

From: Brown, Ron [mailto:Ron_Brown@agenda2020.org]
Sent: Wednesday, October 24, 2012 3:28 PM
To: nnmi_comments
Subject: NNMI Comments

To: NIST
Advanced Manufacturing National Program Office

I am pleased to submit the attached comments from the nation's forest products industry regarding the proposed National Network for Manufacturing Innovation. The attached file includes an overview of the forest products industry and our interests in the NNMI. Specific answers to the questions in the Request for Information are included in the document.

I would appreciate receiving a confirmation email from you acknowledging receipt of these comments. Our comments are summarized as follows:

The NNMI plan to develop a network of Institutes for Manufacturing Innovation (IMIs) offers considerable promise as a way to help manufacturing in the United States become more competitive and sustainable.

The nation's forest products industry has high interest in the NNMI and encourages a program and network of institutes that can help its domestic manufacturing operations become more efficient, sustainable, competitive, and profitable. The Agenda 2020 Technology Alliance works on behalf of many companies in the industry to promote the development of new technologies to meet critical industry needs. We are pleased to voice the views of our members and partners in this document.

As plans for the NNMI are developed, we recommend the following:

- Ensure that continuous process industries are included in the scope of the NNMI and that the NNMI is not directed solely toward the manufacture of discrete parts. Pulp and paper, chemicals, and other continuous process industries are highly important parts of the nation's manufacturing activities.
- Encourage industry-specific IMIs with a national focus rather than regionally focused IMIs.
- Promote the concept of "virtual" Institutes that connect resources and talent at multiple sites throughout the United States, taking advantage of existing facilities and expertise, and do not limit the concept to a single region and location.
- Write NNMI funding opportunity announcements that call for national IMIs targeting advanced separations technologies for the forest products industry in these two critically important theme areas:
 - Separation of wood components – pulp fibers, cellulosic nanomaterials, high-value extractives, sugar-based chemicals, lignin-based chemicals
 - Separation of components in process streams – water from fibers, chemical recovery, concentration of spent pulping streams, recovery and concentration of valuable sugars, cleanup of process water for internal reuse

IMIs centered on separations in forest products manufacturing could significantly reduce energy and water requirements and greenhouse gas emissions while stimulating opportunities for new wood-

derived products and new manufacturing capacity in the United States, thereby supporting national goals of job creation, economic growth in rural areas, and energy independence.

The forest-based sector is a genuine strength of the U.S. economy with significant economic impact, especially in rural areas, and demonstrated leadership in sustainable practices, energy reduction, and recycling. Forest-based products made in the United States from sustainably grown, renewable resources serve a broad range of global markets. The industry uses many advanced manufacturing methods, yet it needs new technologies to be developed, demonstrated, and commercialized in order to achieve its potential for job creation and economic development, and to enhance its competitiveness against industries such as plastics that require non-renewable fossil fuels.

Please contact me to discuss these comments further or to get clarification of any remark.

Sincerely,
Ron Brown

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Transforming the Forest Products Industry through Innovation



Agenda 2020 Technology Alliance

Transforming the Forest Products Industry through Innovation

October 24, 2012

TO: **Advanced Manufacturing National Program Office**

SUBJECT: **National Network for Manufacturing Innovation (NNMI)**
Request for Information on Proposed New Program
Docket No. 120418419-2419-01, Federal Register v.77, no.87, May 4, 2012

FROM: G. Ronald Brown, Ph.D. (202-463-2742 office, ron_brown@agenda2020.org)
President and Executive Director
Agenda 2020 Technology Alliance of the Forest Products Industry

OVERVIEW

Thank you for the opportunity to provide information for the proposed National Network for Manufacturing Innovation (NNMI) and to submit comments in response to the Request for Information. The NNMI plan to develop a network of Institutes for Manufacturing Innovation (IMIs) offers considerable promise as a way to help manufacturing in the United States become more competitive and sustainable.

The nation's forest products industry has high interest in the NNMI and encourages a program and network of institutes that can help its domestic manufacturing operations become more efficient, sustainable, competitive, and profitable. The Agenda 2020 Technology Alliance works on behalf of many companies in the industry to promote the development of new technologies to meet critical industry needs. We are pleased to voice the views of our members and partners in this document.

