sector studies on water and manufacturing, advanced materials, bioscience, agricultural and consumer water use, energy and aerospace—along with findings from a three-dialogue series on American cybersecurity—underpin this report and are the foundation for the Council's call to action.

The recommendations in this report—and the over ten years of work they encompass—have the power to turbocharge America's manufacturing capabilities, improve America's competitiveness and unleash a new wave of productivity, prosperity and resilience for all Americans.

Call to Action

Building upon more than a decade of work on energy and manufacturing policy as key enablers of U.S. productivity, prosperity and security, the Council on Competitiveness in 2015 launched the Energy and Manufacturing Competitiveness Partnership (EMCP). Led by a C-suite group from industry, academia, labor and the national laboratories, the EMCP approached America's diverse industrial landscape not as a monolith, but as a network of distinct yet interdependent sectors, each with its own challenges and opportunities.

Through six sector studies, the EMCP explored how cross-cutting factors play out within each sector, identified discrete factors shaping each sector and assessed common challenges and opportunities that span across the economy—most prominently, cybersecurity, which was explored in-depth through three regional dialogues across the country.

Based on the Council's decade-long leadership and the learnings of the EMCP, this call to action constitutes a national policy agenda to drive America's future energy and manufacturing competitiveness. If implemented, this agenda would turbocharge the U.S. manufacturing renaissance and drive economic prosperity for the nation and for all Americans.

Develop next generation physical and regulatory infrastructure to support the nation's advanced energy and manufacturing enterprise.

1. **Create a modern, enabling regulatory infrastructure to keep pace with innovation and spur economic growth.**
   - 1.1. Encourage state and local governments to continue experimenting with new regulatory frameworks to test and evaluate the viability of disruptive technologies, from autonomous vehicles to next-generation nuclear power.
   - 1.2. Review federal regulations to avoid redundancy and ensure states and other entities have the flexibility to propose and implement innovative regulatory models and explore new technologies needed to enable the advanced energy and manufacturing enterprise.
   - 1.3. Make permanent Executive Order 13771 requiring that, subject to a rigorous cost/benefit analysis, two regulations be eliminated before a new regulation can be promulgated.
2. **Break the cycle of incremental infrastructure improvements to spur creative and forward-looking approaches to the movement of goods, services and people.**
   - 2.1. Substantially increase federal and state investment in U.S. infrastructure to repair and modernize the roads, airports, rails and water systems upon which the economy relies.
   - 2.2. Dedicate a percentage of federal infrastructure funding to leapfrog demonstration projects that leverage next-generation technologies, obviating the "patch and repair" cycle of current infrastructure spending.
   - 2.3. Create partnerships between industry and local governments to develop and propose innovative infrastructure models that support next generation energy and transportation initiatives.
3. **Bring the United States energy market infrastructure and regulatory ecosystem into the 21st century.**
   - 3.1. Secure U.S. leadership and investment in nuclear technology by leveling the regulatory playing field, ensuring adequate funding for basic nuclear research and increasing support for nuclear engineering degree programs.
   - 3.2. Modernize the electric grid by reforming state regulations to allow utilities to depreciate outdated equipment more quickly.
   - 3.3. Catalyze innovation in the utility sector by allowing utilities to recoup a percentage of investments in R&D through rate increases.

Fuel the innovation and production economy from idea to implementation.

4. **Reaffirm U.S. leadership in new knowledge creation and better align research efforts to meet the grand challenges facing the nation and the world.**
   - 4.1. Increase federal investment in research and development across all agencies at a consistent, predictable rate with an overall target of one percent of GDP.
   - 4.2. Under the direction of the Science Advisor to the President, align the national research agenda with industrial grand challenges and prioritize disruptive technologies with high potential for economic and societal impact.
5. **Capture the value of investments in research by supporting and accelerating the development of advanced technologies in the United States.**
   - 5.1. Increase federal and state support for regional technology test beds, such as the Manufacturing USA institutes.
   - 5.2. Incentivize technology transfer and partnerships between national laboratories, universities and businesses by streamlining intellectual property agreements, considering industry collaboration as part of promotion and tenure decisions, and clarifying that industrial partnerships with national labs are consistent with their mission.
   - 5.3 Close the valley of death in private sector financing to enable startup to scale-up.
6. **Leverage and secure the Internet of Things to drive industrial productivity.**
   - 6.1. Incentivize the use of sensors and monitoring equipment for energy and water usage in public and private sector facilities at the state and local level through tax credits and other mechanisms.
   - 6.2. Encourage greater uptake and use of standardized criteria, such as the UL Cybersecurity Assurance Program to increase supply chain security.
   - 6.3. Require that all new technology applied to the electric grid meet widely-accepted security standards to build cyber resilience.
7. **Extrapolate insight and value from the data tsunami.**
   - 7.1. Create a federal verification system for crowdsourced data to enhance the validity and usefulness of knowledge databases across multiple sectors.

Catalyze the power and potential of the American worker to thrive in an advanced manufacturing economy.

8. **Develop a workforce capable of succeeding in the hyper-connected, cross-disciplinary, advanced technology-based economy of the next decade.**
   - 8.1. Integrate technical training into K-12 education, including industrial arts programming, to build a better base of technological understanding by all Americans.
   - 8.2. Strengthen the lifetime linkages between universities and graduates to enable lifelong learning opportunities.
   - 8.3. Develop a multi-stakeholder public awareness campaign to increase scientific literacy.
9. **Facilitate greater collaboration, interaction and exchange between industry and secondary and higher education institutions to spur partnerships and highlight workforce opportunities.**
   - 9.1. Reduce state and education institutional barriers to allow more practitioners into the classroom and to inspire the next generation of advanced manufacturing workers.
   - 9.2. Encourage industry partnerships with educational institutions to enable practitioners to engage with students in K-12 and higher education.
10. **Implement the Council on Competitiveness National Cyber Agenda**
    - 10.1. See appendix A

Setting the Stage

Throughout history, the great leaps in productivity and prosperity at the heart of national competitiveness have come through the emergence, adaptation and adoption of new processes, materials and technologies. Innovation—the intersection of invention and insight, leading to the creation of social and economic value—is the life-blood of the global economy and the catalyst behind these trends. Innovation is deeply embedded in America's DNA. From birth, the United States has been fundamentally about exploration, opportunity and discovery; about new beginnings; about setting out for the frontier.

When the Council began to explore the energy and manufacturing nexus back in 2007 through its Energy Security, Innovation and Sustainability Initiative, the world looked very different. Energy consumption was rising exponentially, driven by worldwide population growth, swiftly developing economies, improving global living standards and the burgeoning use of ever more energy-dependent technologies. America's growing dependence on imports to meet energy needs had become a major factor in the trade deficit, accounting for more than 45 percent, while dependence on foreign oil translated into an outflow of $439 billion dollars annually. At the same time, the growing dependence on foreign sources of natural gas and petroleum was posing a serious challenge to U.S. national and economic security, and private sector leaders were beginning to embrace the imperative for sustainability and transition to a low-carbon world.

Today, America finds itself facing a new, promising frontier shaped by two powerful transformations working in tandem:

"Lower cost, clean and abundant energy from multiple sources have enabled the United States to recapture momentum in the manufacturing sector. We must make sure policy keeps pace to allow the U.S. to capture maximum value from this new reality."

Mr. Christopher Crane
President & CEO
Exelon Corporation

- The generational re-emergence of advanced and highly productive manufacturing capacity in the United States; and
- The increasing abundance of innovative, sustainable, affordable and domestically-sourced energy.

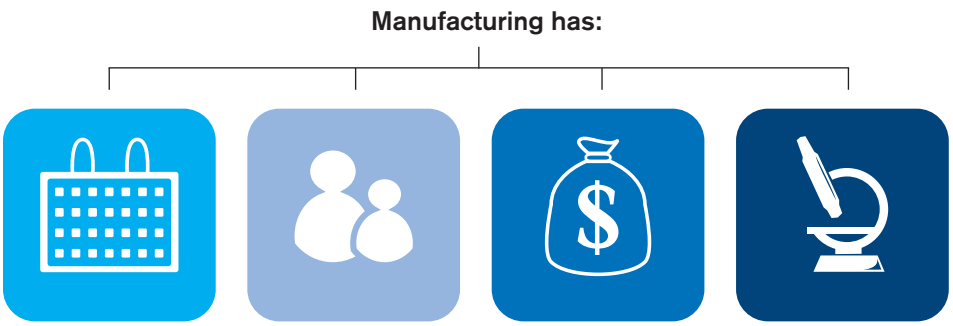
The ability to capitalize on these transformational shifts will be paramount for American competitiveness, now and in the decades to come.

The Manufacturing Engine

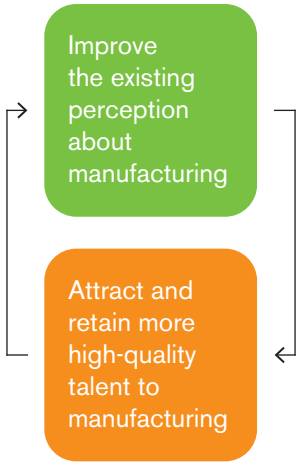
The U.S. manufacturing sector remains the nation's primary driver of research and development, the largest employer of science and engineering graduates in the country and a central catalyst for technology innovation throughout the economy. Manufacturing remains critical to the American economic prosperity and the future of U.S. global competitiveness. As a sector, manufacturing con-

Figure 1. Addressing the Manufacturing Skills Gap: Sharing the Good News to Attract and Retain Top Talent

Source: Deloitte and the Manufacturing Institute. *A Look Ahead: How Modern Manufacturers Can Create Positive Perceptions with the U.S. Public.*



The virtuous cycle of improving the existing image and recruiting the best talent can help reshape the U.S. manufacturing industry and better enable it to compete in the fast-paced, innovative and transformative times.



tributes approximately 11.6 percent of U.S. GDP,[1] and employs more than 12 million people directly in addition to supporting 5.4 million more jobs indirectly.[2] As Figure 1 highlights and the Council's *Make* report made clear, manufacturing jobs are no longer dirty, dumb, dangerous and disappearing, but are high-tech, high-paying and highly sought after positions at the forefront of the U.S. manufacturing resurgence. The effect of this sector's job creation is reflected in the decreasing unemployment rate in the United States over the last several years. Lowering the 2010 unemployment rate from 8.6 percent to 5 percent would have required the creation of 21 million jobs. Today, the U.S. unemployment rate hovers around 4 percent—in large part due to the growth of the manufacturing sector. In addition to its tremendous job creation power, the manufacturing sector adds $1.34 in output from other sectors for every dollar in final sales of manufactured products—the largest multiplier of any sector.[3]

1 Gross Domestic Product by Industry: First Quarter 2018, Bureau of Labor Statistics and Bureau of Economic Analysis.

2 Bureau of Labor Statistics, Employment by Major Industry Sector, October, 2017.

3 Facts About Manufacturing, Manufacturing Institute, MAPI, National Association of Manufacturers.

A Transformation in Production

Today, U.S. manufacturing stands at a critical juncture. A deep and disruptive transition in U.S. manufacturing has taken place since 2000, with more than 60,000 American factories, companies and almost 5 million manufacturing jobs lost from 2001 to 2014.[4]

However, particularly since the Great Recession, the pendulum has started to swing back in the direction of the United States. Wages overseas are rising; for example, labor costs in China more than quadrupled from 2004 to 2016.[5] The shale oil and gas boom has given many American producers a critical cost advantage. Meanwhile, according to the *Global Manufacturing Competitiveness Index*, a joint effort with Deloitte, industry executives now rank the U.S. at No. 2 globally for manufacturing competitiveness, only behind China, and trending up during the past decade.

At the same time, U.S. manufacturing is in the midst of an ever-evolving digital disruption. The physical and digital worlds are converging across numerous dimensions through sensors, networks, additive manufacturing and a data tsunami. Sensing and computing across natural, built and social environments are generating data at unprecedented scale, complexity and speed.

In production alone, companies will have the ability to better understand the operation of every machine and device, the cut of every blade, every movement of material and the consumption of energy minute by minute. Virtual design through modeling and simulation using advanced computing will accelerate innovation and product development, while dramatically reducing costs and risks.

Autonomous systems are advancing rapidly. Applications such as drones and driverless vehicles are being applied in factories to detect and react to problems, enabling the adaptation of machinery and systems to changing conditions. This is a productivity revolution in the making. Investments in smart manufacturing could generate cost savings and productivity gains worth $10-$15 trillion in global GDP over the next 15 years—that is almost as big as the U.S. economy.

Decoupling Energy from Growth

Interestingly, American economic growth is picking up steam without a parallel increase in energy consumption. Since 2008, primary energy usage has shrunk 1.7 percent, even as GDP has accelerated by 15.3 percent (see Figure 2).[6] This occurrence of economic growth without a corresponding increase in energy consumption is consistent with a long-term decoupling trend the United States has seen during the past 20+ years. From the years 1950-1990, demand for electricity increased annually at an average rate of 5.9 percent. However, this pattern took a dramatic turn from 1990 through 2007, when the demand for electricity dropped to 1.9 percent growth per year. Since 2007, however, the United States has seen a contraction in electricity demand per year by an average rate of 0.2 percent. And in 2017, energy usage shrunk 1.7 percent while U.S. GDP increased by 15.3 percent.[7]

4 *Statistics of U.S. Businesses*, The United States Census Bureau, 2015 (accessed September 2018).

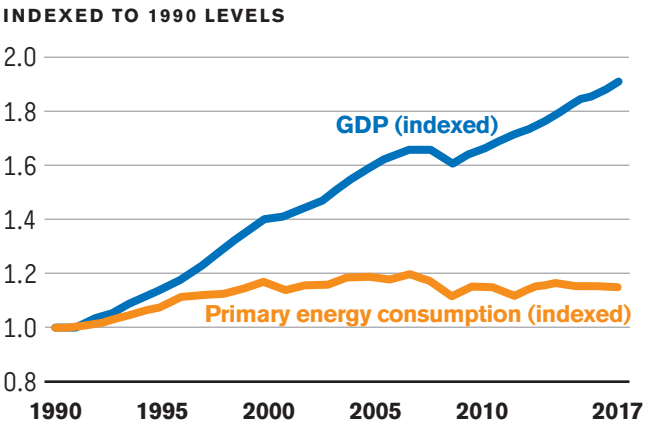
5 Bank of America Merryl Lynch Global Research, January 14, 2016.

6 *2018 Sustainable Energy in America Factbook*, Bloomberg, 2018.

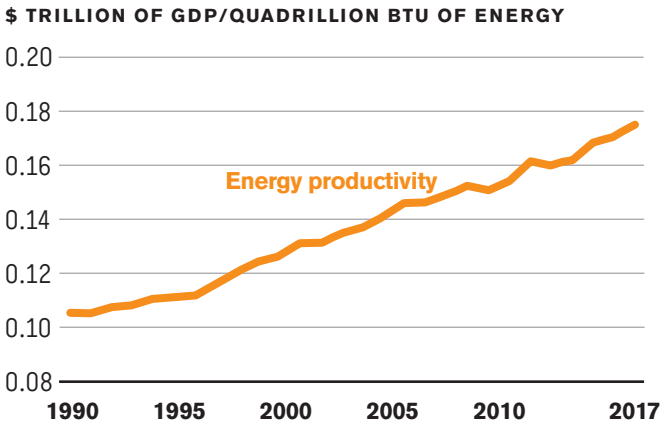
7 ibid.

Figure 2.
Source: Bureau of Economic Analysis, EIA, Lawrence Berkeley National Laboratory, BNEF.

U.S. GDP and Primary Energy Consumption



U.S. Energy Productivity



This decoupling of economic growth from energy use can be attributed to a variety of factors, including an increase in energy productivity—doing more with less—generating greater economic well-being for the amount of energy used, and improving living standards and quality of life.[8] In response to a presidential call to action and in recognition of the importance of energy productivity to American competitiveness, the Council in 2014 partnered with the U.S. Department of Energy and the Alliance to Save Energy to launch a series of public dialogues and executive roundtables to raise awareness, galvanize support and develop the strategies necessary to double the United States' energy productivity by 2030. The outcome, *Accelerate Energy Productivity 2030: A Strategic Roadmap for American Energy Innovation, Economic Growth and Competitiveness*, put forth a plan to achieve significant growth in energy productivity—which, because of this and related work, is largely being realized today.

Another factor that has contributed to the weakened correlation between economic growth and energy usage is the increase in energy-efficient technologies, processes and practices. This transformation has been driven in large part by the availability of low-cost natural gas, which is three times more efficient than electricity in providing energy for end-use applications and has increased exponentially as a share of total energy used in U.S. manufacturing. In fact, natural gas comprised nearly 40 percent of all energy consumed by the industrial sector in 2015—up almost 10 percent from 2006.[9]

8 *Accelerate Energy Productivity 2030*, U.S. Department of Energy, Council on Competitiveness and the Alliance ot Save Energy. September 16, 2015.

9 *U.S. Primary Energy Consumption by Source and Sector*, U.S. Energy Information Administration, 2017.