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THE FOREST PRODUCTS INDUSTRY

The U.S. pulp, paper, packaging, and wood products manufacturing industry is one of the largest industries affecting Americans, yet it is often overlooked because of its business-to-business sales and rural facility locations. Forest products companies are the only source of year-round, good-paying jobs in many rural communities and often serve as economic development engines for entire regions. The economic vitality of companies in the forest products industry is essential not only to these local communities and regions, but also to the nation's manufacturing base and overall economy, as outlined below:¹

- **The forest products industry is a major national employer.**
 - The industry employs nearly 900,000 workers and has a workforce larger than both the automotive and chemical industries (775,000 and 798,000 employees respectively).²
 - Forest products companies are among the top 10 manufacturing sector employers in 47 states.

- **The forest products industry is a major economic contributor locally and nationally.**
 - The U.S. forest products industry ships goods worth approximately \$190 billion annually.
 - The industry represents approximately 5 percent of U.S. manufacturing GDP.
 - Forest products workers earn a combined total of approximately \$50 billion annually.
 - For paper and allied products, 325 jobs are created outside the industry for each 100 jobs in the industry.³

¹ American Forest & Paper Association, Jobs and Economic Impact Fact Sheet, October 2012.

² U.S. Department of Labor, Bureau of Labor Statistics, December 2010 data.

³ Economic Policy Institute Working Paper 268

- **The forest products industry is a leader in sustainability and use of renewable resources.**
 - Forest products operations account for 70 percent of the renewable biomass energy used in U.S. manufacturing.
 - Forest products manufacturing sites are leaders in cogeneration combined heat and power systems.
 - The U.S. in 2011 recovered 66.8 percent of waste paper for reuse. The industry's goal is to reach 70% by 2020.
 - Forest products store carbon and have low carbon profiles.
 - The industry's efficient manufacturing operations continually work to reduce energy and water intensity (demand per unit of production).

While the industry has an impressive record in making its resources and products more sustainable, it is striving for more progress. Members companies of the American Forest & Paper Association have committed to achieving specific sustainability goals by 2020 in its "Better Practices, Better Planet" program, and issues regular updates on progress. The 2012 AF&PA Sustainability Report⁴ highlights progress in product recycling, energy efficiency, reduction of greenhouse gas emissions, sustainable forestry, and water reduction.

Making manufacturing operations more sustainable, with lower demands for energy and water and reduced emissions of greenhouse gases, is a key focus of innovation in the industry. New technologies need to be developed and demonstrated. Support of Federal resources on collaborative programs to address these areas will be particularly helpful as a catalyst for progress. The World Business Council for Sustainable Development (WBCSD) highlighted progress on forest-based sustainability initiatives in its recent publication, "Facts & Trends: Forests, Forest Products, Carbon, and Energy."⁵ The WBCSD emphasizes the importance of the forest-based industry as a key part of a low-carbon and bio-based economy.

The forest products sector is energy-intensive. The most recent set of EIA's MECS data indicates that the sector used 2,799 Tbtu of onsite energy in 2006, making it the third most energy-intensive of U.S. manufacturing industries.⁶ Purchased energy is the industry's third largest manufacturing cost. Innovations that target reductions in the industry's energy requirements can have a large national impact.

In order for new technologies to make a significant impact by 2050, they must be developed in the next few years due to the investment cycles of the industry. This fact is a key finding of a recent roadmapping study by the Confederation of European Paper Industry (CEPI) that investigated how manufacturers could achieve the European Union's 2050 target for 80% reduction in carbon emissions. The report, *Unfold the Future: The Forest Fibre Industry 2050*

⁴ 2012 AF&PA Sustainability Report, American Forest & Paper Association, July 2012.

<http://afandpa.org/Sustainability/>

⁵ Facts & Trends: Forests, Forest Products, Carbon and Energy, World Business Council for Sustainable Development, September 2012.

<http://wbcscd.org/Pages/EDocument/EDocumentDetails.aspx?ID=14964&NoSearchContextKey=true>

⁶U.S. Department of Energy, Advanced Manufacturing Office,

http://www1.eere.energy.gov/manufacturing/industries_technologies/forest_profile.html

Roadmap to a Low-Carbon Bio-Economy,⁷ notes that the best currently-available technologies are not sufficient and that breakthrough technologies need to be developed and deployed over the next decade.