A Changing Energy Mix

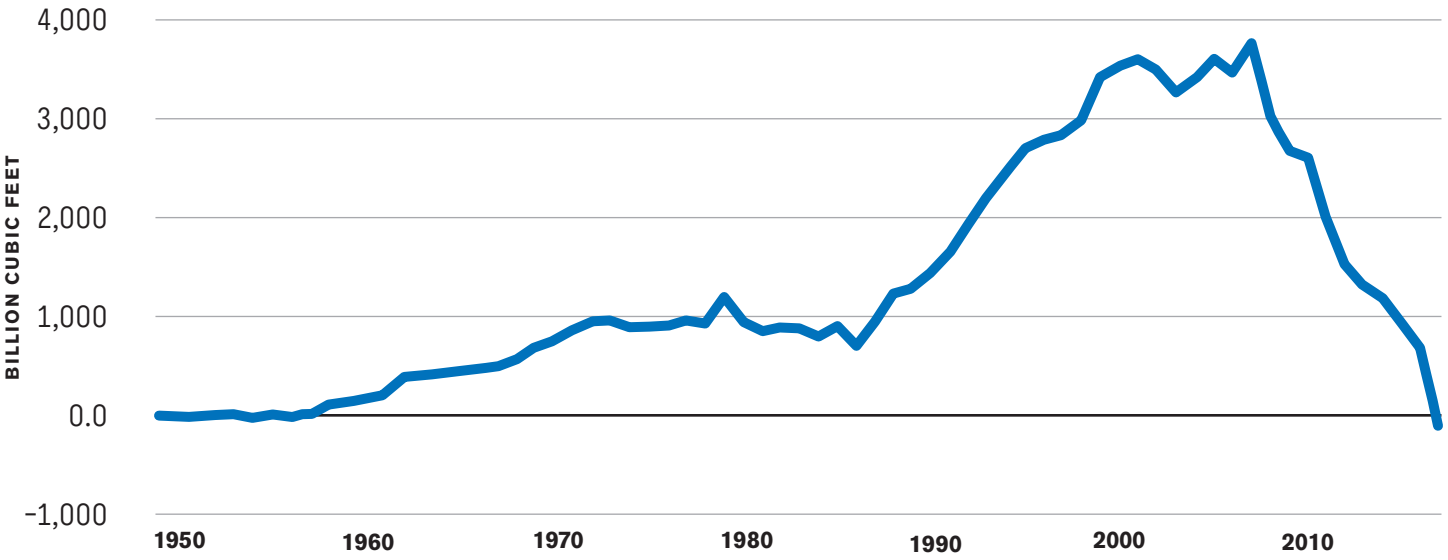
Historically, industrial power prices in the United States have been among the most affordable in the world—second among the G7 nations only to Canada.[10] Even as exchange rates have brought down the dollar cost of energy for consumers in China, Japan and Mexico, U.S. energy costs remain competitive, with prices nearly half as low as Japan and Germany. And as the energy mix in the United States continues to shift away from its former reliance on fossil fuels, corporations and state and federal governments are increasingly driving the energy transformation, demanding cleaner energy and seeking to capture gains from energy efficiency.

Meanwhile, the legacy coal and gas-supported electric grid is under tremendous strain due to increasingly diverse energy sources coupled with environmental instabilities and extreme weather phenomena and volatility. American advanced manufacturing requires a reliable, resilient, diverse and flexible energy mix that encourages efficiency and supports the opportunity for investment in new technologies that benefit Americans, underpin national security needs and convey competitive global advantage to U.S. businesses.

From Scarcity to Abundance

Concurrent with the divergence between energy use and economic growth, the United States solidified its role as a global exporter of liquefied natural gas in 2017 when, for the first time, it became a net exporter—rather than importer (see Figure 3)—of natural gas in each month of the year.[11] Enabled largely by a 7.2 percent decline in the amount of

Figure 3. Natural Gas Imports
Source: U.S. Energy Information Administration



10 *2018 Sustainable Energy in America Factbook*, Bloomberg, 2018.

11 ibid.

natural gas used to generate gas-fired power, domestic gas demand decreased by 2.8 percent year-on-year. The growth in foreign demand for liquified natural gas occurred at the same time as this growth in efficiency, allowing the United States to become a net exporter of natural gas. The United States currently exports liquified natural gas to 25 countries, with its primary importers being Mexico, South Korea, China and Japan.[12]

But natural gas is just one piece of America's energy puzzle. Nuclear power, for example, is an important part of the energy sector and provides another clean, viable energy alternative. In the past thirty years, operating capacity in nuclear power plants increased from 60 percent to over 90 percent.[13] Yet even with this marked increase, regulatory barriers hinder the nuclear industry from reaching its full potential. A recent study by the Nuclear Energy Institute (NEI) found that oil, gas, hydro, solar, wind and biomass received more than 90 percent of all economic incentives—tax policies, regulation, research and development, market activity, government services and disbursements—provided to the energy industry since 1950.[14] And while the government has supported nuclear energy development through research and development programs, over the last twenty years, federal spending on research and development for coal and renewables has exceeded funding allocated to the nuclear industry. Throughout a recent six year period alone (2011–2016), renewable energy obtained more than 27 times more federal aid in incentives than nuclear energy. Maintaining America's leadership position in nuclear technology and innovation is essential for economic competitiveness in the global energy market.

The stage is set for the United States to leverage these transformations in energy and manufacturing through a comprehensive public and private sector strategy that capitalizes on the nation's unparalleled competitive assets. An America that operates in a 21st century infrastructure—with a high-skilled workforce and access to the capital needed to grow and scale entrepreneurial businesses—has the potential become the catalyst for a new wave of productivity and prosperity and to usher in a low-carbon world.

12 *2018 Sustainable Energy in America Factbook*, Bloomberg, 2018.

13 *Nuclear Power in the USA*, World Nuclear Association, August 4, 2017.

14 *Analysis of U.S. Energy Incentives–1950-2016*, Nuclear Energy Institute, 2017.

A Decade of Leadership in Energy and Manufacturing

The EMCP builds upon and merges more than a decade of leadership in the Council's energy and manufacturing work streams, including most recently the Energy Security, Innovation and Sustainability Initiative (ESIS, 2007–2009), the U.S. Manufacturing Competitiveness Initiative (USMCI, 2010–2011) and the American Energy and Manufacturing Competitiveness Partnership (2012–2016).

Each of these initiatives sought to navigate the ever-evolving currents of national and global economies punctuated by technological, demographic and financial disruptions. In 2008, the goal was energy security rather than independence, interest rates were headed to near zero and the potential economic impact from technologies like artificial intelligence were more theoretical than quantifiable. Today, the United States is an energy exporter, the Federal Reserve is raising rates in the face of full employment and rising inflation and AI is projected to be a trillion-dollar industry. The Council's policy efforts have adapted, as well.

Energy Security, Innovation & Sustainability Initiative

In July 2007, the Council launched the ESIS Initiative in recognition of the critical linkages among these three issues and their profound impact on future U.S. productivity, standard of living and global market access. The genesis for the initiative was the Council's 2004 groundbreaking report of the National Innovation Initiative (NII), *Innovate America*. The NII recognized energy security as a significant challenge on the horizon—one that, if left unaddressed, could undermine America's competitiveness in the years ahead (see Appendix B).

Drawing upon more than a year's work of inquiry and real-time research and analysis, in anticipation of the 2008 change in administration, the Council issued *Prioritize: A 100-Day Energy Action Plan for the 44th President of the United States* in September 2008. The plan identified six "pillars" as integral to U.S. energy transformation and as top priorities for presidential action upon taking office:

- Setting the global bar for energy efficiency;
- Assuring access to clean and competitive energy;
- Jumpstarting energy infrastructure investments;
- Spawning technological breakthroughs and entrepreneurship;
- Mobilizing a world-class energy workforce; and
- Clearing obstacles to a national transmission superhighway.

At that time, the Council stressed that the action plan recommended in *Prioritize* marked the beginning, not the end, of a concerted commitment to ensuring the United States achieves energy security in a sustainable manner, while driving the competitiveness of its workers, industries and economy.

Following *Prioritize*, the Council released *Drive: A Comprehensive Roadmap to Achieve Energy Security, Sustainability and Competitiveness* at the 2009 National Energy Summit in Washington, D.C. *Drive* built upon the energy action plan in *Prioritize* and set forth the next set of integrated building blocks for America's energy transformation, sustainability and competitiveness in a low-carbon world (see Figure 4). The recommendations presented in *Drive* sought to unleash a new era of American innovation, create new industries, revitalize and re-build manufacturing jobs across the nation, keep and grow high-skilled jobs for this generation and the next, and accelerate economic prosperity for all Americans.

Figure 4. *Prioritize* and *Drive* Recommendations

***Prioritize* Pillar**	***Drive* Recommendation**
1. Setting the Global Bar for Energy Efficiency	Reward Efficiency
2. Assuring Access to Clean and Competitive Energy	Use It All and Price It Right
3. Jumpstarting Energy Infrastructure and Manufacturing Investments	Capitalize Growth and Make it Here
4. National Transmission Superhighway and Smart Grid	Build It Fast and Smart
5. Spawning Technological Breakthroughs and Entrepreneurship	Discover the Future and Break the Technology Barriers
6. Mobilizing a World-Class Energy Workforce	Bridge the Skills Gap and Train the Talent

Prioritize and *Drive* laid out the prerequisites that must be met to be successful in developing and deploying large-scale sustainable energy solutions worldwide. Additionally, *Drive* set forth, in its comprehensive roadmap building upon the six pillars, specific recommendations that, if implemented, would achieve the trifecta of simultaneously promoting America's economic competitiveness, enhancing national security and improving the global environment (see Appendix C).

U.S. Manufacturing Competitiveness Initiative

Building on the heritage of the NII, the Council also identified manufacturing as an issue critical to the preservation and growth of U.S. innovation capacity.

In June 2010, the Council launched the U.S. Manufacturing Competitiveness Initiative (USMCI) to begin a new dialogue on the policies and practices necessary to ensure the long-term success of American manufacturing. Over two years, this initiative identified critical research, innovation and policy trends contributing to the re-emergence of America's high-value, advanced and productive domestic manufacturing sector.

The USMCI culminated in the report *Make: An American Manufacturing Movement* that identifies key trends and offers solutions that enable manufacturing to strengthen America's competitiveness, stan-

National Innovation Initiative

The National Innovation Initiative (NII) began in 2003 as a multi-year effort engaging hundreds of leaders across the country and from all walks of life to optimize the entirety of American society for a future in which innovation is the single most important factor in shaping prosperity.

In 2004, more than 500 leaders from around the world attended the National Innovation Summit in Washington, D.C., where the Council released the landmark report, *Innovate America: Thriving in a World of Challenge and Change*.

Innovate America defined innovation as the intersection of invention and insight, leading to the creation of social and economic value, and called for America to "innovate or abdicate." The groundbreaking agenda put forth in the report includes more than 60 detailed recommendations grouped under the innovation platforms: talent, investment and infrastructure.

In August 2007, President George W. Bush signed the America COMPETES Act into law, which finds its roots in *Innovate America* and in the work of the Council's National Innovation Initiative.

Along with the America COMPETES Act, the NII would underpin the next 15 years of Council policy leadership and forms the base upon which this report is built.

Talent	Investment	Infrastructure
Build a National Innovation Education Strategy for a diverse, innovative and technically-trained workforce	Revitalize Frontier and Multidisciplinary Research	Create National Consensus for Innovation Growth Strategies
Catalyze the Next Generation of American Innovators	Energize the Entrepreneurial Economy	Create a 21st Century Intellectual Property Regime
Empower Workers to Succeed in the Global Economy	Reinforce Risk-Taking and Long-Term Investment	Strengthen America's Manufacturing Capacity
		Build 21st Century Innovation Infrastructures—the health care test bed

COUNCIL CHAIRMEN

Mr. F. Duane Ackerman, Chairman & CEO, Bell South

Mr. Charles O. Holliday, Jr., Chairman & CEO, DuPont

2003 2004 2005 2006 2007 2008 2009 2010

The Energy Security, Innovation & Sustainability initiative, led by Mr. James Owens, former Chairman and CEO of Caterpillar, Inc.; Mr. D. Michael Langford, National President of the Utility Workers Union of America; and the Honorable Shirley Ann Jackson, President of Rensselaer Polytechnic Institute, united industry, labor and academia to present a blueprint for America's energy future to the private sector and to the incoming president ahead of the 2008 election.

Energy Security, Innovation & Sustainability initiative

National Innovation Initiative

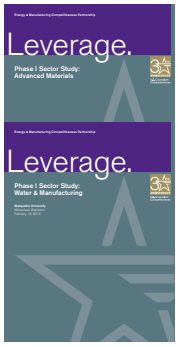
The National Innovation Initiative, co-chaired by Mr. Samuel J. Palmisano, Chairman and Chief Executive Officer, IBM Corporation and Dr. G. Wayne Clough, President, Georgia Institute of Technology, presented a National Innovation Agenda that has been put to action in many ways and underpins the America COMPETES Act signed into law by President George W. Bush in 2007.

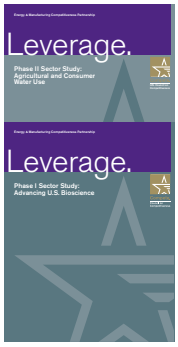
U.S. Manufac

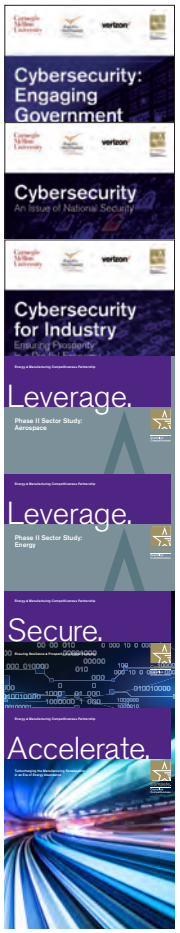
Mr. Samuel R. Allen, Chairman & CEO, Deere & Company

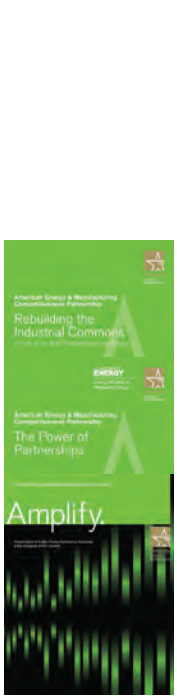
2011	2012	2013	2014	2015	2016	2017	2018

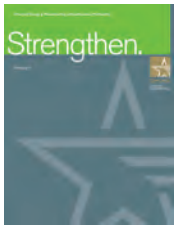
Energy & Manufacturing Competitiveness Partnership











American Energy & Manufacturing Competitiveness Partnership

U.S. Manufacturing Competitiveness Initiative

At the vanguard of the movement to build an American manufacturing renaissance, the U.S. Manufacturing Competitiveness Initiative—led by Dr. Susan Hockfield, former President of MIT; Dr. George Miller, former Director of Lawrence Livermore National Laboratory; and Mr. James Quigley, former CEO of Deloitte LLP, established an ambitious agenda to bolster America's manufacturing sector—an agenda which continues to inform public policy in and beyond Washington.

dard of living and national security. *Make* put forth a comprehensive agenda to solve five critical challenges facing American manufacturing:

- Fueling the innovation and production economy from start-up to scale-up;
- Expanding U.S. exports, reducing the trade deficit, increasing market access and responding to foreign governments protecting domestic producers;
- Harnessing the power and potential of American talent to win the future skills race;
- Achieving next-generation productivity through smart innovation and manufacturing; and
- Creating competitive advantage through next generation supply networks and advanced logistics and infrastructure.

As a part of the USMCI effort, the Council, in partnership with Deloitte, created the *Global Manufacturing Competitiveness Index (GMCI)*, which reflects the views of more than 400 senior manufacturing executives worldwide. The GMCI, conducted first in 2010 and then again in 2013 and 2016, found that in order to succeed in the rapidly evolving global manufacturing landscape, companies will need to embrace a targeted approach to some of the key elements of manufacturing competitiveness, including: ensuring talent is the top priority; embracing

Call to Action: Five Challenges and Solutions to Make an American Manufacturing Movement
See full text in Appedix D, page 76.

1. **Challenge:** Fueling the innovation and production economy from start-up to scale-up

   Solution: Enact fiscal reform, transform tax laws and reduce regulatory and other structural costs and create jobs.

2. **Challenge:** Expanding U.S. exports, reducing the trade deficit, increasing market access and responding to foreign governments protecting domestic producers.

   Solution: Utilize multilateral fora; forge new agreements; and advance IP protection, standards and export control regimes to grow high-value investment and increase exports.

3. **Challenge:** Harnessing the power and potential of American talent to win the future skills race.

   Solution: Prepare the next generation of innovators, researchers and skilled workers.

4. **Challenge:** Achieving next-generation productivity through smart innovation and manufacturing.

   Solution: Create national advanced manufacturing clusters, networks and partnerships; prioritize R&D investments; deploy new tools, technologies and facilities; and accelerate commercialization of novel products and services.

5. **Challenge:** Creating competitive advantage through next generation supply networks and advanced logistics and infrastructure.

   Solution: Develop and deploy smart, sustainable and resilient energy, transportation, production and cyber infrastructures.

advanced technologies to drive competitive edge; leveraging strengths of ecosystem partnerships beyond traditional boundaries; developing a balanced approach across the global enterprise; and cultivating smart, strategic public-private partnerships.

Most notably, in 2016, respondents predicted for the first time that the United States will take the top spot in the Global Manufacturing Competitive Index (GMCI) by 2020 while China, the manufacturing competitiveness leader in 2010, 2013, and 2016, falls to second place as it transitions toward higher-value manufacturing and adjusts to rising material and labor costs. This would have significant competitiveness implications for the United States and the world.

The *Ignite 1.0-3.0* report series, another collaboration with Deloitte, succeeded the initial GMCI. The multi-part, interview-driven project collected insights from CEOs, university presidents, national laboratory directors and labor leaders, and captured several areas in which these diverse perspectives converge on actions needed to invigorate American manufacturing. The series illuminated several key findings that have informed the Council's work to date, including: the criticality of infrastructure development to job creation and competitiveness; the demand for government policies to address uncertainty and encourage business; the importance of manufacturing to America's ability to compete in the global marketplace; and the role of superior talent as key to America's competitiveness.

American Energy & Manufacturing Competitiveness Partnership

Prior to 2009, the tone of the nation's energy conversation was centered on methods for addressing long-standing energy security challenges and scarcity. By 2013, the conversation had shifted and began to focus on seizing emerging energy growth opportunities to transform America's industrial base and job creation outlook—centering on energy abundance and strength.

In this context, the Council and the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy launched the American Energy & Manu-

Foundation of AEMC Partnership

REPORTS

184 reviewed

↓

28 selected for in-depth analysis

↓

180 **recommendations**

26 **policy categories analyzed**

PUBLIC-PRIVATE PARTNERSHIPS

30+ reviewed

↓

19 selected for in-depth analysis

↓

4 **PPP models developed**

facturing Competitiveness (AEMC) Partnership to tackle two major goals through a multi-year initiative. The AEMC Partnership identified means to:

- Increase U.S. competitiveness in the production of clean energy products—by strategically investing in technologies that leverage American competitive advantages and overcome competitive disadvantages, and
- Increase U.S. manufacturing competitiveness across the board by increasing energy productivity—by strategically investing in technologies and practices to enable U.S. manufacturers to increase their competitiveness through energy efficiency, combined heat and power, and taking advantage of low-cost domestic energy sources.