The forest products industry is a global, interactive marketplace. The United States represents about one-third of the global industry, and its competitiveness with other regions is a continuing concern. Some regions have lower costs for labor and wood.

In many regions, such as Europe and Canada, the forest products industry receives sizeable funds from government sources for research and development purposes. In contrast, the United States has funded very little R&D directed at making the forest products industry more efficient and helping it grow.

AGENDA 2020 – ALLIANCE OF COMPANIES FOR INNOVATION

The Agenda 2020 Technology Alliance represents companies in the forest products industry that have a strong interest in developing new manufacturing technologies to make the industry more efficient, sustainable, and competitive. Agenda 2020, organized as a 501(c)3 non-profit, operates as a partnership of companies, universities, and government. It encourages innovation in the industry by identifying R&D priorities and promoting collaborative programs to address the technology needs.

The 2010 Forest Products Industry Technology Roadmap⁸ highlights numerous technology needs in six strategic areas: energy and emissions, water, wood supply, value from woody biomass, novel materials and products, and recycling. The Roadmap resulted from workshops involving more than 100 experts. It was developed by Agenda 2020 in partnership with the U.S. Department of Energy's Industrial Technologies Program and Georgia Tech's Institute of Paper Science and Technology.

Current R&D priorities from the Roadmap, which were selected as those the industry needs to be developed most urgently, include:

- Sustainable manufacturing
 - Energy – reduce energy intensity by 25%
 - Water – reduce water demand by 50%
- Value-added wood-derived biofuels and chemicals
 - Biorefineries integrated with pulp and paper mills
 - Chemicals and feedstocks from wood rather than petroleum
- Nanomaterials
 - Energy-efficient, cost-effective production of cellulosic nanomaterials
 - Applications of nanocellulose
- Forest productivity – trees with high growth rates grown for specific purposes

⁷ Unfold the Future: The Forest Fibre Industry 2050 Roadmap to a Low-Carbon Bio-Economy, Confederation of European Paper Industry, 2011. <http://www.unfoldthefuture.eu>

⁸ 2010 Forest Products Industry Technology Roadmap, Agenda 2020 Technology Alliance, available for download at <http://www.agenda2020.org/technology-roadmap.html>

Agenda 2020 is prepared to be the organizer and leader of a public-private partnership as envisioned in the Advanced Manufacturing Initiative for administration of each NNMI Institute for Manufacturing Innovation (IMI). Companies supporting Agenda 2020 in 2011 and 2012 include ArborGen, Fibria, Georgia-Pacific, Imerys, Kadant, KapStone Paper & Packaging, MeadWestvaco, Metso, Nalco, NewPage, Sappi, ThermoChem Recovery International, UPM-Kymmene, and Verso Paper.

ADVANCED MANUFACTURING IN FOREST PRODUCTS

Manufacturing in the forest products industry includes a diverse range of operations, many of which fit the PCAST definition of advanced manufacturing – activities that:

- Depend on the use and coordination of information, automation, computation, software, sensing, and networking
- Make use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences

The forest products industry fully embraces the view that advanced manufacturing involves new ways to manufacture existing products and the manufacture of new products emerging from new advanced technologies.

Modern pulp and paper mills depend heavily on state-of-the-art process information and automation systems. The measurement and control system for a paper machine is an excellent example, in which on-line sensors measure mass density, moisture, caliper, and other properties continuously on a web often less than 0.005" thick moving at speeds of 6,000 fpm. The sensor information is the basis for automated control of fiber flow to the paper machine, enabling very precise control of key product properties. Computer-based control systems for pulping and papermaking became commonplace in the 1970s, and since then have developed more and more advanced algorithms. Opportunities exist to develop, demonstrate, and implement advanced inferential intelligent control techniques.

Advances in biological science have led to dramatic increases in the rate of wood growth in sustainably managed forests. Current programs are employing new methods in biotechnology to develop trees tailored for specific end use purposes. Understanding how nature grows wood is a key to learning how to obtain and produce advanced materials.

While the industry has long been interested in manufacturing new wood-based products, a current focus is on cellulosic nanomaterials. Nanocellulose is a component of wood that occurs naturally and has unique properties and high strength similar to steel or Kevlar fiber. More efficient methods for separating nanocellulose from the rest of the wood components and demonstrating the value of nanocellulose in a wide variety of applications for many industries, such as composite structures, lightweight components for the aircraft and automotive sectors, lightweight renewable and recyclable packaging, vapor barrier layers, etc., are active areas of current R&D activity.

Implementing additional advanced manufacturing methods in the nation's forest products sector is a key to the continual growth of new jobs and investments in the United States, and will strengthen the foundation of the industry as an integral part of the nation's economic strength. The NNMI provides means of ensuring the continuing economic health and growth of the U.S. forest products industry.

FOREST PRODUCTS INSTITUTES FOR MANUFACTURING INNOVATION

The forest products industry envisions two themes for industry-specific national IMIs that have a strong technical focus on advanced separations processes, as follows:

- **Separating and isolating components of wood**
 - Separating cellulosic fibers from lignin
 - Isolating high-value nanocellulose and wood-derived nanomaterials
 - Recovering valuable fatty acids, terpenes, and natural resins
 - Processing lignin-based aromatic chemicals
 - Processing carbohydrates, especially valuable sugars

- **Separating water from solutes and solids in process streams**
 - Removing water from fibers in a paper manufacturing steps
 - Washing pulp fibers to recover pulping chemicals, reaction products, and dissolved wood components
 - Concentrating spent pulping liquors for energy and chemical recovery
 - Separating sugar streams for conversion to value-added chemicals and fuels
 - Drying paper and coatings
 - Recycling waste fiber and paper
 - Removing contaminants from water-based process streams to enable reuse
 - Processing water effluent from manufacturing operations

Separations are critically important to the forest-based sector and new technologies can help make domestic manufacture of pulp, paper, packaging, and wood products more competitive on the global stage, leading to significant investments in new production capacity in the United States and the associated jobs and economic benefits.

Each IMI will serve as a hub of excellence in manufacturing technologies that will leverage the industry's strengths in use of renewable resources to make next-generation products with continual progress in sustainability, particularly in terms of energy, carbon emissions, water, and recycling. It will promote the development of novel processes and products that will catalyze investments in new manufacturing capacity in the United States.

Each forest-sector IMI will be structured as a public-private partnership organized and led by Agenda 2020 that links industrial companies, related companies in the supply chain, universities, research institutions, community colleges, and government agencies at the national, state, and local levels. The companies will include large corporations as well as small and medium enterprises. Industry non-profit organizations and trade associations will be involved actively.

The IMI will take full advantage of existing infrastructure, including manufacturing and pilot facilities that are available at many universities and plant locations, and will build new capabilities as needed to develop new technologies that are industrially relevant and have broad applications with large potential impact. It will include shared assets that can help companies of

all sizes access leading-edge expertise, capabilities, and equipment. It will offer an unparalleled opportunity for workforce education and training for students at all levels, workers new to the industry, and experienced members of the workforce.

The organizations in this long-term partnership will collaborate to develop, demonstrate, and transition advanced manufacturing technologies into new investments in the nation's forest products industry. Each IMI will help bridge the gap between applied research and commercial implementation. Flexible teams will be formed from multiple disciplines to tackle difficult challenges. The IMI will emphasize the analysis of critical emerging technologies with the potential for transformational impact. Getting patents to protect inventions will be an important aspect of IMI management.

The Agenda 2020 Technology Alliance will oversee the development of each IMI plan. A key part of the plans will be an explanation of how the IMI will become a self-sustaining center of technology excellence that will encourage investment in U.S. manufacturing capability and new jobs.

RECOMMENDATIONS

The recommendations below are made to the Advanced Manufacturing National Program Office as it prepares requests for proposals and funding opportunity announcements for the National Network for Manufacturing Innovation:

- Plan for industry-focused national Institutes for Manufacturing Innovation as well as Institutes that are regional.
- Recognize that many elements of advanced manufacturing exist in continuous process industries such as forest products manufacture.
- Ensure that Institutes are as effective and efficient as possible by enabling virtual centers for manufacturing innovation that build upon existing facilities and expertise in multiple locations in the United States.
- Request proposals for Institutes for advanced separations technologies for the forest products industry that will contribute to national goals of energy independence, jobs creation in rural areas, and sustainable economic development.