Over a span of three years, the AEMC Partnership hosted nine regional dialogues and four national summits and obtained insights from industry, academia, national laboratories and government to drive U.S. competitiveness in manufacturing clean energy products, energy efficiency products and advanced manufacturing products. Among the most notable accomplishments of the AEMC Partnership are:

- The creation of the High Performance Computing for Manufacturing Program—a program of up to $3 million available to national labs to couple U.S. manufacturers with the national laboratories' world-class computational research and development expertise to address key challenges in U.S. manufacturing;
- The creation of the Clean Energy Manufacturing Analysis Center at the National Renewable Energy Laboratory; and

- The launch of a new "Technologist in Residence" to strengthen U.S. clean energy manufacturing competitiveness and enhance the commercial impact of its national laboratories.

The Council is proud to trace key accomplishments in manufacturing policy and innovation back to its thought leadership and advocacy, including the America COMPETES Act, Manufacturing USA—centers of excellence formerly known as the National Network for Manufacturing Innovation—and the National Digital Engineering and Manufacturing Consortium (NDEMC) that highlighted the regional importance of advanced computing. Each of these efforts brought together businesses, government and academia to meet grand technological challenges with the potential to unleash generations of American manufacturing innovation, jobs and prosperity.

The Energy and Manufacturing Competitiveness Partnership

In 2007, at the launch of the ESIS Initiative, the Council declared, "the cost of energy is clearly impacting the competitiveness of the United States. But the story does not end there. The economic toll exacted by maintaining the current state of U.S. energy, as well as the prospective windfall for ending it, has not been adequately captured or communicated in the context of national competitiveness." American energy strength and independence—once distant aspirations—are now within our grasp, with huge implications for America's global political, strategic and economic leadership.

Building on the promise of the ESIS Initiative, the Council's USMCI identified critical research, innovation and policy trends contributing to the re-emergence of America's high-value, advanced and productive domestic manufacturing sector—a key driver and beneficiary of these advances in energy technology, research and development.

Concurrent with the USMCI, the AEMC Partnership utilized dialogues, summits and the creation of public-private partnerships to identify and make recommendations to enhance U.S. competitiveness in manufacturing energy technologies and strengthen its foundations through increased energy productivity.

Through the ESIS Initiative, the USCMI, the AEMC Partnership and many other efforts spanning the last three decades, the Council and its members have contributed to a tectonic shift not only in how the United States consumes energy—with energy intensity levels steadily flattening and even declining, and improving relative to our competitors in Europe and Asia—but also in how the manufacturing sector can leverage energy abundance to create a competitive advantage if the right policies are put in place.

These two areas of our nation's economic and social fabric—manufacturing and energy—are deeply interconnected. America's ability to compete in the global economy, to rebuild the middle class and to steward its natural resources and environmental demands relies on coordinated, thoughtful policy solutions that leverage America's innovation ecosystem, workforce, technology, and business and policy-making communities.

The EMCP Methodology

On March 3, 2015, the Council officially launched the Energy & Manufacturing Competitiveness Partnership (EMCP) at a meeting hosted by Dr. William Powers, former president of The University of Texas at Austin. The C-suite conversation among 40 executives and experts from industry, academia, the national laboratories and labor catalyzed the private sector-driven effort to deepen understanding of a convergence between two forces essential to America's long-term productivity and prosperity: energy and manufacturing.

The EMCP was designed to approach the country's diverse industrial landscape as a network of distinct but interdependent productive sectors, each with its own challenges and opportunities. Through a series of sector studies hosted around the nation by members of the Steering Committee, the EMCP identified the salient questions and challenges facing the energy-manufacturing nexus within key sectors as identified by the Steering Committee. Seeking input from leaders throughout the private sector, academia, the research and scientific community, NGOs and government, each sector study looked at the challenges and opportunities through the Council's cross-cutting competitiveness pillars—technology, talent, investment and infrastructure.

Pillars of Competitiveness

Technology

- What role are energy abundance and innovation playing in increasing the productivity and competitiveness of American manufacturing? What innovations are occurring—or are urgently needed—for manufacturers to leverage natural gas, renewables and efficiency technologies to improve their competitiveness in the global marketplace?

- How is demand for new energy technologies impacting innovation, manufacturability and business outlooks for domestic technology manufacturing?

- How are energy and technology regulatory regimes impacting the competitiveness outlook of U.S. manufacturing across these sectors? What regulations and policy interventions could enhance innovation and accelerate the development and deployment of energy technologies and greater industrial energy productivity?

Talent

- What skills will define the 21st century energy and manufacturing economy? How is the private sector communicating needs to educators and students?

- What domestic skill shortages and talent deficits hinder America's ability to achieve the full potential of the new energy economy?

- What formal, alternative and continuing education platforms must be established or strengthened to ensure a robust talent pipeline and domestic workforce in these sectors?

Investment

- How are the tectonic shifts occurring across today's energy landscape—as the U.S. moves from "energy weak" to "energy strong"—changing the decision-making processes and competitiveness propositions for domestic and foreign manufacturers? And, what investments are U.S. manufacturers making in response to growing demand for new energy technologies, products, and services?

- How is America's energy abundance reflected in the competitiveness of sectors downstream from energy-intensive sectors of the economy?

- What hurdles do technologists, entrepreneurs and firms across sectors face in commercializing promising technologies and deploying them on a market-scale? What new institutions, mechanisms and knowledge-transfer systems must the investment community create to capture U.S. technology innovation and scale it domestically?

Infrastructure

- What investments in infrastructure—physical, educational, financial and beyond—are necessary to fully exploit the opportunity of America's growing energy strength and innovation ecosystem?

- In efforts to optimize the nation's full energy potential—and consequent competitiveness—how can policymakers and the nation's business, research and labor communities come together to resolve conflicts hindering the build-out the nation's energy infrastructure, including pipelines, the grid and new technology deployment?

Common challenges and opportunities illuminated key policy gaps and recommendations specific to each sector, and, equally as importantly, across these discrete sectors:

Water & Manufacturing

In February 2016, the Council launched the first phase of regional sector studies with a dialogue focusing on water and manufacturing. It was co-chaired by Dr. Michael Lovell, president, Marquette University and Mr. Ajita Rajendra, chairman & CEO, A. O. Smith Corporation. This first dialogue brought together more than 50 experts in the water and manufacturing industries for a closed-door conversation at Marquette University in Milwaukee. Common challenges were identified as well as opportunities relating to water, energy and manufacturing in the United States. *Leverage: Water & Manufacturing* was released at a press conference hosted by A. O. Smith Corporation in Milwaukee, WI, in September 2016.

Advanced Materials

Hosted at the Council's offices in Washington, D.C., and co-chaired by Dr. Laurie Leshin, president of Worcester Polytechnic Institute and Dr. Aziz Asphahani, president of QuesTek Innovations, LLC, the April 12, 2016 dialogue focused on challenges and opportunities regarding the design, production and scaling of advanced materials to accelerate the transition from discovery to manufacturing. *Leverage: Advanced Materials* was released in October 2016, at a briefing on Capitol Hill attended by key policymakers and representatives from industry, academia and the national laboratories.

Advancing U.S. Bioscience

In July 2016, EMCP members gathered for a dialogue on the role of bioscience in driving U.S. innovation in sustainable energy, chemical engineering, agriculture and food production. The meeting was followed by a briefing on Capitol Hill the next day, in which representatives from Council members Pacific Northwest National Laboratory and Lawrence Berkeley National Laboratory spoke to lawmakers on the applications for bioscience technologies.

The Council's efforts in this space continued, with the release of the fourth EMCP report—*Leverage: Advancing U.S. Bioscience*—at a widely-attended event on Capitol Hill in July 2017. Speakers at the briefing emphasized the importance of retaining America's leadership position in bioscience, and Congressman Randy Hultgren (IL-14) called for bipartisan, bicameral support of science leadership in the United States. These efforts continued into 2018, when the Council headed to Sacramento to present key findings before the state legislature.

Agricultural and Consumer Water Use

In January 2017, the Council launched its second phase of sector studies with a dialogue on agricultural and consumer water use hosted by Mr. James Hagedorn, chairman and chief executive officer of the Scotts Miracle-Gro Company, at its headquarters in Marysville, OH. The dialogue was co-chaired by Mr. Hugh Grant, chairman and CEO of Monsanto Company. *Leverage: Agricultural and Consumer Water Use*, was released on World Water Day at an event hosted by Scott's Miracle-Gro in Florida and at the U.S. Water Partnership's annual meeting at the State Department in Washington, D.C.

Energy

Hosted in Chicago, IL, by EMCP Industry Co-chair Mr. Christopher Crane, president & CEO of Exelon Corporation, in partnership with Dr. Paul Kearns, director of Argonne National Laboratory, and Dr. Eric Barron, president of Penn State University, the Council convened in May 2017 a group of more than 30 experts to address the competitiveness of America's energy sector. The report, *Leverage: Energy*, was released at Penn State's Energy Days conference on May 31, 2018, in State College, PA, and will inform the Council's future work across and beyond energy and manufacturing.

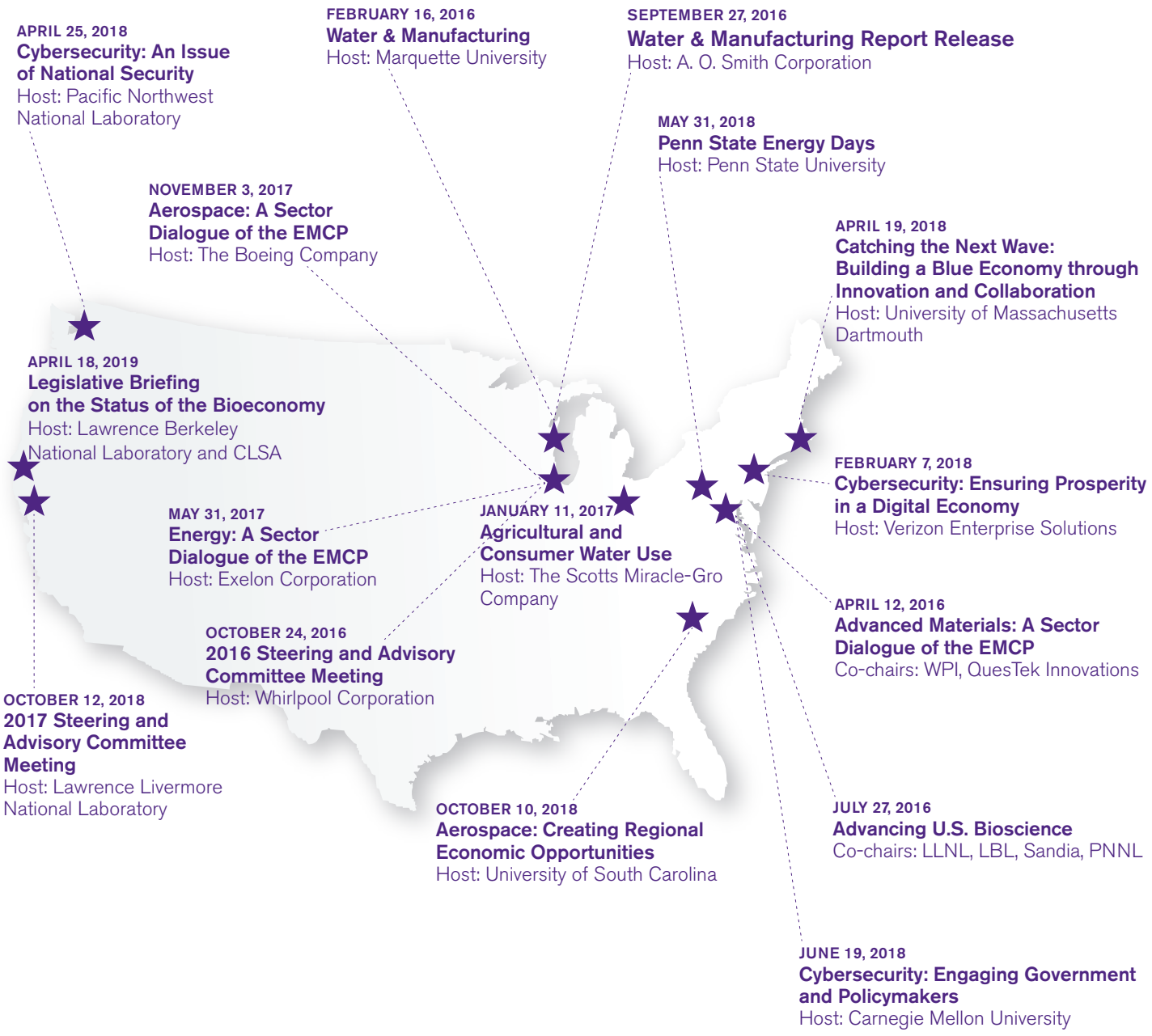
Aerospace

In November 2017, the EMCP returned to Chicago for a dialogue on competitiveness in the aerospace sector, hosted by Boeing's Chief Technology Officer and Senior Vice President, Boeing Engineering, Test & Technology, Dr. Greg Hyslop, in partnership with Dr. Harris Pastides, president of the University of South Carolina. The final report, *Leverage: Aerospace*, was released at the South Carolina Aerospace Conference & Expo in October 2018.

Cybersecurity

In February 2018, the Council launched an effort to develop a national agenda on cybersecurity co-chaired by Dr. Steven Ashby, director of Pacific Northwest National Laboratory, Mr. George Fischer, senior vice president and group president of Verizon Enterprise Solutions and Dr. Farnam Jahanian, president of Carnegie Mellon University. The **National Agenda for American Cybersecurity** is informed by three dialogues hosted by the co-chairs, each of which drew on the expertise of practitioners and policymakers from industry, academia, government and the national laboratories.

Figure 5. EMCP Dialogues and Events



Challenges Identified by the Sector Studies

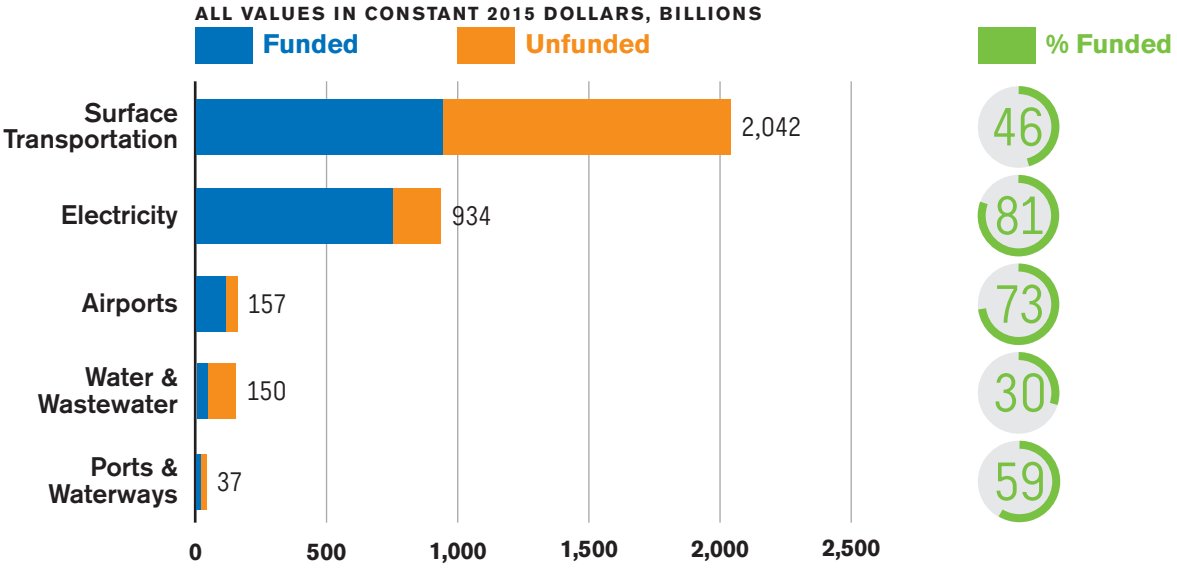
Outdated Infrastructure

A healthy modern economy relies on robust physical infrastructure to support productive economic activity. Yet, the Council's annual *Clarion Call for Competitiveness* report card has consistently given policymakers a D on addressing infrastructure needs. Similarly, the 2017 American Society of Civil Engineers report card on American infrastructure gives the United States an aggregate grade of D+ across 16 categories, estimating that $4.59 trillion will be necessary to improve critical infrastructure (see Figure 6).

When it comes to America's water infrastructure, approximately 1.7 trillion gallons of water are lost per year due to natural deterioration, damage and leaks resulting from aging infrastructure.[15] Land devoted to agricultural production across wide swaths of the United States is not water- or drainage-controlled, creating runoff and contamination issues for major waterways. In the energy sector, increasing consumption from the industrial sector and a heavy reliance on shale gas creates growing pressure on the extraction infrastructure.[16] And America's aerospace industry suffers from the constraints of a technologically- and financially-limited system that has fallen behind the satellite systems and business models of global competitors.

The challenges posed by this outdated infrastructure present a threat to U.S. competitiveness. America's infrastructure must be improved if the nation hopes to achieve its full potential.

Figure 6. America's Infrastructure Investment Gap
Funding needs of major infrastructure sectors in the U.S., 2016–2025
Source: ASCE



15 Challenge and Opportunity, The Value of Water Campaign, 2015.

16 For the First Time, Majority of Americans Oppose Nuclear Energy, Gallup, March 2016.

Regulation Not Keeping Pace With Innovation

Balancing regulation and innovation opportunity is a challenge constantly at the forefront of American competitiveness. While regulations are necessary to ensure new technologies meet the high safety and ethical standards of American society, smart policies must be enacted that allow the innovation ecosystem to develop and thrive.

There are numerous areas of policy that affect or are affected by technology-driven reorganization of the economy. For example, the current regulatory environment doubles the normal construction time of nuclear plants and offers investors only long-term returns on wind and solar investments. These policies incentivize producers to move to places like China where relaxed environmental regulations result in faster construction with higher returns. In the aerospace sector, which has been driven by technological innovation since its inception, drones and space-based technology present new ethical and security concerns that, if not collaboratively addressed by policymakers and industry, could hinder America's competitiveness in space exploration and travel.