RESPONSE TO SPECIFIC QUESTIONS

Technologies with Broad Impact

1. *What criteria should be used to select technology focus areas?*

The primary criterion should be the estimated opportunity of the focus area to have large impacts on national goals of job creation, economic growth, and energy independence. The size of the existing manufacturing base related to the focus area must be considered, as well as its geographic diversity and opportunity to benefit high numbers of people in the United States.

The opportunities of each focus area that could result from the work of an IMI should be developed through targeted roadmapping workshops and analyses that clarify technology needs and the ways in which national goals can be supported. The roadmapping activities must include knowledgeable experts from the industrial sector so that business sense is an integral part of the analysis, and it is not simply an academic exercise.

Selection of IMI technology focus areas must show a balance between continuous process manufacturing, as practiced in the chemical and forest products industries, and discrete parts manufacturing, as seen in automotive, aircraft, and similar industries.

The technology focus areas should promote the economic strengthening of large existing manufacturing industries, and not be directed only toward emerging industries and technologies. Companies with large domestic footprints want to invest in these operations with new technologies and advanced methods so they remain viable in the U.S.

2. *What technology focus areas that meet these criteria would you be willing to co-invest in?*

Advanced separation processes for forest products manufacture that enhance sustainability, reduce energy and water requirements, decrease greenhouse gas emissions, and enable the isolation of high-value components for economic value, with a clear focus on breakthrough approaches that will encourage significant new investment in U.S. production capacity.

3. *What measures could demonstrate that Institute technology activities assist U.S. manufacturing?*

To evaluate IMI proposals and project concepts for technology development:

- Projections of jobs to be created
- Estimates of economic impact locally, regionally, and nationally
- Consideration of negative economic impacts if new technologies are not developed for a specific manufacturing sector, such as paper and forest products
- Participation of a broad range of companies
- Involvement of a diverse group of university programs and government agencies
- Specific plans for education, training, and workforce development

To evaluate completed projects and programs:

- Successful transfer of technology into manufacturing operations
- Patents and licensing agreements
- Achievement of promised goals for jobs, impact, energy saving, etc.

4. *What measures could assess the performance and impact of Institutes?*

To evaluate the performance and impact of an Institute:

- Successful transfer of technology into manufacturing operations
- Level of industrial sponsorship
- Extent of funding for projects – federal, state, local, industrial, other
- Patents and licensing agreements

- Achievement of promised goals for jobs, impact, energy saving, etc.

Institute Structure and Governance

5. *What business models would be effective for the Institutes to manage business decisions?*

The management of each IMI should be the responsibility of the public-private partnership. The model that is diagrammed in Figure 4 of the PCAST report on competitiveness⁹ issued in July 2012 shows the multiple stakeholders that must be part of the IMI structure and have influence in the IMI governance.

Virtual institutes representing multiple physical locations must be allowed, in addition to the basic concept of an entire institute at one site. A virtual organization composed of resources sited in multiple locations is best for industry-centered national IMIs, in order for the best available talent and resources to be aligned with the IMI programs.

6. *What governance models would be effective for the Institutes to manage governance decisions?*

The public-private partnership should be managed by a non-profit 501(c)(3) tax-exempt organization set up for scientific purposes that is not a trade association and does not perform lobbying activities.

A Board of Directors for the IMI must include representation from all stakeholder groups: large corporations, small and medium businesses, universities, research institutions, community colleges, non-government organizations, and communities.

Technology advisory groups acting as “circles of excellence” in relevant technology areas should be established to give advice on program objectives, project selection, and progress reviews.

The Federal funding agency should avoid too much involvement in the management of the Institute. It should take a hands-off approach regarding day-to-day and month-to-month decisions.

7. *What membership and participation structure would be effective for the Institutes, such as financial and intellectual property obligations, access and licensing?*

The IMI structure should be centered on a specific industry. In most cases, an industry-centered IMI will be national in scope. The National Network should ensure collaboration and coordination among the industry-centric Institutes particularly with regard to cross-cutting technologies and approaches that promise a broad array of applications.

IMIs based on a regional design are not recommended because of the national nature of manufacturing industries in the United States.

⁹ Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing, President’s Council of Advisors on Science and Technology, July 2012.

8. How should a network of Institutes optimally operate?

Each Institute should function as a stand-alone center. The National Network should be a loose confederation sharing good practices, with minimal oversight and governance from the National Network.

9. What measures could assess effectiveness of Network structure and governance?

Since the National Network should exist to help individual Institutes perform more effectively, the best measures would relate to the extent to which good practices are shared and adopted by multiple Institutes across the Network.

Strategies for Sustainable Institute Operations**10. How should initial funding co-investments of the Federal government and others be organized by types and proportions?**

Initially, the Federal funding should range from 50 to 80% for an Institute based on its portfolio of technology development programs and their technology readiness levels (TRLs). Each Institute will have a mix of programs, some in early TRLs and some in later stages. Programs at TRLs 1-6 should be supported by 80% Federal funding since they are considered R&D. Programs involving TRLs 7-8 should be funded at 50% since they are targeting commercial-scale demonstration.

A Federal support level that does not exceed 50% will not succeed in developing breakthrough technologies. For new technologies that are likely to have large impact potential, their development costs are high and individual companies are reluctant to support them. Collaborative R&D programs funded mostly through government funds offer the best approach for making a real impact in the future.

In-kind contributions from non-Federal sources should be encouraged. The involvement of experts, use of expensive lab and pilot facilities, and support of ongoing manufacturing operations are essential for good rates of progress, and will be encouraged if in-kind contributions receive adequate recognition as a funding source.

11. What arrangements for co-investment proportions and types could help an Institute become self-sustaining?

Basing the cost of participation of a company in part on the potential economic benefit is a way to encourage more small and medium businesses to participate in the Institute.

12. What measures could assess progress of an Institute towards being self-sustaining?

The best measure is the financial support, both direct and in-kind, received from its participating companies. Growth in this measure would be an indicator of the Institute working on useful programs that attract broad industry support.

13. What actions or conditions could improve how Institute operations support domestic manufacturing facilities while maintaining consistency with our international obligations?

Establishing Institutes that directly relate to manufacturing sectors that currently have large domestic footprints will help ensure that domestic manufacturing is supported. An industry that is already well established in the U.S. has many reasons to continue investing in its operations with new technologies.

Funding Institutes to target emerging industries and technologies that can lead to investments in any nation should be avoided. These new industries do not have the U.S. base that will drive future investments domestically. Conversely, the established domestic manufacturing industries, such as chemicals and forest products, have large workforces and supply chains in place that support domestic investments in new plant facilities.

14. How should Institutes engage other manufacturing related programs and networks?

Each Institute should work to collaborate and coordinate with other Institutes, research programs, national labs, university research centers, and related organizations on areas that cut across Institute boundaries to reduce duplication of effort and to benefit from synergies in technology development. The cross-cutting programs should be visible to outside programs. In particular, cross-cutting programs for the continuous process industries offer much promise for improvements that could benefit several large national industries, such as chemicals and pulp and paper.

Each Institute should adopt an “open innovation” mindset in which the best available talent and capability is sought to address its program goals.

15. How should Institutes interact with state and local economic development authorities?

Involvement and direct participation of state and local governmental agencies should be encouraged. Many states have active programs for developing and implementing new technical approaches in manufacturing. However, the Institute must keep a primary focus on developing new technologies with local and state economic development as an outcome of the Institute’s work. The economic development agenda should not drive the technology agenda.

16. What measures could assess Institute contributions to long term national security and competitiveness?

Impacts on energy independence and economic sustainability address long-term national security and competitiveness goals.

Education and Workforce Development

17. How could Institutes support advanced manufacturing workforce development at all educational levels?

Institutes should include programs for continuing education of current workers and for training of new workers through community colleges, land-grant colleges, etc. Universities will train undergraduate and graduate students in disciplines that are relevant to the

Institute's mission. Graduate students are expected to be directly involved in Institute development programs.

Institutes should build upon and complement existing workforce development programs, rather than replacing any of them.

18. How could Institutes ensure that advanced manufacturing workforce development activities address industry needs?

Use a governance structure that sufficiently represents industry interests.

19. How could Institutes and the NNMI leverage and complement other education and workforce development programs?

Conferences, webinars, journals, blogs, and similar means of communications can increase awareness of opportunities to leverage and complement other programs.

20. What measures could assess Institute performance and impact on education and workforce development?

Satisfaction of the industry companies involved with the Institute is the best metric.

21. How might institutes integrate R&D activities and education to best prepare the current and future workforce?

The governance structure should require Institutes to address this topic.

FOR MORE INFORMATION OR TO DISCUSS THESE COMMENTS:

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