Important steps are being taken. In 2017, Congress passed multiple pieces of legislation, including the 21st Century Cures Act, the American Innovation and Competitiveness Act and the National Defense Authorization Act that included provisions to help eliminate, reduce and streamline research-related regulations. But the rate of technological advancement continues to outpace the ability of regulators to react to innovation, widening the gap between the promise of new technologies and their applications.

"The national laboratories engage industry, academia and other stakeholders, both to help ensure success in their missions and to enable their cutting-edge research to have as broad an impact as possible."

Dr. William H. Goldstein
Director
Lawrence Livermore National Laboratory

The resulting regulatory uncertainty can discourage investment, new business formation and technology adoption, as well as hinder U.S. competitiveness in the long run.

Lack of Coordinated, Defined Research Agenda

Long-term technology leadership relies on strategic investments in research that push the frontiers of knowledge. Yet, many cutting-edge sectors lack clear, community-defined research agendas, often resulting in duplication of efforts and inefficient use of limited financial resources.

In the bioscience field, for example, the United States lacks a unifying roadmap, hindering strategic, long-term efforts and instead creating uncoordinated and disjointed programs and priorities. In the cybersecurity space, many in the private sector are calling

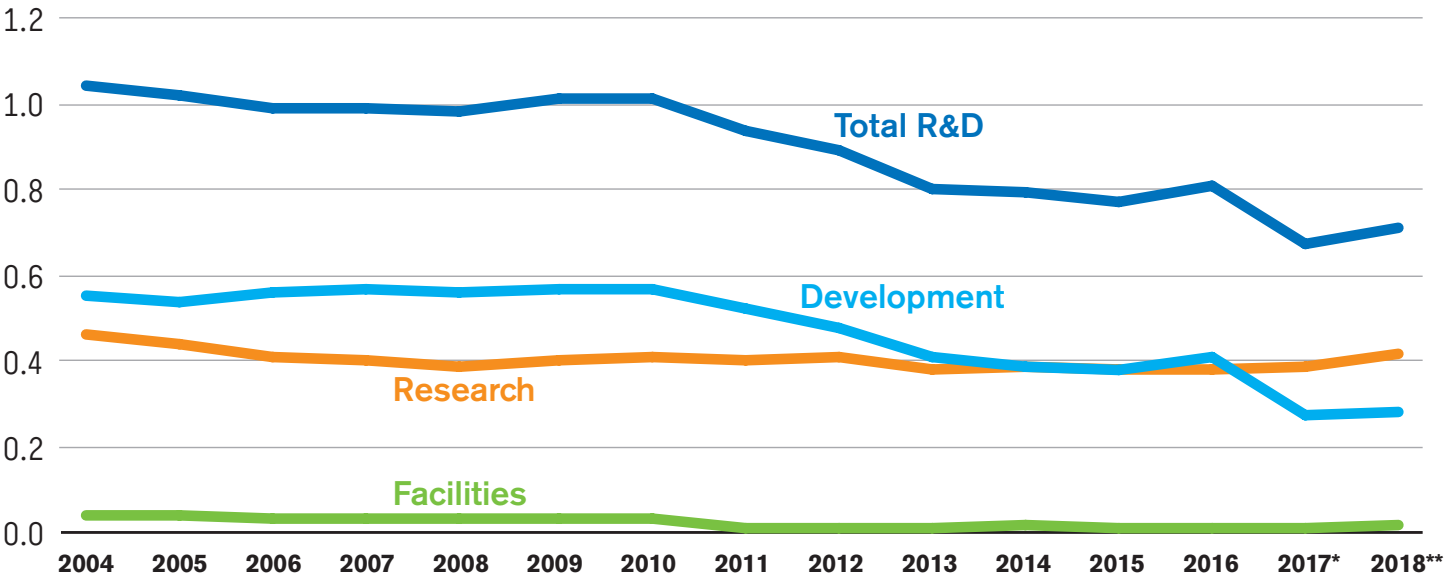
for a consensus-driven prioritization of research questions and a mechanism for illuminating long-term challenges to better prioritize the allocation of limited research dollars.

With limited federal funding available to support basic research, the need for coordination continues to grow. By incorporating a strategic agenda and streamlining the innovation process, the United States can better leverage outstanding research into global economic competitiveness.

Insufficient Research Funding

2018 was just the second time in a decade in which federal investment in R&D increased, hopefully indicating the reversal of a long-term trend and representing a step forward for the U.S. to regain its global innovation leadership (see Figure 7). But, public investment has not kept pace at a rate that will allow for the optimization of America's scientific assets, especially as companies have moved away from exploratory research toward nearer-term applied research and technology development.

Figure 7. Trends in Federal R&D as Percent of GDP, FY 2004-2018
Source: AAAS R&D report series, based on OMB and agency R&D budget data.



Note: Includes conduct of R&D and R&D facilities. Total R&D figures account for DOD adjustments to rectify differences in total obligational authority and new budget authority.

*Beginning in FY 2017, a new official definition of R&D has been adopted by federal agencies. Late-stage development, testing, and evaluation programs, primarily within the Defense Department, are no longer counted as R&D.

**FY 2018 figures are AAAS estimates based on omnibus-enacted appropriations.

Although federal investment in R&D is higher in the United States than any other individual country, several economies have greater R&D intensity—the ratio of R&D expenditure to gross domestic product (GDP). Over the last decade, R&D intensity in the United States has fluctuated only slightly. Yet, the U.S. rank in this indicator has been slowly falling in recent years: No. 8 in 2009, No. 10 in 2011, and No. 11 in 2013 and 2015.[17]

A focus on multidisciplinary funding is also critical—and tends to be insufficient—often due to structural, political and parochial concerns. This gap is particularly troubling as the diverse applicability of research cuts across multiple industries, including medicine, food, renewable energy and agriculture, among others. A lack of investment among cross-disciplinary fields or in a diverse collection of industries may inhibit promising advancements, thus hindering progress in these industries.

Looking solely at the private sector, while the United States maintains a decisive global edge in venture capital investment, which amounted to $66.6 billion and accounted for 86 percent of total venture capital investment in the OECD in 2016, the tendency of funders to allocate resources to projects with low risk and short-term payoffs hinders advancement in areas like the energy sector, where innovation is often characterized by extended project lifecycles.

Bringing Research to Market

While the federal government is the primary funder of basic research, the private sector, as innovators, investors and adopters, is pivotal when it comes to commercializing new technologies and bringing research to market. But, in many sectors, market incentives encourage low-risk, incremental improvements to technologies rather than the commercialization of radically new components and products.

When it comes to the water sector, affordability and awareness are significant impediments to the uptake of new and smart water and energy system technologies. Both the bioscience and advanced materials sectors face challenges in linking research to marketable industries and products, which can lengthen or even halt the discovery-development-deployment cycle. When it comes to the agriculture, lawn and garden and related industries, new, advanced products such as smart membranes, fertilizers and pesticides can improve water efficiency, but research and development is often cost-prohibitive. And in the aerospace sector, it can take 10-20 years for new materials to transition from design to deployment in the United States.

The ability to transition research to market is an essential leg of the innovation spectrum. Entrepreneurs are the conduits through which innovations appear in the market and create value. Entrepreneurs underscore the need to enable innovators to create successful startups that drive job creation and productivity growth and contribute to America's global competitiveness.

Insufficient Knowledge Sharing

The research and innovation ecosystem in the United States comprises a wide variety of stakeholders. Oftentimes, there is limited sharing of information across this landscape, which can lead to inefficiencies and duplication of efforts.

17 Science and Engineering Indicators, National Science Board, 2018.

In the materials sector, data gathered and entered into digital knowledge databases is extremely limited and under-developed, resulting in a significant amount of reliable data that cannot be utilized because it is not connected or curated. Regarding bioscience, quick and robust exchanges of information among industry and government partners, as well as within agencies of the federal government, remain a challenge despite the extensive infrastructure available to support innovation in the bioeconomy.

In other cases, the challenge is data collection rather than knowledge sharing. In the water space, for example, the amount of data available on water quality and efficiency is scarce. This lack of information often means issues go unrecognized until catastrophes arise. The United States also lags behind other parts of the world when it comes to developing and implementing the technology needed for weather forecasting and climate modeling, which hinders the agriculture sector's ability to manage and mitigate risk associated with changing weather patterns.

As the proliferation of data sweeps through modern industry, the challenges around collecting, validating and then sharing reliable information becomes central to America's industrial efficiency and competitiveness. Collaboration among public and private sector stakeholders will be essential to the United States' ability to maximize the potential of this wave of information.

Scientific Illiteracy

Science has a perception problem. One area in which this is particularly relevant is in the case of genetically modified food, which research shows to be safe, yet according to a recent ABC News poll of a random sample of 1,024 adults, 92 percent of Americans favor mandatory labelling for genetically modified foods and 46 percent do not believe genetically modified foods are safe to eat.[18] Greater science literacy is vital to combatting uninformed, negative perceptions of groundbreaking new technologies and products.

The challenges around creating an informed, scientifically-literate workforce begin with early education in the science, technology, engineering and mathematics fields. The Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) 2015 data, for example, show that the U.S. average mathematics assessment scores were well below the average scores of the top-performing education systems. With regard to science achievement, U.S. fourth and eighth graders have not improved their international position since 1995—in fact, among the 17 education systems that participated in the 1995 and 2015 grade 4 TIMSS science assessments, the United States slipped in rank, from No. 3 in 1995 to No. 5 in 2015.[19]

At the professional level, insufficient scientific knowledge can translate into inefficiency. For example, when it comes to sustainable water management, neither the average consumer nor corporate leader typically understands the environmental and economic impacts of sustainable water use. This creates a barrier for the implementation of best practices at the industry and household levels that can carry significant costs.

18 Poll: Modified Foods Give Consumers Pause, David Morris, ABC News, July 15, 2018.

19 Science and Engineering Indicators, National Science Board, 2018.

The Skills Gap

Every instance of technological development requires the workforce to quickly adopt new skills to remain competitive and ensure innovation is leveraged to its maximum capacity. With the pace of innovation accelerating rapidly, the pressure to create a workforce with the skills needed to take on the jobs of the future is constantly mounting.

As one example, curricula at state colleges, junior colleges and universities are often misaligned with the changing needs of industry pertaining to managing water in the agriculture, lawn and garden and related industries. There is also a growing need for computing and data management skills among professionals in the water and agriculture space. In the bioscience industry, the talent pipeline is constantly evolving and now demands non-traditional biologists who have trained skills in multidisciplinary areas, such as computer science and ethics.

America's ability to prepare its workforce for current and future opportunities is a key aspect of the country's ability to remain competitive and must be collectively addressed by policymakers, industry and academia.

The Changing Workforce Demographic

As the skills required to participate in the workforce change, so does the structure of the workforce—further complicating the challenges industry faces now and in the future regarding securing the talent necessary to succeed.

"The education and skills necessary to compete and prosper are changing rapidly and it's critical that universities respond and adapt to ensure our students are prepared to excel in this evolving economy."

The Honorable Rebecca Blank
Chancellor
University of Wisconsin—Madison

One particular shift in the United States is the aging of the baby boomer generation. 2017 marked a peak in the number of Americans collecting Social Security benefits, up nearly 2.4 times the number of total beneficiaries in 1970.[20] Moreover, over 50 percent of utility workers are set to retire in the next decade.[21]

At the same time, the disappearance of industrial arts and vocational training in K-12 education has made it more difficult to find talent for the manufacturing sector. In fact, a 2014 survey by Deloitte revealed that respondents between the ages of 19 and 33 would be least likely to select a manufacturing career among the options presented.[22]

20 Table: Number of beneficiaries receiving benefits on December 31, 1970-2017, Social Security Beneficiary Statistics, Social Security Administration.

21 Who will Replace Nuclear Power's Aging Workforce?, Russell Ray, Power Engineering, February 5, 2015.

22 Overwhelming Support U.S. Public Opinions on the Manufacturing Industry, Deloitte United States (Deloitte Development LLC) and The Manufacturing Institute, 2014.

While America's industry executives have made clear that finding and developing talent is of the highest priority, it remains true that without action the skills gap is likely to leave up to 2 million American jobs unfilled over the next decade (see Figure 8).[23]

Increasing Global Competition

Globalization and the increasing technological and innovation capabilities of countries worldwide are changing the competitiveness landscape drastically. In 2016, worldwide total R&D expenditure grew 3 percent, indicating that countries around the world are increasing R&D funding for innovation.[24]

The global private sector is becoming increasingly involved in the funding of R&D as well, with business sectors in Germany, China, South Korea and Japan funding as much as 78 percent of R&D compared to 62 percent in the United States.

The strategies for allocating R&D funds vary globally as well. While the United States focuses more heavily than many of its competitors on basic research, with 17 percent of R&D funds to China's 5 percent, China dedicates 84 percent of its R&D spending to experimental development and moving new technology to market compared to 64 percent in the United States.[25]

Figure 8.

Sources: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, *2016 Global Manufacturing Competitiveness Index*; Deloitte and The Manufacturing Institute, *The skills gap in US manufacturing: 2015 and beyond*

23 2014 Skills Gap Study, Deloitte and The Manufacturing Institute.

24 Global Innovation Index 2018.

25 Science and Engineering Indicators, National Science Board, 2018.

As the global landscape changes, international competition increases. While the United States reached a five-year high rank of No. 4 in the Global Innovation Index (GII) in 2017, the nation dropped to No. 6 in 2018 (see Figure 9). And, in key areas such as regulatory environment, infrastructure and education, the nation ranks No. 12, No. 24 and No. 47 respectively.

With regard to investment in specific sectors, more than 40 countries have shown interest in promoting the bioeconomy, and many have strategic plans in place to create a competitive bioeconomy in their respective countries. This includes China, which has called for hundreds of billions of dollars to fund the application of biotechnology in the healthcare sector.

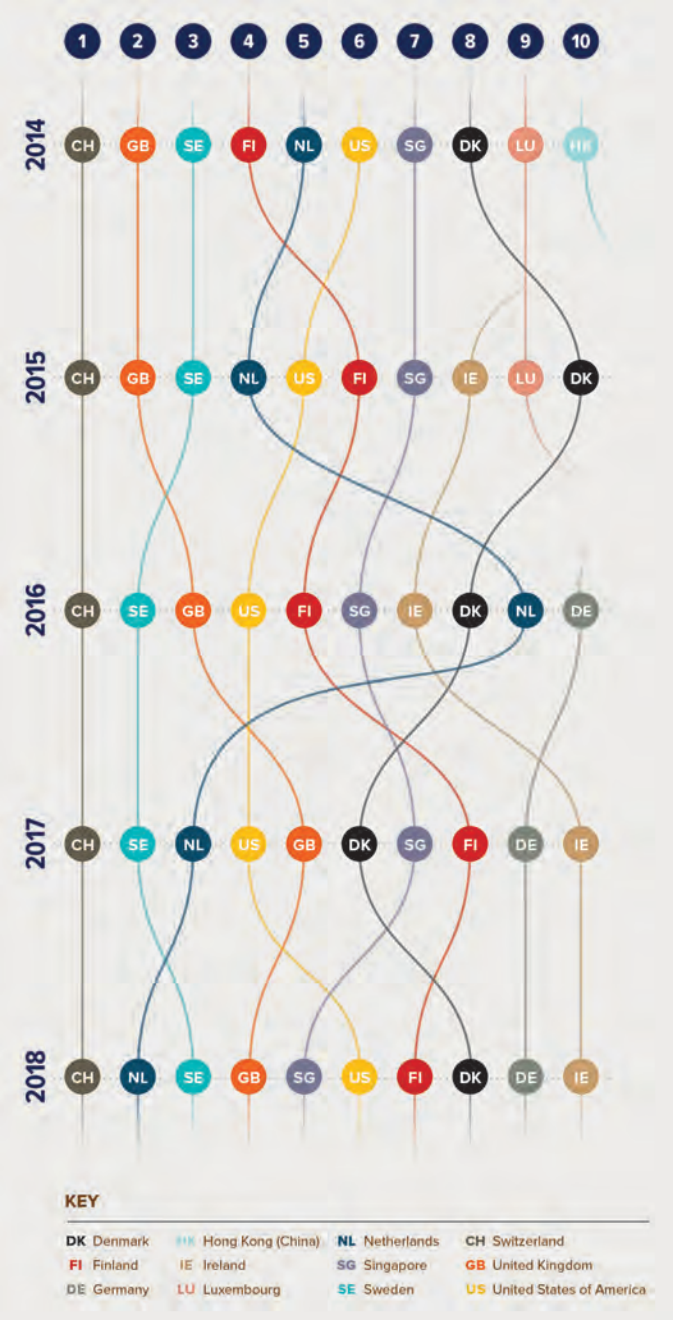
When it comes to measuring water quality and scarcity and implementing strategies to mitigate risk in these areas, the U.S. is falling behind countries like Australia and Israel, which have made significant investments in this area. And countries such as Singapore, Portugal and Denmark are becoming leaders in incentivizing and implementing advancements in the aerospace sector.

Another indicator of rising global competition is an increase in the number of science and engineering graduates. Between 2000 and 2014, the number of science and engineering (S&E) bachelor's degrees awarded in China rose more than 350 percent, significantly faster than in the United States and in many other European and Asian regions and economies.[26]

As nations begin to recognize the advantages of investing in a strong innovation ecosystem, the United States must re-prioritize science and technology to remain a global leader.

Figure 9. Movement in the GII Top 10

Source: *The Global Innovation Index 2018: Energizing the World with Innovation*, Global Innovation Index Database, Cornell, INSEAD, and WIPO.



26 Science and Engineering Indicators, National Science Board, 2018.

Emerging Cyber Threats

The interconnectedness and openness made possible by the Internet and the broader digital ecosystem create unparalleled value for society. Over 20 billion devices are expected to be connected to the Internet by the year 2020. However, these same qualities make securing today's cyber landscape difficult.

As the United States continually advances and modernizes its energy systems, efficiency is sometimes prioritized over security, making grid and nuclear plant monitoring a significant concern. In the aerospace sector, the increasing density of aircraft in the skies leads to a higher need for communication between the air and the ground, making cybersecurity an area of particularly high importance. Yet, in a 2015 survey conducted by the Airport Cooperative Research Program and sponsored by the Federal Aviation Administration, only 34 percent of airport respondents indicated they had implemented a national cybersecurity standard or framework.[27] And as more industries see the proliferation of sensors and monitoring equipment, the surface area of connected devices continues to grow exponentially—creating more room for infiltration.

Despite the notable risks cyber threats pose to American prosperity, there remains a wide disparity in investment, maturity, coordination and training on cybersecurity across the country's critical infrastructure sectors. The White House Council of Economic Advisers estimates that malicious cyber activity cost the U.S. economy between $57 billion and $109 billion in 2016, and estimates costs to reach $2.1 trillion globally by 2019. If stakeholders across government, academia and industry fail to implement strong, coordinated cybersecurity strategies and practices, the United States will become increasingly vulnerable to the growing cyber threat.

In response to these challenges, the Council developed, and has put forth in this report, a Call to Action to turbocharge the U.S. manufacturing renaissance in an era of energy abundance (see pages 9-12). In addition, *Secure: Ensuring Resilience and Prosperity in a Digital Economy* is being simultaneously released under separate cover. The Council's National Agenda for Cybersecurity can be found in Appendix A on page 66.

27 *Guidebook on Best Practices for Airport Cybersecurity*, Airport Cooperative Research Program, 2015.

Moving Forward

The United States is at a critical moment in time in national innovation systems research and action. New, transformational models driven by the democratization and self-organization of innovation are emerging and taking root across the nation.

These developments, which were called out in the 2017 Council report *Transform*, are occurring against the backdrop of increasing global, innovation-based competition and growing capacity for innovation in countries around the world. *Transform* went on to highlight rising internal challenges in the U.S. innovation system—such as changing demographics, lack of diversity and inequality of opportunity in the U.S. education system—that are changing the shape of the U.S. workforce. In response, innovation practitioners and stakeholders are facing difficult questions about how individuals, teams, communities and national institutions of knowledge creation and innovation will transform to support current and future U.S. innovation.

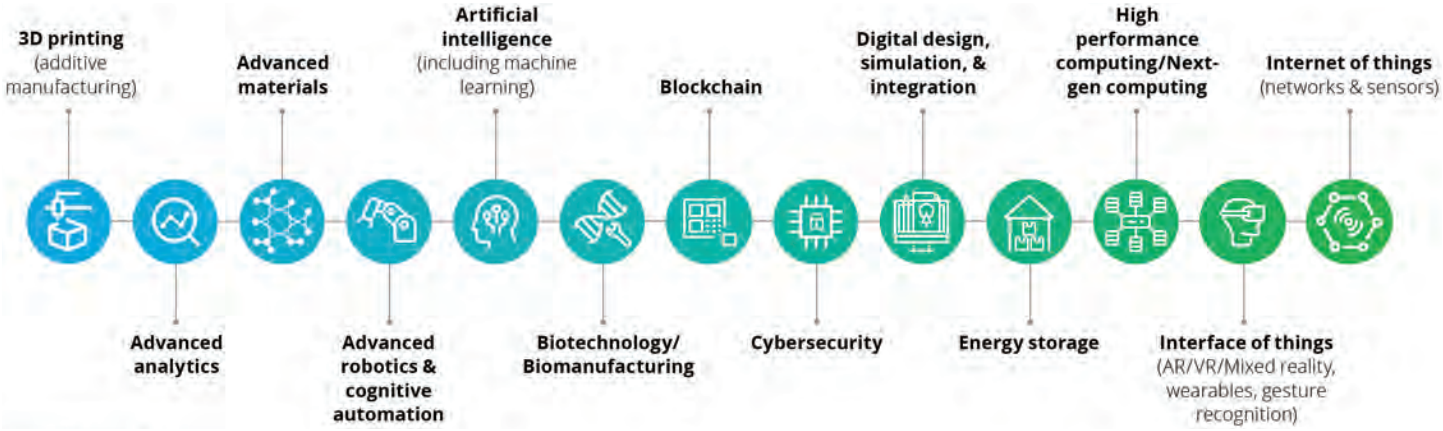
As changes in the process of innovation unfold, increasing attention is being paid to the science of the innovation process itself, and how to reduce its risk and uncertainty. Researchers and academics have contributed for decades to the field of corporate management, and are now beginning to focus their attention on new types of organizational structures, and methods to accelerate and optimize technology commercialization.

The recommendations in this report—and the over ten years of work they encompass—have the power to turbocharge America's manufacturing capabilities, improve America's competitiveness and unleash a new wave of productivity and prosperity for all Americans. But more work remains to be done. U.S. leadership is under threat. The United States faces now what are perhaps existential challenges to its global leadership in innovation. America's role in technology advancement is diminishing globally—now accounting for only one-quarter of global research & development, down from two-thirds in 1960. Competitors around the globe are increasing their capacity for innovation. And rapid technological change and disruption have impacted the workforce and communities.

As Figure 10 highlights, there are numerous exciting, disruptive technologies and tools just beginning to impact the global economy that have the potential to completely change the way people travel, shop, build, explore and interact. And the impact on companies and universities is likely to be just as consequential.

With these challenges in mind, in 2019, the Council will launch a **National Commission on Innovation & Competitiveness Frontiers** to double down on all efforts to optimize the nation for this new, unfolding innovation reality. The Commission will build on the Council's intellectual capital in this space developed over the past thirty years, including the recently

Figure 10. A Snapshot of Exponential Technologies
Source: Deloitte, Council on Competitiveness, Singularity University. 2018. *Exponential Technologies in Manufacturing*.



completed two-year partnership with the National Science Foundation—the Exploring Innovation Frontiers Initiative—that culminated in the release of *Transform*. Organized around three critical competitiveness pillars—capitalizing on emergent and converging technologies; optimizing the environment for innovation systems; and exploring the future of production, sustainable consumption and work—the Commission will acknowledge and respond to the urgency of the challenge at hand, understand and describe this new reality and position the nation to prosper and thrive with a clear set of recommendations that will enhance and expand the nation's innovation capacities at the heart of competitiveness.

Sector Study Overviews and Recommendations

Water & Manufacturing

CO-CHAIRS

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President
Marquette University

Mr. Ajita G. Rajendra
Chairman & CEO
A. O. Smith Corporation

Water is necessary for industry, society and individuals to survive and thrive. Nearly half of industry water consumption is attributable to manufacturing products and services.[28] As fundamental changes such as urbanization and population growth take hold, innovation is needed in infrastructure, technology, investment and talent to meet the increasing demand for water. This requires taking a stewardship approach in which all sectors come together to look beyond compliance and view water as a finite resource that must be managed efficiently.

The EMCP sector study dialogue on water & manufacturing, hosted on February 16, 2016 by Marquette University in partnership with A. O. Smith Corporation and the Council, gathered national leaders and water experts from all sectors of the economy to discuss the important issues around water and manufacturing. The day, broken down into four sections—talent, technology, investment and infrastructure—featured robust conversations on these key pillars.

Leverage: Water & Manufacturing was released in September, 2016 at a press conference hosted by A. O. Smith Corporation in Milwaukee, WI. The event was widely covered by local radio, TV and print media.

Findings and Recommendations

- **Use a stewardship approach to water management in which laws and regulations surrounding water reuse support natural processes whenever possible and treat water as the limited resources it is rather than a limitless commodity.** Industry uses approximately 350 billion gallons of water each day, nearly half of which is attributable to manufacturing products and services. In some countries, safe water supply has the potential to increase GDP up to 7 percent, making it increasingly important to understand the true value of water and price the commodity appropriately in order to improve efficiency.
- **Integrate natural infrastructure, including roof installments, rain barrels and constructed wetlands, into water management approaches to improve energy efficiency and water quality while reducing overall water infrastructure investment costs.** Green infrastructure is often considered a cheaper and more sustainable alternative to water management than traditional gray infrastructure. Operations and maintenance

28 Water and the Economy, Water's Value, The Value of Water Coalition, 2015.

costs for natural infrastructure projects such as constructed wetlands can be dramatically lower than those associated with traditional wastewater treatment alternatives, with green infrastructure in general presenting a cost savings of more than $1.5 billion. These projects also often have additional ancillary benefits for the community and environment and help companies comply with EPA water discharge requirements.

- **Encourage development and deployment of technologies and microbiological barriers that increase overall water supply by diversifying sources and improving quality and efficiency such as desalinization, nutrient recovery and wastewater re-use.** As America's population increases and converges on cities, demand for fresh water and dependence on reliable water infrastructure will grow exponentially. The resulting need to diversify water sources presents a distinct opportunity for these types of innovative solutions such as the development of advanced materials that can remove specific compounds in a more efficient manner.
- **Promote the uptake of sensors and monitoring equipment and aggregation of big data across sectors and geographies to improve water management and increase information available on water quality and efficiency.** Data on efficiency and water quality is scarce. This lack of information often means issues go unreported until catastrophes arise. Increased access to knowledge would allow water issues to be addressed proactively before they reach a point of crisis.
- **Increase federal funding available for water technology test beds to accelerate development and reduce cost and risk associated with deployment of advanced technologies for improving water quality and efficiency.** Affordability and awareness are significant impediments to uptake of new smart water and energy system technologies necessary for the water industry. Government funding and strategic placement of these testing facilities near the companies investing in new water technologies would de-risk the adoption of these technologies.
- **Model water consumption and availability using high performance computing to address gaps in supply and demand and reduce overall waste and costs associated with managing water and energy systems.** Approximately 1.7 trillion gallons of water are lost per year due to natural deterioration, damage and leaks resulting from aging infrastructure. The use of new sensors and measurements, as well as high performance computers, would facilitate collection and dissemination of data in a universally accessible and understandable fashion.
- **Engage government and private sector stakeholders in an enhanced public awareness campaign to address water conservation needs.** Given the current pricing structure of water, neither the average consumer nor company fully understands the importance of conserving this resource. Social marketing and public awareness campaigns can elevate the visibility of water-related issues. This would likely include collaboration with existing initiatives to enhance the overall reach and level of knowledge regarding water issues among consumers.

- **Address the skills gap in the water and manufacturing sector by de-stigmatizing technical careers, reintroducing hands-on training in K-12 and encouraging cross-sector partnerships between industry and academia.** 2016 marks a peak in the number of people on social security benefits, amounting to nearly 2.4 times the number of total beneficiaries in 1970. This creates a skills gap in which talent is not properly matched with available jobs. Partnerships between technical colleges and industry can bring talent directly onboard and highlight specific skill sets to produce a strong talent pipeline.

Advanced Materials

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Chief Executive Officer
QuesTek Innovations LLC

Dr. Laurie Leshin
President
Worcester Polytechnic Institute

Advanced materials are critical building blocks that can drive significant enhancements in America's energy production, manufactured products and the overall economy. Early adoption of advanced materials by manufacturers can differentiate U.S. products from those of competitors by increasing performance and durability, decreasing production and maintenance costs and improving energy efficiency over the life cycle use of the product. Use of these new materials in commercial products also drives the market for the materials themselves.

The EMCP sector study dialogue on advanced materials, hosted on April 12, 2016, by the Council on Competitiveness in partnership with QuesTek Innovations, LLC and Worcester Polytechnic Institute convened national leaders and materials experts from all sectors of the economy to discuss how the development and deployment of advanced materials can increase U.S. competitiveness. The day focused first on the current capabilities in U.S. national labs, universities and across the private sector in advanced materials, barriers and impediments to fully deploying the promise of advanced materials across the manufacturing and energy sectors and solutions to these challenges.

Leverage: Advanced Materials was released at a briefing on Capitol Hill in October, 2016. Panelists included representatives from the Council, QuesTek Innovations, LLC, Worcester Polytechnic Institute and Lawrence Livermore National Laboratory, who shared the key findings and recommendations with policymakers.

Findings and Recommendations

- **Promote the uptake of more public private partnerships (PPP) between the national laboratory system and industry partners, small businesses and universities.** The development stage of materials is suffering when it comes to scaling-up materials for mass production and use. Small and medium-sized businesses must have consistent access to laboratory spaces and

other critical infrastructure and technologies. PPPs would allow designers to develop new innovative products, and the gathering of key university experts to perform fundamental research in science, engineering and technology areas under one location would connect American manufacturers to global markets.

- **Develop a national knowledge platform to ensure that accurate, pedigreed, curated and easily accessible data is developed to support the creation, processing, modeling and manufacturing of advanced materials.** The current digital knowledge database on materials is extremely limited and underdeveloped. As a result, there is a significant amount of usable data that cannot be absorbed because it is not connected or curated. The leap forward for technology in the area of advanced materials will likely come from the broad dissemination of tools with interoperability as a key enabler.
- **Gather critical masses of materials experts into business groups or entities to work with materials technologies as a collective effort to combine distinct knowledge bases and spur unique funding opportunities.** Materials experts operate separately from one another, which creates gaps in data management and further complicates the standardization needed to advance this field. Cross-functional collaboration throughout and between various small and medium-sized businesses can become part of leading expert groups specializing in accelerating both discovery and development of materials.
- **Dedicate area-specific pilot-plant facilities to collaborate with national laboratories, universities and small and medium-sized companies to accelerate deployment and decrease the commercialization time horizon for advanced materials.** Industry access to scientific and technical resources will help manufacturers develop and deliver new, innovative products to market and qualify materials in faster-paced, more efficient systems. Such pilot-plant facilities will help decrease the expected deployment time and accelerate the entire discovery-to-deployment cycle. In the absence of private sector support of the needed pilot-plant facilities, it is recommended that government agencies (e.g., DoE, DoD, NIST) take the lead by establishing a "Materials Genome Processing Center", as the first pilot-plant facility that is needed to achieve the Materials Genome Initiative (MGI) goal of ensuring a manufacturing infrastructure for materials innovations.
- **Address the skills gap in the advanced materials and manufacturing sector by embracing an interdisciplinary approach to education that combines traditional materials science curricula with data science, modeling and simulation and computational sciences.** A recent survey revealed that respondents between 19 and 33 years old would select a manufacturing career last. Reintroducing hands-on training at the K-12 level can address the misconceptions around the manufacturing sector and lack of knowledge regarding the emerging opportunities in advanced manufacturing, while partnerships between academia and industry

designed to nurture cross-disciplinary skill sets at the undergraduate and graduate levels can ensure a strong talent pipeline.

Advancing U.S. Bioscience

CO-CHAIRS

Lawrence Berkeley National Laboratory

Lawrence Livermore National Laboratory

Pacific Northwest National Laboratory

Sandia National Laboratories

Bioscience is a top manufacturing technology priority across the federal government and is critical for U.S. competitiveness. While the United States maintains a world leadership position in engineering biology and bioscience technology development, other countries are investing heavily in these areas putting the U.S. at risk of losing its competitive advantage.

The EMCP sector study dialogue on advancing U.S. bioscience, hosted on July 27, 2016 by the Council on Competitiveness in partnership with Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Pacific Northwest National Laboratory and Sandia National Laboratories gathered national leaders and experts on the bioeconomy to discuss the importance of bioscience to U.S. competitiveness. The day-long session focused on the actions needed to be taken in the United States to capitalize on the capabilities and individual successes across the bioscience landscape. The following afternoon, the Council and leaders from industry and the national laboratories briefed congressional staffers at a joint program between the American Society of Mechanical Engineers (ASME) and the House Manufacturing Caucus.

In July 2017, *Leverage: Advancing U.S. Bioscience* was released before policymakers, experts, and representatives from industry and academia at a senate briefing on Capitol Hill, where over 100 participants heard from Council members as well as Representative Randy Hultgren (IL-14), who underscored the importance of U.S. leadership in this space.

The conversation continued in April, 2018 when the Council partnered with the California Life Sciences Association to provide a briefing in Sacramento to members and staff of the California State Legislature on the status of California's bioeconomy and to discuss opportunities to leverage the state's assets in this space.

Findings and Recommendations

- **Develop an annual strategic roadmap for the advancement of bioscience and biotechnologies to meet energy, environmental, agricultural, national security and economic goals.** The Office of Science, Technology and Policy (OSTP), research agencies, industry, national laboratories and academic experts should partner for the purpose of creating a Bioeconomy Roadmap to be implemented as a top economic priority of the incoming administration.

- **Create tools and processes that capture and analyze basic applied research data, private sector and government-funded activities, and community feedback on the Bioeconomy Roadmap's goals, objectives and milestones.** With the 2012 National Bioeconomy Blueprint 1 as its foundation, a performance indicator document is needed to review the progress of various aspects of bioscience research on a yearly basis. Information pertaining to the success of policy and science programs such as data analysis, workforce development, regulatory barriers and future federal activities will leave researchers better equipped to establish areas of improvement and increase public awareness of the importance of the bioeconomy.
- **Coordinate investments across government agencies, broaden disbursement to cross disciplinary fields, and focus federal investment in the development of research platforms that more quickly deliver solutions to society.** The diversity of bio-based products cuts across multiple industries like medicine, food, renewable energy, agriculture and many more, creating challenges when coordinating investments. A lack of investment among cross-disciplinary fields or in a diverse collection of industries may inhibit promising advancements, therefore hindering forward movement for bioscience as a whole.
- **Address the issue of public distrust of science and regulation by raising awareness and increasing education and outreach efforts to the public and policymakers.** The public perception of bioscience as a whole is incredibly important to moving forward, and scientists must remain ethically grounded to gain public trust. Combatting uninformed, negative perceptions requires improving U.S. scientific literacy through an education and outreach program that includes STEM education and progress metrics.
- **Provide opportunities and incentives for stakeholders to determine next generation bio-targets that biotechnologists can use to reinvent products and make them marketable to consumers.** The notion of using biotechnologies to recreate products with next generation applications, like chemicals and fuels that release fewer toxic gases into the atmosphere, simply does not have a strong enough economic value that will appeal to the consumer. Biotechnologists need a target with both next generation properties and next generation values in order to succeed in the market.
- **Develop widespread and easily accessible knowledge bases of principles, methods, processes, successes and failures to more quickly deliver helpful information to stakeholders.** Industry access to central scientific and technical resources will help experts develop and deliver new, innovative products to the market. This will improve the maturation and impact metrics of the bioeconomy and assist in the technology innovation pipeline from development in the laboratory to scaling-up in the manufacturing plants on to consumer outlets.
- **Enable bioscience research platforms to deliver novel and cost prohibitive capabilities to industry.** From start-ups to large companies, academic and agencies' scientists, federal and industry investments in research platforms and

bioscience knowledge bases will help overcome the steep barriers to entry for biomanufacturing and product development.

- **Address the talent gap in multidisciplinary areas where bioscience has evolved to require frequent translation of information, updating of codes, and data management skills in high performance computing.** The bioscience talent pipeline has significantly transformed and now demands non-traditional biologists who have trained skills in multidiscipline areas. There must be a frank dialogue among industry and academic leaders about workforce development so we can reestablish training and employment opportunities for graduating students and continue to expand science beyond its current capabilities.

Agricultural and Consumer Water Use

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American agriculture—including the related industries and value-add sectors that fuel and depend upon it—is a case study in innovation-driven productivity and competitiveness, and one of the United States' largest exports. Since World War II, investment and R&D in agricultural science, technology, and land and resource management have increased the agricultural industry's energy productivity by nearly 100 percent. Agricultural products and technologies remain a key component of American exports, and are a key factor in the growth of the domestic service and manufacturing economy, supporting restaurants, tourism, apparel, furniture and design.

Competition for water, climate change and new consumer demands are also driving change in the agriculture, lawn and garden, and related industries, including greater interest in new products and sustainable production processes. A changing legal and regulatory environment is facilitating the entry of new products into the market, while increasing the already competitive demand for water and energy. Inputs across the agricultural value chain are evolving, which begs a new set of questions regarding innovation and efficiency in growing and manufacturing processes.

The EMCP sector study dialogue on agricultural and consumer water use gathered national leaders and experts on water as it relates to these industries to discuss the implications for U.S. competitiveness. The day-long session focused on the role of subsidies in driving or hindering sustainable water use, the implications of increasingly unpredictable weather patterns for the agriculture, lawn and garden, and related industries, and the need for infrastructure—both regulatory and physical—and a workforce appropriately equipped with the skills necessary to manage water quality and quantity.

Leverage: Agricultural and Consumer Water Use was released on World Water Day in 2017 at the U.S. Water Partnership Annual Meeting at the State Department in Washington, DC, as well as at an event hosted by Scott's Miracle-Gro in Florida.

Findings and Recommendations

- **Invest in the technology needed to better model climate data.** As an issue that impacts the competitiveness of multiple U.S. industries, the government and the private sector must invest in the development and deployment of technologies that monitor total soil health, ocean temperatures and other climate predictors to allow farmers and researchers to better monitor and model weather patterns.
- **Create a verification system for crowdsourced data related to weather patterns and agricultural processes and inputs to facilitate a trustworthy knowledge database that comprises public- and private-sector information.** Collaborative public data can significantly increase precision and automation in water management and improve modeling capabilities and predictive future planning of crops, while improving climate forecasting in the critical three to nine month period. A verification system around individually reported data would filter quality data and allow for better, more efficient convergence of public- and private-sector data.
- **Leverage high-value crops as a test bed for innovation.** New, advanced materials such as smart membranes, fertilizers and pesticides can improve water efficiency, but research and development is often cost-prohibitive. Testing smart materials and other high-cost innovations on high-value crops would promote innovation by reducing the financial risks in the early stages of product development.
- **Better align subsidies on agricultural products with water efficiency and conservation goals.** Financial incentives and regulations must look at the entire landscape comprehensively to encourage smart water management and insulate against negative externalities, including heavy water use in water stressed areas and spiraling commodity prices.
- **Develop industry standards and disclosure processes for water use.** Financial disclosure, and more recently carbon and other climate related disclosures, are important aspects of a company's license to operate. Using baseline measurements can improve overall understanding of water use and allow for better monitoring of business operations' effects on the quantity and quality of the water they use and return to the environment. These baselines also encourage cost-saving efficiency improvements with the co-benefit of positive environmental and community-level impacts.
- **Encourage the use of reclaimed water in place of potable water where possible for landscaping needs.** Using reclaimed wastewater, which is most commonly used in irrigation, has the potential to significantly lower landscaping costs.

Increasing urban and industrial use of recycled water can be a cost-effective way to increase water supply without drawing from a limited supply of groundwater and freshwater. Many states throughout the United States have adopted guidelines for recycled water use.

- **Better align training and education programs to increase the pool of experts with skills in water management.** Educational requirements at state colleges, junior colleges and universities in horticulture and related areas often lack the appropriate level of focus on water conservation and management. This is in part due to a lack of state-level funding in the absence of extreme conditions such as drought. Increased alignment between industry and academia at the undergraduate and postgraduate levels is necessary to produce a strong talent pipeline.
- **Train upper-level managers with the skills needed to recognize the technical requirements around water management during the hiring process.** While the pool of engineers and professionals trained in water management is small, there is also a gap in knowledge among upper-level managers with regard to hiring employees with the proper skills to implement sustainable water systems and practices. A top-down approach is needed to better integrate water management into core business strategy, particularly in less densely populated areas where there is increased difficulty attracting top talent.

Energy

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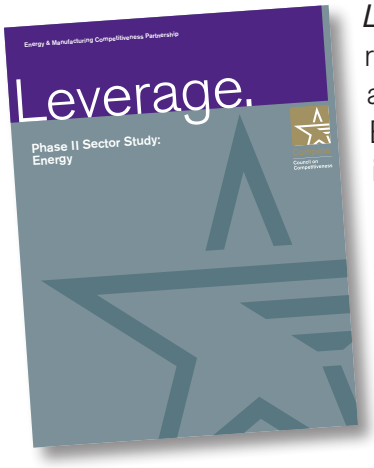
Argonne National Laboratory

Energy is the linchpin of economic growth and prosperity. In its abundance, low-cost, efficient energy can create a competitive advantage for the United States, enabling increased productivity and efficiency across industries. The country's commitment to energy efficiency has helped not only to reduce the negative environmental impacts associated with heavy industrial and consumer reliance on energy, traditionally in the form of coal and other fossil fuels, but also to reduce costs and drive innovation and competitiveness.

As the world sits on the precipice of a clean energy revolution, energy resides as an attractive investment that both supports preserving the nation's existing zero emission technologies and enables new technologies and innovative strategies to reduce our carbon footprint and remain sustainable for generations to come. But America's energy security is also an issue of national security. As we continue to advance and modernize America's energy systems, it is important to ensure grid modernization does not occur at the expense of security. Monitoring cyber

activity and guarding against infiltrations of America's grid and nuclear plants are a significant concern, and grid security is a national security risk of the highest order.

The Council on Competitiveness hosted the Energy and Manufacturing Competitiveness Partnership (EMCP) sector study dialogue on energy on May 31, 2017 in partnership with Exelon Corporation, Penn State University and Argonne National Laboratory to address these and other current issues in the energy economy. The dialogue focused on strategies for a sustainable, economically viable energy future that satisfies the sometimes-competing needs of consumers, industry and the environment.



Leverage: Energy was released in May, 2018 at Penn State's annual Energy Days conference in State College, PA. The event was attended by over 200 experts from industry and academia, and included a follow-up conversation linking the report and recommendations to Pennsylvania's energy opportunity to create regional prosperity.

Findings and Recommendations

- **Implement regulatory policies that encourage the preservation, development and implementation of more efficient, clean energy solutions.** With gains being made in efficient energy technologies, the United States is becoming more self-reliant and even an exporter of energy and energy technologies. The approach of preservation and investment provides a comparative advantage in many fuel-based sectors of the economy, increases cost-efficiency in major manufacturing sectors and promotes investment in existing and new technologies. Policymakers and regulators in the United States must embrace new scientific discoveries and modeling and simulation technologies to maximize efficiency for non-renewable energy sources and increase production of clean energy.
- **Direct funding and investment toward innovation in energy storage capabilities and clean energy technology.** It is widely accepted that innovation is responsible for one third of gains in economic growth in the United States. For example, by shifting focus toward innovation, nuclear plants have been able to increase operating capacity from 60 percent to more than 90 percent in the past 30 years. Policymakers must create incentives that accelerate the pace of change in the energy sector, which would allow for more immediate returns on innovation as well as future economic development. This includes modernizing the energy grid, updating our energy infrastructure, preserving the nation's zero emission resources and focusing on clean, resilient and renewable energy sources.
- **Secure America's critical energy infrastructure from cyber attacks.** According to the Department of Homeland Security, last year, of the cyber incidents targeting industrial control systems in the 16 infrastructure sectors designated as critical, 20 percent were in the energy sector. Technological advancements made in favor of

energy efficiency are outpacing security and will continue to do so unless we change the way we approach and implement cybersecurity strategies and practices. Protecting America's energy infrastructure against cyber-attacks is an issue of national security, and requires a model for valuation of cybersecurity and best practices that includes input from a diverse group of stakeholders from industry, academia and government.

- **Utilize national labs to develop innovative energy technologies.** The national labs, when provided appropriate funding, have the means to design improvements for reliable and efficient energy equipment such as wind turbines or oil and gas drills that are cost-effective and less prone to traditional wear. By investing in national labs and making their resources available to private entrepreneurs and innovative startups, researchers can hope to foster major technological breakthroughs in the areas of energy production and storage.
- **Guide research to the market and provide guidance on where investment can be most impactful to speed the commercialization of new technologies.** Building the bridge between universities, national labs and the business world is critical to ensure research is not stranded in universities or labs. Universities, companies and the federal government must ensure adequate and predictable R&D spending to foster technological development and the federal government must encourage investments that put the United States in a more competitive position.
- **Encourage a multidisciplinary approach to education that includes opportunities for students to learn technical skills, soft skills, teamwork and critical thinking skills from early development through post-graduate education.** Education must distance from teaching by syllabus as this stifles creativity. Policymakers must provide funding for technical education in high schools and give students hands-on training while de-stigmatizing well paying "blue collar" jobs. Students should have access to occupational engineers in hands-on problem solving, and teachers must continue to learn and communicate with industry experts to evolve science curriculum.
- **Encourage lifelong learning opportunities that allow students to gain more skills and stack credentials.** Every time a new technology is developed, there must be a ripple of new training within the industry so workers can operate these new machines and researchers can build on intermediary technologies to develop breakthrough inventions. Utilities, technical companies and labor unions can ensure their current employees' skill sets are meeting the evolving needs of the energy industry by providing education opportunities to people across diverse ages and stages of their careers.

Aerospace

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The United States is on the verge of another golden age in aerospace. Encouraging innovation the aerospace sector goes beyond U.S. competitiveness and is at the core of America's imagination. Freeing people from the confines of terrestrial travel is on the horizon and will change the world significantly. Whether aerospace manufacturing will ever reach an automotive scale, however, is still uncertain.

As a critical economic incubator for emerging businesses, the aerospace industry can provide job opportunities to help offset the loss of traditional U.S. manufacturing positions. Given the importance of aerospace business to U.S. innovation and economic progress, the industry receives strong bipartisan support from policymakers. The United States is, however, at risk of losing a key opportunity to gain an economic advantage in a growing business sector as advancements in technology, talent, investment and infrastructure on the part of global competitors begins to outpace that of the United States.

In this sixth sector study of the Energy and Manufacturing Competitiveness Partnership (EMCP), the Council on Competitiveness' dialogue on competitiveness in the aerospace sector gathered experts to identify friction points, ideas and challenges facing Introduction the aerospace sector. During the day-long session, participants focused on the respective roles of government and industry in funding and supporting basic research and applied research, the need for regulation to keep up with innovation and the importance of collaboration between industry and academia to fill the growing talent needs in this industry.

Leverage: Aerospace was released in August 2018 at an event hosted by the University of South Carolina. The event featured a follow-up conversation which sought to identify avenues through which to implement the recommendations in a way that would create economic opportunity for South Carolina's manufacturing sector.

Findings and Recommendations

- **Increase coordination between federal, state and local governments on aerospace infrastructure spending.** The United States is falling behind in infrastructure and is now ranked lower than many of its compatriots in airport efficiency. Many difficult technological problems must be solved if the aviation infrastructure needed for the future will provide the level of safety enjoyed today. Much of this stems from the disconnect of spending, as most airports are funded by state and local governments, and there is a lack of federal involvement.

Better coordination and additional government funding for basic research are needed to reclaim competitiveness in this sector.

- **Reform policy in a way that encourages and keeps up with the fast pace of innovation.** Aerospace has been a technologically driven sector from its inception. Policymakers must quickly address potential concerns around certain technological innovations, such as drones and space-based technology, in order to avoid the wealth of ethical and security concerns that could arise and regain the global lead in space exploration and travel.
- **Capitalize on America's energy opportunity to encourage innovation in the aerospace sector.** As the energy sector innovates and moves away from traditional fossil fuels, the aerospace sector has the opportunity to innovate its energy efficiency. This could include building upon innovations already being implemented in other countries, as well as in other sectors in the United States, including investment in areas from battery powered planes to solar-powered aircraft.
- **Increase the velocity of adoption of new materials to outpace global competition. It takes 10–20 years to take an aerospace material from design to deployment in the United States.** In order to maintain a competitive edge, computational techniques and methods must be applied to the qualification of new material systems through increased modeling and simulation. This will require an increased focus on science investment and commercialization and deliberate linkages between academic research and commercial deployment.
- **Build cybersecurity into aerospace technology and infrastructure.** Given the outstanding safety record of the aerospace industry and high levels of risk aversion, safety must evolve innovation, not after. As the flow of data and sharing of information becomes crucial to this sector and an increasing density of aircraft in the skies leads to a higher need for communication across the air and to the ground, cybersecurity will continue to become increasingly more important.
- **Encourage sharing of best practices between the aerospace and automotive sectors.** It is unlikely that cars and ground travel will ever be completely overshadowed by air transportation. Self-driving car models are now in development at multiple companies, with some already being tested for usability. Thus, it is necessary to think with a system-integration approach, where the two forms of travel and transport can work in conjunction for the betterment of society.
- **Promote partnerships between industry and academia to increase the talent pool.** The current promotion and tenure reward system discourages applied research, leaving a void to be filled by industry. But when viewed against the backdrop of decreasing federal research funding and shrinking R&D activity in many industries, the need for cooperation and collaboration to ensure innovation and motivation can be effectively translated into results and impact.
- **Redesign academic curricula at all levels to create a multidimensional workforce.** Creating a talent pool diverse in gender, ethnicity and skill will be essential to building competitiveness in the aerospace sector. Educators and employers

alike—as early as K-12 and up to mid-career professionals—must encourage the pursuit of opportunities in this growing industry. This might include everything from engineering competitions to opportunities through trade schools, classes offered by companies, online courses or community college offerings.

Cybersecurity

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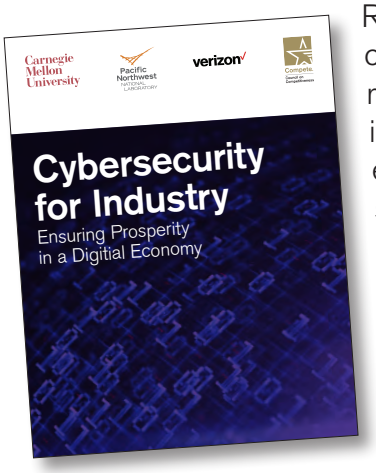
Cybersecurity for Industry: Ensuring Prosperity in a Digital Economy



Rapid advancement in cyber technology development is being fueled by industry modernization, e-commerce and consumer entertainment. The interconnectedness and openness made possible by the Internet and the broader digital ecosystem creates unparalleled value for society.

Advancements in computing, networking and communications technology permeate through every sector of the economy and are being made at a pace that is both breathtaking and unprecedented in human history. But these same qualities make securing today's cyber landscape extremely challenging. Technological advancement is outpacing security and will continue to do so unless we change the way we approach and implement cybersecurity strategies and practices.

With attribution of cyber-attacks becoming more difficult, and with these events happening at increasing rates, companies and organizations need a revised tool set to handle cyber-attacks quickly and effectively. And as adversarial AI becomes significantly more sophisticated in the next 3-5 years, the need to promote a cyber moon shot becomes increasingly more urgent. Cybersecurity is no longer a predominantly tech-related problem—due to the tremendous financial burden of cyber-attacks incurred as a consequence of disruption to operations, loss of data and cost of security among other concerns, cyber-attacks have become a risk management issue, while strong cyber defense/response can be a productivity enabler.

Despite the clear importance of cybersecurity in the current technological and political climate—and the threat cyber-attacks pose to critical infrastructure and intellectual property, and therefore to business operations and national security—resource constraints, both financial and human, are pervasive. Small- and medium-sized companies often face budgetary constraints that preclude them from affording the latest security technology. And firms of all sizes see talent shortages and knowledge gaps that leave them vulnerable to cyber risks and slow to recover from cyber-attacks.

These are just a few of the multidimensional security challenges companies in the United States face in an era marked by transformational innovation and the digitization of an exponential amount of data. These challenges, while difficult and numerous, are not insurmountable. They will, however, require collaboration on the parts of both the public and private sectors to improve America's mitigation, adaptability and resilience to the growing number of cyber threats from state and non-state actors

Initial Findings

Voluntary, industry-led cybersecurity standards, created in partnership with the government, are needed. While risk management frameworks and industry guidelines around cybersecurity exist, there is a need for industry-sponsored standards that define basic cybersecurity terms, and set security thresholds for products and systems. These standards could be used to benchmark security posture and create a competitive advantage for companies. The National Institute of Standards and Technology (NIST) could act as an umbrella infrastructure for these standards.

Security must be integrated into products and processes early on in the development cycle, rather than being considered an add-on component. As the pace of technological advancement accelerates at record speeds and products become increasingly connected through the proliferation of sensors and data, vulnerability to data theft and operational disruption increases. As the threat of cyber-attacks becomes more grave, products and processes must be designed with cyber resiliency in mind.

An overwhelming amount of data creates challenges with regard to credibility of cyber threats and ability to operationalize data. With the volume of useful, actionable information greater than ever before, a balance must be struck between information sharing required for legitimate policy interests and guarding private enterprise interests. Standardizing the gathering and valuation of cybersecurity data would improve security across all industries, but building trusted relationships is currently the best way to facilitate sharing of high-quality data on cybersecurity threats and attacks.

Cybersecurity must be transformed into a competitive advantage rather than a sunk cost by focusing on the confluence of risk, capabilities and resources. By treating cybersecurity as a pre-competitive issue, being proactive in addressing threats rather than reactive to attacks, and looking at cyber technologies and cybersecurity posture as valued capital rather than as a liability, companies can raise their security posture and insulate themselves from cyber threats. This requires more research into quantifiable risk that can enable a meaningful regulatory approach and insurance market that should in time be rewarded by the market.

All organizational levels, including company boards and C-suite leaders, must be engaged in cyber planning, response and recovery efforts. Cybersecurity is often considered the job of policy and IT experts. A shift in organizational culture across all organizational functions and levels to view cybersecurity as an issue of larger corporate relevance, rather than simply a technology problem, is necessary to improve companies' ability to protect against, respond to and recover from cyber-attacks.

Industry and academia must work together to create a baseline curriculum to educate a knowledgeable, cyber-savvy workforce. It is vitally important for the United States to have an adequate, viable cybersecurity workforce with a consistent, baseline level of knowledge. Diversity and inclusion will be essential in order to meet the burgeoning needs in this field. Hands-on experience and mentorship programs would also help increase interest while combatting the slow pace of curriculum change. It would also be mutually beneficial for industry and academia to cross-pollinate and cycle practitioners and educators through both worlds.

Cybersecurity must be integrated into educational curricula outside traditional four-year universities and post-grad studies, including high schools and community colleges. The responsibility of educating on cybersecurity and computer science should not rest entirely on college and universities. College-level courses in cyber or computer science at the high school level would help expand the talent pool. Community colleges, with the support of industry executives, should also be considered a viable option for students and a viable recruitment pool for employers.

Cybersecurity: An Issue of National Security

The digitization of society, proliferation of data and increased connectedness of products and services—particularly in America's critical infrastructure sectors— have transformed the ways Americans live and organizations operate. Yet, the tremendous growth in the level of connectivity poses risks to U.S. global competitiveness as firewalls become the next frontline for battle in the United States. As a result, cybersecurity has become an issue of national security.

The United States is facing a steady increase in the volume, types and sophistication of cyber-attacks. Organizations of all types—including industry, government, academia and national laboratories—are assailed relentlessly by efforts from state and private entities to disrupt operations, steal information and increase their own competitiveness. These threats, which come in the form of traditional cyber-crime, military and political espionage, economic espionage and cyber warfare, carry considerable costs for the United States and the world. In fact, a study by Juniper Research suggests the annual cost of data breaches will reach $2.1 trillion globally by 2019, an increase of almost four times the estimated cost of breaches in 2015.[29]

Cyber-attacks are particularly concerning when it comes to the 16 critical infrastructure sectors as defined by the Department of Homeland Security[30] —each of which plays an integral role in America's economic and national security. A reliable energy grid, for example, is essential for any institution to operate. And while the U.S. Department of Energy currently

29 The Future of Cybercrime & Security, Juniper Research, March 25, 2017.

30 PPD-21 identifies 16 critical infrastructure sectors: chemicals; commercial facilities; critical manufacturing; dams; defense industrial base; emergency services; energy; financial services; food and agriculture; government facilities; healthcare and public health; information technology; nuclear reactors; materials and waste; sector-specific agencies; transportation systems; and water and wastewater systems. https://www.dhs.gov/critical-infrastructure-sectors.

has plans to improve preparedness, response and recovery capabilities, 90 percent of the energy grid is operated by private companies—requiring strong public and private partnerships to ensure these suppliers are resilient against and have the tools needed to respond quickly to potential cyber-attacks.[31]

The increasing sophistication of cyber-attacks poses a constant threat to critical infrastructure. And as the availability of networks is called into question every day, the economic viability of U.S. businesses and the freedoms Americans exercise daily are in jeopardy.

Initial Findings

Cybersecurity should be built into industry and government contracts to incentivize broader adoption. Cybersecurity must be better incentivized using new, innovative market mechanisms. This could include building security into procurement mechanisms or advancing how technologies are measured for security in order to institutionalize the adoption of security measures across the supply chain.

A unified, clear research agenda across industry and government is needed in the cybersecurity space. When it comes to cybersecurity research, there is no clear, community-defined research agenda, resulting in duplication of efforts and inefficient use of limited financial resources. A mechanism is needed to organize the research community and marshal appropriate stakeholders and topics to shape the research agenda.

Effort is needed to connect industry with laboratory and academic research to ensure knowledge transfer and reduce duplication. Discoverability of existing capabilities—both on the part of industry and the R&D community—is a significant challenge. Better coordination would reduce duplication of efforts—both within and across these communities—and help better align research priorities and commercial needs to scale up security solutions.

There must be a clearly-articulated federal model for cyber response to critical infrastructure attacks. While numerous government agencies are factoring cybersecurity into their programming and funding, there is minimal coordination across these programs. This would decrease duplication of efforts and improve resiliency and response capabilities in the face of cyber threats.

There is an opportunity at the state or regional level to capitalize on the patriotism, altruism and tech savviness of younger generations to create coalition(s) of cyber first-responders. Current recovery times from cyber-attacks are long and static, threatening American security and economic interests. The United States needs a coordinated first-response effort to further regional cyber protection and response. One potential home for this effort could be within the National Guard.

Globally-defined, security baselines are needed and must be informed by relevant stakeholders. Useful and practical security baselines would level the playing field and set basic expectations around how systems and networks can be deployed in recommended, secure configurations. Advances

31 Cybersecurity for Critical Energy Infrastructure, U.S. Department of Energy, 2018.

must be made through the product lifecycle to improve design, default and deployment, thereby building assurance around the resiliency of critical infrastructure to cyber-attacks and disruption.

Applying automated security monitoring to critical infrastructure sectors would significantly improve cyber defense. When applied to the observe-orient-decide-act loop, continual evaluation of security through artificial intelligence and machine learning can enable adversary detection, attribution and action prediction and improve response in a way that would reduce the asymmetric advantage of attackers and level the cyber defense playing field for critical infrastructure providers.

Cybersecurity must be integrated into the academic curricula of related topics. While training cybersecurity professionals is a valuable endeavor, cybersecurity must be a key educational component for computer scientists, engineers and other professions in which security is a foundational concern. This will increase the pool of professionals with relevant and applicable cybersecurity skills across the most critical areas of need and ensure that future engineers across all disciplines are able to design and build secure systems.

Barriers prohibiting practitioners to serve as educators must be reduced. While there are significant challenges around a mismatch between supply and demand of cybersecurity professionals, academia faces the compounding challenge of a lack of educators to train the workforce of tomorrow. A strategic effort on the part of industry and academia is needed to fill this gap.

Cybersecurity: Engaging Government & Policymakers

As computing power rapidly increases, the U.S. faces the challenge of protecting the latest technology from the increasing threat of cyber-attacks. This task will only become more difficult given the rising number of devices connected to the electric grid as smart homes and buildings become the norm. Although the United States is progressively making cybersecurity a higher priority for the nation, there is still much work to be done to secure critical infrastructure.

Already at a disadvantage in comparison to its adversaries, U.S. policymakers must act to build resilience to the increasing threat and occurrence of cyber-attacks. Without a single group or entity within government designated to take charge in the face of a large-scale attack, adversaries are able to maximize their already asymmetric advantage and exploit weaknesses in U.S. response capabilities. And while agencies like the Department of Energy have taken critical steps to protect America's energy infrastructure, coordination and effective communication with Congress is necessary to ensure efficient use of the limited resources available to support nationwide cybersecurity.

Simultaneously, the challenges posed by the increasing cyber threat from state and non-state actors continue to outpace the size of the workforce equipped with the skills to mitigate the growing risk. While programs exist throughout the federal government, including the National Science Foundation's CyberCorps®: Scholarship for Service, a scholarship program to recruit and train the next generation of information technology professionals, industry control system security professionals and security managers, these efforts must be amplified in order to keep pace with the growing need for cybersecurity professionals.

Together, policymakers across all federal agencies must address the growing threat of cyberattack to the United States. Coordination and collaboration, are essential if the United States is to secure against the threat of attack, enhance cyber resilience, strengthen the cyber workforce and boost the awareness needed to remain competitive.

There must be a clear, practical model for cyber response that identifies roles and responsibilities of the public and private sectors. Numerous federal agencies currently have jurisdiction over different aspects of cybersecurity, leaving uncertainty as to where responsibilities lie in the wake of an attack. Similarly, there is a lack of clarity on the part of industry as to the requirements. Clear leadership in the cybersecurity space would help the United States maintain its competitive advantage by thwarting cyber threats.

Small- and medium-sized businesses often lack access to the knowledge and resources needed to maintain an appropriate level of cybersecurity. Much of industry is below the cyber "poverty line", meaning they do not have access to the resources needed for basic cyber hygiene, much less defending against nation-states. These businesses can serve as a gateway into larger organizations for attackers. Tools and guidance for small and medium businesses would improve supply chain cybersecurity writ large.

Tools for assessing the performance, benefit and risk associated with cyber tools must be developed. Independent consumer reports tests or assurance programs that correlate to improved cybersecurity posture would improve supply chain security and enable the uptake of proven security technologies.

The current talent pool cannot meet the rising demand for cybersecurity workers. Without intervention, the United States will experience a debilitating lack of talent to fill cybersecurity needs essential for maintaining our competitive advantage globally. Tools must be developed to train cybersecurity professionals at all levels—from first response practitioners to experts.

Cybersecurity must be incentivized as a risk management issue to raise the overall security posture of American industry and critical infrastructure. When cybersecurity is perceived by businesses as cost, decisions are made from a cost-benefit perspective rather than a risk management vantage point. This becomes a challenge as cybersecurity risks span beyond the source of the incident. Cyber protections and processes must be valued as capital rather than cost.

Security must be built into products and systems from the very earliest stages of development. The pace of innovation and technology uptake by the general public has historically been driven by convenience and functionality as opposed to security. This creates a situation where technology is used long before its security implications are understood. Creating a basic blueprint that provides a succinct path for security-enabled technologies to transition from research to market will minimize stranded research and increase the overall security posture of the United States by facilitating the introduction of new, more secure products to the market.

About the Council on Competitiveness

For more than three decades, the Council on Competitiveness (Council) has championed a competitiveness agenda for the United States to attract investment and talent, and spur the commercialization of new ideas.

While the players may have changed since its founding in 1986, the mission remains as vital as ever—to enhance U.S. productivity and raise the standard of living for all Americans.

The members of the Council—CEOs, university presidents, labor leaders and national lab directors—represent a powerful, nonpartisan voice that sets aside politics and seeks results. By providing real-world perspective to Washington policymakers, the Council's private sector network makes an impact on decision-making across a broad spectrum of issues from the cutting-edge of science and technology, to the democratization of innovation, to the shift from energy weakness to strength that supports the growing renaissance in U.S. manufacturing.

The Council's leadership group firmly believes that with the right policies, the strengths and potential of the U.S. economy far outweigh the current challenges the nation faces on the path to higher growth and greater opportunity for all Americans.

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APPENDIX A

A National Agenda for Cybersecurity

A national cyber agenda must ensure the United States has the infrastructure, technology and talent needed to build resilience to cyber-attacks, along with the ability to respond and recover in the event of such attacks.

The interconnectedness and openness made possible by the Internet and the broader digital ecosystem create unparalleled value for society. The architects of the Internet could not know, however, that it would reach the breadth and scope seen today. Throughout human history, technological advancement has outpaced security. While this is unlikely to change, America's ability to remain resilient in the face of increasing cyber threats will require a shift in the understanding of—and dynamic between—innovation and security. The evolution to a new way of thinking that focuses on deliberate, risk-informed trade-offs will be essential.

What follows are a series of concrete, actionable recommendations cutting across the public and private sectors that, taken together, will strengthen U.S. cyber defenses and ensure greater resilience in the face of growing and malicious cyber threats.

Secure America's Critical Assets and Infrastructure Against Cyber-attacks

With the average cost of a data breach in the United States at an all-time high of $7.91 million and over 1,300 significant breaches in the last year, malicious cyber activity in the United States is a substantial threat to America's economic and national security.[32] The increasing sophistication of cyber-attacks poses a constant threat to critical infrastructure. And as the availability of networks is called into question every day, the economic viability of U.S. businesses and the freedoms Americans exercise daily are in jeopardy.

1. Curtail the foreign acquisition by hostile actors of American cybersecurity assets to better manage risk. Regional powers have a growing potential to use purchased cyber tools to conduct catastrophic attacks on U.S. critical infrastructure.[33] While cyber threats from state and non-state actors come in many forms, including cyber-crime and military and political espionage, the acquisition by hostile foreign governments of U.S. cyber assets constitutes a significant security risk for the United States.

Recommendations

1.1. Require under the new authorities of the Foreign Investment Risk Review Modernization Act (FIRRMA) in the National Defense Authorization Act for Fiscal Year 2019 that the Committee on Foreign Investment in the United States (CFIUS) conduct full reviews and regulatory approval for any foreign investment or ownership interest in American advanced cybersecurity startups, joint ventures or acquisitions.

32 *2018 Cost of a Data Breach Study*, Ponemon Institute, July 2018.

33 *Task Force on Cyber Deterrence*, Department of Defense Defense Science Board, February 2017.

1.2. Require all U.S. securities and SEC-registered securities and investment funds of any size to provide the U.S. Department of the Treasury and the FBI full transparency on sources of investment capital and intellectual property, and limit partners from countries deemed high-risk or sanctioned by the Treasury Department.

1.3. Expand the authority of the Bayh-Dole Act and federal tech transfer act to prevent the licensing of U.S. cyber technology developed with federal funding to foreign countries deemed high risk.

2. Leverage public and private sector purchasing power to ensure cybersecurity protections are upfront requirements throughout the value chain. While DoD contractors and subcontractors are required to meet certain security protocols, there is no universal clause across federal procurement contracts. And, industry largely lacks a consistent approach to applying best practices for security design, development and deployment of Internet-connected devices.

Recommendations

2.1. Extend Defense Federal Acquisition Regulation Supplement DFAR 252.204-7012 language mandating adequate security to all government agencies.

2.2. Call on Congress to take immediate action on the Internet of Things ('IoT') Cybersecurity Improvement Act of 2017, requiring the inclusion of specific cybersecurity protections in procurement contracts with all federal and state agencies for Internet-connected devices.

2.3. Incentivize vendors' awareness and adoption of security best practices utilizing industry purchasing power.

2.4. Promote greater uptake and use of existing cybersecurity standards to increase supply chain security.

3. Establish a means of coordinating cyber R&D investments and research agendas. When it comes to cybersecurity research, there is no community-defined research agenda, resulting in duplication of efforts and inefficient use of limited financial and human resources.

Recommendations

3.1. Establish the National Cybersecurity R&D Initiative, chaired by the White House Science Advisor, to identify challenges, solicit industry input, define priorities and, on an ongoing basis, coordinate government investment to optimize talent and resources and avoid duplication of efforts.

3.2. Convene a Basic Research Needs working group including leaders from the public and private sectors to define a set of research priorities to address the technology R&D challenges and Science Grand Challenges that, if solved, will strengthen U.S. cybersecurity capability.

3.3. Create data-driven processes to develop specific cybersecurity countermeasures unique to sectors and sub-sectors, and disseminate these processes through Information Sharing and Analysis Centers and Community Emergency Response Teams to mitigate the risk of cyber incidents.

4. Develop, upgrade and deploy cybersecurity technology to enhance America's resilience to cyber-attacks. The pace of technological advancement is accelerating at record speeds, increasing vulnerability to data theft and operational disruption increases. As the threat of cyber-attacks becomes more grave, products and processes must be designed to meet basic security standards.

Recommendations

4.1. Require that all new technology applied to the electric grid meet industry standards to ensure basic cybersecurity.

4.2. Expand funding and private sector engagement for testbeds for the creation and adoption of new cybersecurity technologies such as Digital Manufacturing Design and Innovation Institute (DMDII) Cyber Hub for Manufacturing and the Army Cyber-research Analytics Laboratory.

4.3. Expand the NIST cybersecurity framework to better guide secure development of IoT, operational technology (OT) and information technology (IT) platforms and technologies as a means to bolster private industry certification programs.

Strengthen America's Cyber Response and Recovery Capabilities

According to the latest data, in the United States, the average time required to identify a data breach incident is 201 days, while the average amount of time to contain a breach is 52 days.[34] America's ability to detect, withstand and recover from cyber events that disrupt the economy and society in a quick and coordinated manner is essential for the nation's security and competitiveness.[35]

5. Enhance coordination across departments and agencies at the federal and state levels responsible, with the goal to improve resiliency and response to cyber threats. While numerous federal agencies are factoring cybersecurity into their programming and funding, there is minimal coordination across departments.

Recommendations

5.1. The administration should reinstate and empower a White House cybersecurity czar to oversee a government-wide interagency task force to develop and implement, within 180 days, a coordinated cyber defense strategy that includes mechanisms for owners and operators of critical infrastructure to more easily share appropriate data.

5.2. Governors should convene state and local representatives from across the public and private sectors to develop statewide cyber-attack prevention and response strategies.

34 "IBM Study: Hidden Costs of Data Breaches Increase Expenses for Businesses," PRNewswire, IBM Security, July 11, 2018.

35 "Protecting Small Businesses from Cyber Attacks: the Cybersecurity Insurance Option", Testimony of Robert Luft, Owner, Surefire Innovations, National Small Business Association, July 26, 2017.

5.3. Convene biannual meetings of the private sector chairpersons of federal government advisory committees and external boards to share agency priorities, best practices and identify areas to strengthen interagency collaboration.

6. Develop agile, mobile and technically trained state and/or regional coalitions of cyber first-responders. Current recovery times from cyber-attacks are long and protracted, threatening American security and economic interests. With the average cost of a data breach in the United States at an all-time high of $7.91 million,[36] efficient incident response is critical and current assets are insufficient.

Recommendations

6.1. Institute state Cyber Protection Teams through the National Guard Bureaus and tactical analysis groups.

6.2. Governors and state legislators must provide funding and reduce legal and liability barriers to resources acting in state capacity.

6.3. Expand to additional states existing programs[37] to provide veterans with access to cybersecurity training opportunities and resources to help veterans enter the cybersecurity workforce.

6.4. Establish and fund, at the state level, "civilian reserve cyber corps" comprising volunteers from private industry security and IT professionals to be deployed in the event of a regional cyber incident.

6.5. Create a tiered technology approach to cyber that enables technically-trained cyber experts—people who are experts in using tools but that don't require advanced degrees—to obtain the technical skills needed to act in this capacity.

7. Expand access to cyber resources for small and medium-sized companies. Small businesses—those with fewer than 100 workers—represent more than 98 percent of total businesses in the United States.[38] In fact, 58 percent of data breach victims are small businesses.[39] Small businesses estimated their average cost for incidents in the last 12 months to be $34,604.[40]

Recommendations

7.1. Sustain funding for the Manufacturing Extension Partnership (MEP) National Network and expand resources available for cybersecurity tools and training and certification such as the NIST MEP Cybersecurity Assessment Tool.

7.2. State and metropolitan Small Business Administrations should establish cybersecurity training initiatives in partnership with Workforce Development Boards to reach a broad array of small and medium-sized businesses below the cyber poverty line.

7.3 Expand federal and state outreach to small and medium-sized businesses to increase knowledge of existing resources, including top resources identified by the DHS U.S. Computer Emergency Readiness Team (US-CERT).

36 *2018 Cost of a Data Breach Study: Global Overview*, Ponemon Institute, July 2018.

37 Cyber Virginia: Cyber Veterans Initiative, The Commonwealth of Virginia, July 2017.

38 *Annual Survey of Entrepreneurs*, U.S. Census Bureau, 2016.

39 *2018 Data Breach Investigations Report*, Verizon, 2018.

40 *2018 HISCOX Small Business Cyber Risk Report,* Hiscox Inc, 2018.

8. Engage corporate leadership in the development of procedures necessary to plan for, respond to and recover from cyber incidents. Cybersecurity has become an urgent concern for companies of all sizes and across all industries. Cyber threats pose significant risks to economic security and competitiveness and have become increasingly costly in terms of detection and response.

Recommendations

8.1. Corporate cybersecurity leads should report directly to executive team members and align responsibilities with risk management strategies.

8.2. Companies should embrace the Securities and Exchange Commission Guidance on Public Company Cybersecurity Disclosures[41] and take all required actions to inform investors of material cyber risks and incidents in a timely fashion.

Develop and Deploy a 21st Century Cyber Workforce

Further adding to the growing risk of cyber threats to American prosperity, the world is on pace to reach a cybersecurity workforce gap of 1.8 million by 2022.[42] It is vitally important that the United States have an adequate cybersecurity workforce to secure the nation's critical infrastructure; respond to the ever-expanding cyber threat; and equip businesses of all sizes and governments at all levels with the talent to meet the next generation of cyber challenges.

9. Expand and upskill the cybersecurity workforce to meet the complex and growing cyber threat. The cybersecurity field faces a constant shortage of practitioners, with approximately 350,000 current cybersecurity openings unfilled, according to CyberSeek, a project supported by the National Initiative for Cybersecurity Education (NICE).

Recommendations

9.1. Ensure NSF funding for the CyberCorps®: Scholarship for Service (SFS) program meets the growing demand.

9.2. The National Science Foundation should expand and expedite the implementation of the Community College Cyber Pilot Program (C3P) under the CyberCorps® SFS program.

9.3. Congress should take immediate action to pass S. 754, Cyber Scholarship Opportunities Act of 2017 to permanently extend support for cybersecurity education in primary and secondary schools.

9.4 Expand cybersecurity awareness programs in secondary schools to increase interest and awareness of students from diverse backgrounds regarding career opportunities in the cybersecurity field.

41 Commission Statement and Guidance on Public Company Cybersecurity Disclosures, 2018.

42 *2017 Global Information Security Workforce Study*, Frost & Sullivan, 2017.

10. Reform curricula at the nations's colleges and universities to better meet the demand for cyber-savvy students and workers. The race to respond to cyber workforce needs has led to inconsistency in program quality and stove piping of expertise. The ability of academia, industry and government to address these challenges while meeting the growing workforce demand will be a key driver of American competitiveness.

Recommendations

10.1. Expand the number of colleges and universities with programs and credentials that meet the criteria required for designation as National Centers of Academic Excellence in Cyber Operations or Cyber Defense by the National Security Agency and the DHS.

10.2. Embed cybersecurity concepts into a broad range of existing degree programs at the university level.

11. Break down legal and organizational barriers prohibiting or limiting cybersecurity practitioners from serving as educators. While there are significant challenges around a mismatch between supply and demand of cybersecurity professionals, academia faces a compounding challenges of a lack of educators to train the workforce of tomorrow.

Recommendations

11.1. States and educational institutions must reduce barriers to allow cybersecurity practitioners to serve as professors of practice.

11.2. Establish industry-academia-national laboratory exchange programs to facilitate cross-pollination between cyber experts and practitioners.

Boost Cyber Awareness Among Policymakers and the Public

Human error is one of the most significant challenges when it comes to protecting against cyber-attacks. In fact, 90 percent of cyber incidents are human-enabled,[43] while as many as 24 percent of attacks may be due to employee actions or mistakes. [44]

12. Increase the awareness and understanding of cybersecurity issues among members of Congress and their staffers. With at least 36 states, D.C. and Puerto Rico having introduced and/or considered more than 265 bills or resolutions related to cybersecurity[45] and as many as 12 committees holding jurisdiction over various departments, agencies and programs addressing cyber issues, all policymakers on Capitol Hill must understand the technology and implications of cyber threats.

Recommendation

12.1. Members in the House of Representatives and Senate should reinvigorate the bipartisan House and Senate Cyber Caucuses, which have been largely dormant in recent years, to provide members of Congress and their staffers with access to experts in the field.

43 Shifting the Human Factors Paradigm in Cybersecurity, Calvin Nobles, Ph.D., March 15, 2018.

44 2016 Data Security Incident Response Report, BakerHostetler, 2016.

45 Cybersecurity Legislation 2018, National Conference of State Legislatures, May 18, 2018.

13. Increase the cyber awareness of the general public. An ever-evolving number of cyber threats target what is, in many ways, the weak link in the U.S. cyber ecosystem—the general public. Spam, phishing, spyware, malware, trojan horses and a litany of targeted consumer attacks can ruin personal financial security and be a gateway to a broader attack with the consumer as the entry point. Cyber savviness is no longer a luxury, but a necessity for all Americans.

Recommendations

13.1. Fund, develop and implement a major national cyber-awareness campaign, that builds on existing efforts, to increase the general public's awareness and capability to prepare for and respond to cyber threats.

13.2. Call on local economic development authorities to put in place programs that encourage cybersecurity education at the K-12 level.

13.3. Implement and enforce basic cybersecurity protocols throughout industry, government and academia including patching, multi-factor authentication and identity management as standard business practices.

APPENDIX B

Innovate America National Innovation Agenda

Talent

Build a **National Innovation Education Strategy** for a diverse, innovative and technically-trained workforce

- Establish tax-deductible private-sector "Invest in the Future" scholarships for American S&E undergraduates
- Empower young American innovators by creating 5,000 new portable graduate fellowships funded by federal R&D agencies
- Expand university-based Professional Science Masters and traineeships to all state university systems
- Reform immigration to attract the best and brightest S&E students from around the world and provide work permits to foreign S&E graduates of U.S. institutions

Catalyze the **Next Generation of American Innovators**

- Stimulate creative thinking and innovation skills through problem-based learning in K-12, community colleges and universities
- Create innovation learning opportunities for students to bridge the gap between research and application
- Establish innovation curricula for entrepreneurs and small business managers

Empower **Workers to Succeed in the Global Economy**

- Stimulate workforce flexibility and skills through lifelong learning opportunities
- Accelerate portability of healthcare and pension benefits
- Align federal and state skills needs more tightly to training resources
- Expand assistance to those dislocated by technology and trade

Investment

Revitalize **Frontier and Multidisciplinary Research**

- Stimulate high-risk research through "Innovation Acceleration" grants that re-allocate 3 percent of agency R&D budgets
- Restore DoD's historic commitment to basic research by directing 20 percent of the S&T budget to long-term research
- Intensify support for physical sciences and engineering to achieve a robust national R&D portfolio
- Enact a permanent, restructured R&E tax credit and extend the credit to research conducted in university-industry consortia

Energize the **Entrepreneurial Economy**

- Build 10 Innovation Hot Spots over the next 5 years to capitalize on regional assets and leverage public-private investments
- Designate a lead agency and an inter-agency council to coordinate federal economic development policies and programs to accelerate innovation-based growth
- Increase the availability of early-stage risk capital with tax incentives, expanded angel networks, and state and private seed capital funds

Reinforce **Risk-Taking and Long-Term Investment**

- Align private-sector incentives and compensation structures to reward long-term value creation
- Create safe-harbor provisions to promote voluntary disclosure of intangible assets
- Reduce the cost of tort litigation from 2 percent to 1 percent of GDP
- Convene a Financial Markets Intermediary Committee to evaluate the impact of new regulations on risk-taking

Infrastructure

Create **National Consensus for Innovation Growth Strategies**

- Enact a federal innovation strategy through the Executive Office of the President
- Catalyze national and regional alliances to implement innovation policies and innovation-led growth
- Develop new metrics to understand and manage innovation more effectively
- Establish National Innovation prizes to recognize excellence in innovation performance

Create a **21st Century Intellectual Property Regime**

- Build quality in all phases of the patent process
- Leverage patent databases into innovation tools
- Create best practices for collaborative standards setting

Strengthen **America's Manufacturing Capacity**

- Create centers for production excellence including shared facilities and consortia
- Foster development of industry-led standards for interoperable manufacturing and logistics
- Create Innovation Extension Centers to enable SMEs to become first-tier manufacturing partners
- Expand industry-led roadmaps for R&D priorities

Build **21st Century Innovation Infrastructures – the health care test bed**

- Expand electronic health reporting
- Establish and promote standards for an integrated health data system
- Establish pilot programs for international electronic exchanges on healthcare research and delivery
- Expand use of performance-based purchasing agreements

APPENDIX C

Drive. Private Sector Demand for Sustainable Energy Solutions Recommendations

Create the Foundation for Success

Global Prerequisites

Recommendation: Expand Trade and Global Growth

- Remove tariffs and non-tariff barriers for sustainable energy products and services while not creating a dual track for preferential trade liberalization
- Assure intellectual property rights (IPR) for all industrial products and services, copyrights and sustainable energy solutions

Recommendation: Take the Lead in Copenhagen

- Commit to reduce U.S. emissions on a set timetable
- Promote reduction targets for all major emitters

Recommendation: Collaborate with Developing Nations in Reducing Emissions

- Provide financial and technical support

American Prerequisites

Recommendation: Clarify Policies and Inform the Public

- Clarify and coordinate energy and environmental policies across federal agencies
- Take a "systems approach" to policy and funding decisions
- Increase America's energy knowledge
- Disclose energy and carbon data for buildings and products

Setting the Bar for Energy Efficiency

Recommendation: Reward Efficiency

- Provide tax credits and federal financing for home efficiency improvements
- Provide tax credits to accelerate the turnover to advanced technology vehicles
- Make a step change in vehicle efficiency standards and vehicle miles traveled
- Peg appliance standards to best-in-class
- Allow utilities to profit from energy efficiency so customers receive incentives

Assuring Access to Clean and Competitive Energy

Recommendation: Use it All and Price it Right

- Rationalize federal and state regulatory policies
- Drive diversification to low-carbon energy sources
- Assure renewables access to the grid
- Expedite nuclear power plant approvals and re-commissioning
- Eliminate regulatory uncertainty for nuclear waste
- Expedite construction of carbon capture and storage facilities
- Establish a price floor for gasoline
- Link the gasoline tax to CAFÉ standards
- Price carbon emissions

Jumpstarting Energy Infrastructure and Manufacturing Investments

Recommendation: Capitalize Growth and Make It Here

- Reduce the corporate tax rate
- Generate a revenue pool for infrastructure financing
- Enable high-risk, high-return energy projects
- Invest in nuclear industry expansion
- Provide a steady stream of manufacturing and job creation financing
- Designate Clean Energy Technology Manufacturing Development Zones
- Establish Clean Energy Manufacturing Centers of Excellence
- Provide federal financial investment in initial manufacturing facilities for clean energy technologies
- Incentivize production retooling and efficiency for clean energy technology production
- Enhance industrial access to HPC resources

Clearing Obstacles to a National Transmission Superhighway

Recommendation: Build it Fast and Smart

- Set national criteria for transmission siting
- Recover transmission costs on a regional basis
- Develop standards for device interoperability and security

Spawning Technological Breakthroughs and Entrepreneurship

Recommendation: Discover the Future and Break the Technology Barriers

- Provide a steady, robust stream of R&D funding
- Launch clean energy research consortia for enabling energy technologies
- Fast-track technology demonstrations and pilots for CCS and energy storage
- Fast-track demonstrations of new nuclear reactors

Mobilizing a World-Class Energy Workforce

Recommendation: Bridge the Skills Gap and Build the Talent

- Boost funding for workforce training in clean technology
- Develop and nurture world-class energy researchers and educators
- Provide full scholarships for energy-related education
- Make worker training benefits portable
- Harness global talent by amending U.S. immigration laws
- Cultivate youth interest in clean energy and environmentally-sound industry
- Give private industry a stake in creating a pipeline of workers
- Bridge funding gaps for community colleges
- Galvanize local coalitions

APPENDIX D

Make: Five Challenges and Solutions to Make an American Manufacturing Movement

Priorities

The priority recommendations from the five challenges are:

1. Congress should permanently replace the current world-wide double taxation system with a territorial tax system to facilitate the repatriation of earnings and restructure the corporate tax code to increase investment, stimulate production at scale and neutralize sovereign tax incentive investment packages.
2. Congress, the administration and industry should intensify efforts to support the President's goal to double exports from $1.8 to $3.6 trillion and reduce the trade deficit by more than 50 percent.
3. Federal, state and local governments along with high-schools, universities, community colleges, national laboratories and industry should prioritize Career and Technical Education (CTE) programs and push for greater integration of community colleges in the innovation pipeline.
4. Congress and the administration should leverage R&D investments across the federal research enterprise to solve challenges in sustainable smart manufacturing systems and to ensure a dynamic discovery and innovation pipeline.
5. Congress and the administration should drive the private sector to develop and utilize all sources of energy on a market basis while enforcing efficiency standards to ensure a sustainable supply of energy to manufacturers.

CHALLENGE

Fueling the Innovation and Production Economy from Start-up to Scale-up.

SOLUTION

Enact fiscal reform, transform tax laws and reduce regulatory and other structural costs and create jobs.

1. Congress should require agencies to begin reducing the costs and burdens of current and proposed regulations.
2. Congress should immediately reform section 404 of the Sarbanes-Oxley Act to increase entrepreneurs' access to U.S. public capital markets and grow new companies.
3. Congress should reduce the costs of tort litigation from the current level of almost two percent of GDP—some $248 billion—down to one percent by 2020.
4. Congress and the administration must take action on fiscal reform to achieve $4 trillion in debt reductions by 2021.

CHALLENGE

Expanding U.S. Exports, Reducing the Trade Deficit, Increasing Market Access and Responding to Foreign Governments Protecting Domestic Producers.

SOLUTION

Utilize multilateral fora, forge new agreements, advance IP protection, standards and export control regimes to grow high-value investment and increase exports.

1. Industry CEOs and government leaders should elevate and advance U.S. technical standards and the voluntary consensus standards-setting process.
2. Congress and the administration should ensure the President's Export Control Reform Initiative is completed by the end of 2012 and push for improved foreign export control systems.
3. Focus on actions to encourage China to make permanent the special intellectual property rights campaign it ran from October 2010 to June 2011.

CHALLENGE

Harnessing the Power and Potential of American Talent to Win the Future Skills Race.

SOLUTION

Prepare the next generation of innovators, researchers and skilled workers.

1. Congress should implement immigration reform to ensure the world's brightest talent innovate and create opportunities in the United States.
2. Congress, states, academia, industry and national laboratories should renew efforts to expand STEM education and create opportunities to integrate into the workplace.
3. The Small Business Administration (SBA) should create a program modeled after the SCORE program for retired business executives to mentor and counsel entrepreneurs.
4. Industry and labor should develop state-of-the-art apprenticeship programs for 21st century manufacturing.
5. The administration should create a Veterans in Manufacturing Program to create opportunities for America's soldiers.
6. Academia, industry and government should launch the American Explorers Initiative to send more Americans abroad to study, perform research and work in global businesses.
7. Congress should create opportunities and incentives for older Americans to remain vibrant contributors in the workforce.

CHALLENGE

Achieving Next-Generation Productivity through Smart Innovation and Manufacturing.

SOLUTION

Create national advanced manufacturing clusters, networks and partnerships, prioritize R&D investments, deploy new tools, technologies and facilities, and accelerate commercialization of novel products and services.

1. Congress, the administration, industry, academia and labor should develop partnerships to create a national network of advanced manufacturing clusters and smart factory ecosystems.
2. Congress, the administration, national laboratories and universities should advance the U.S. manufacturing sector's use of computational modeling and simulation and move the nation's High Performance Computing capabilities toward Exascale.
3. The U.S. Department of Commerce through the Economic Development Administration, in partnership with the Council on Competitiveness should expand the Midwest Project for SME–OEM Use of Modeling and Simulation through the National Digital Engineering and Manufacturing Consortium (NDEMC).
4. Accelerate innovation from universities and national laboratories by facilitating greater sharing of intellectual property and incentivizing commercialization.

CHALLENGE

Creating Competitive Advantage through Next Generation Supply Networks and Advanced Logistics.

SOLUTION

Develop and deploy smart, sustainable and resilient energy, transportation, production and cyber infrastructures.

1. Congress should increase the number of public-private infrastructure partnerships and explore opportunities to privatize large infrastructure projects.
2. Congress should authorize the Export-Import Bank to fund domestic infrastructure projects.
3. Congress should develop and implement a national strategy to reduce overall energy demand by rewarding efficiency and improving transmission infrastructure.
4. Congress and the administration should create a Joint Cyber Command to improve cyber infrastructure and protect traditional defense, commercial and consumer interests.

APPENDIX E

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Cybersecurity: An Issue of National Security

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