Quadrennial Technology Review

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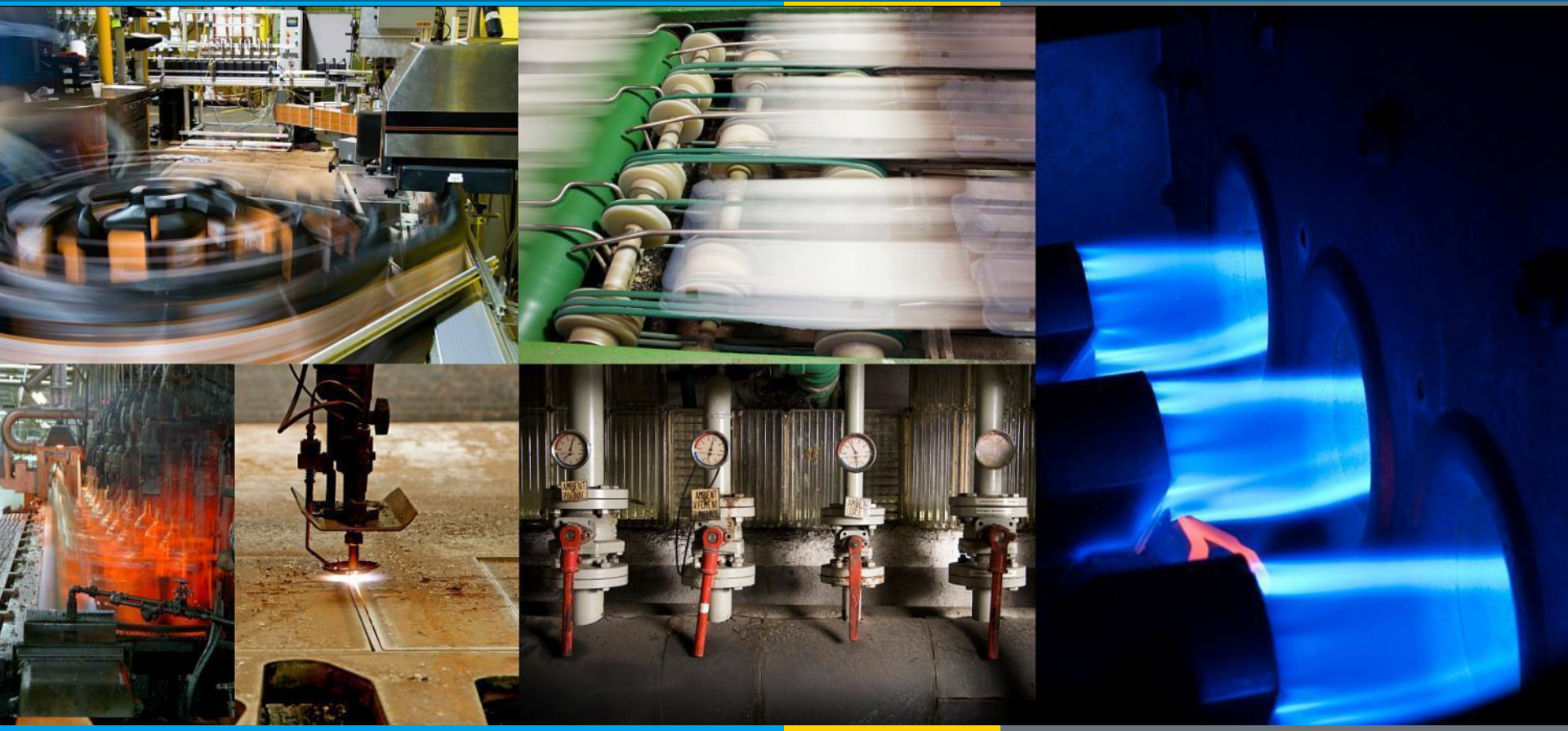

Manufacturing & Materials R&D

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Next-Generation Industry Vision

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- Innovate new, cost-competitive materials, products, and processes for the low-carbon economy
- Develop novel manufacturing methods for producing materials and components that substantially reduce energy and carbon footprints
- Revitalize the manufacturing sector by developing rapid manufacturing processes that allow for continuous innovation and shorter product lifetimes

Focus on energy-efficient, affordable, high-performing materials and processes to generate energy and carbon savings throughout the manufacturing value chain.

Reduced primary energy requirement ← **Advanced materials & processes** → **Less energy and carbon embedded in products**

TMS Vision Study and Energy Initiative

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The Minerals, Metals, and Materials Society (TMS) convened an Energy Materials Blue Ribbon Panel to create a vision for materials and identify high-value materials and processing opportunities. TMS Technical Working Groups also identified a set of innovation priorities for materials science and engineering with potentially high impacts on energy and carbon:

- **Functional surface technology** (catalysts, coatings, advanced photovoltaic materials, enhanced surfaces, etc.)
- **Higher-performance coatings for extreme environments** (high-temperature alloys, thermoelectric materials, lightweight and high-strength ductile alloys, etc.)
- **Materials integration in clean energy systems** (low-cost carbon fibers, joining for multi-materials, fuel cell catalysts, low-cost battery cathodes, etc.)
- **New paradigm materials manufacturing processes** (net-shape processing of structural materials, additives manufacturing, low-cost composites, etc.

http://energy.tms.org/docs/pdfs/VisionReport2010.pdf ; http://energy.tms.org/docs/pdfs/Opportunity_Analysis_for_MSE.pdf

Specific Next-Generation Materials Opportunities

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Next-generation materials will achieve reductions in cost, energy, and pollution with improved product quality and performance. Potential areas of R&D investment include:

Low-cost titanium

Improved performance and life in energy-intensive systems (process heaters, power generation) and other applications (aircraft, geothermal, automotive)

Lightweight metallic materials

Magnesium and metal matrix composites for structural applications in vehicles

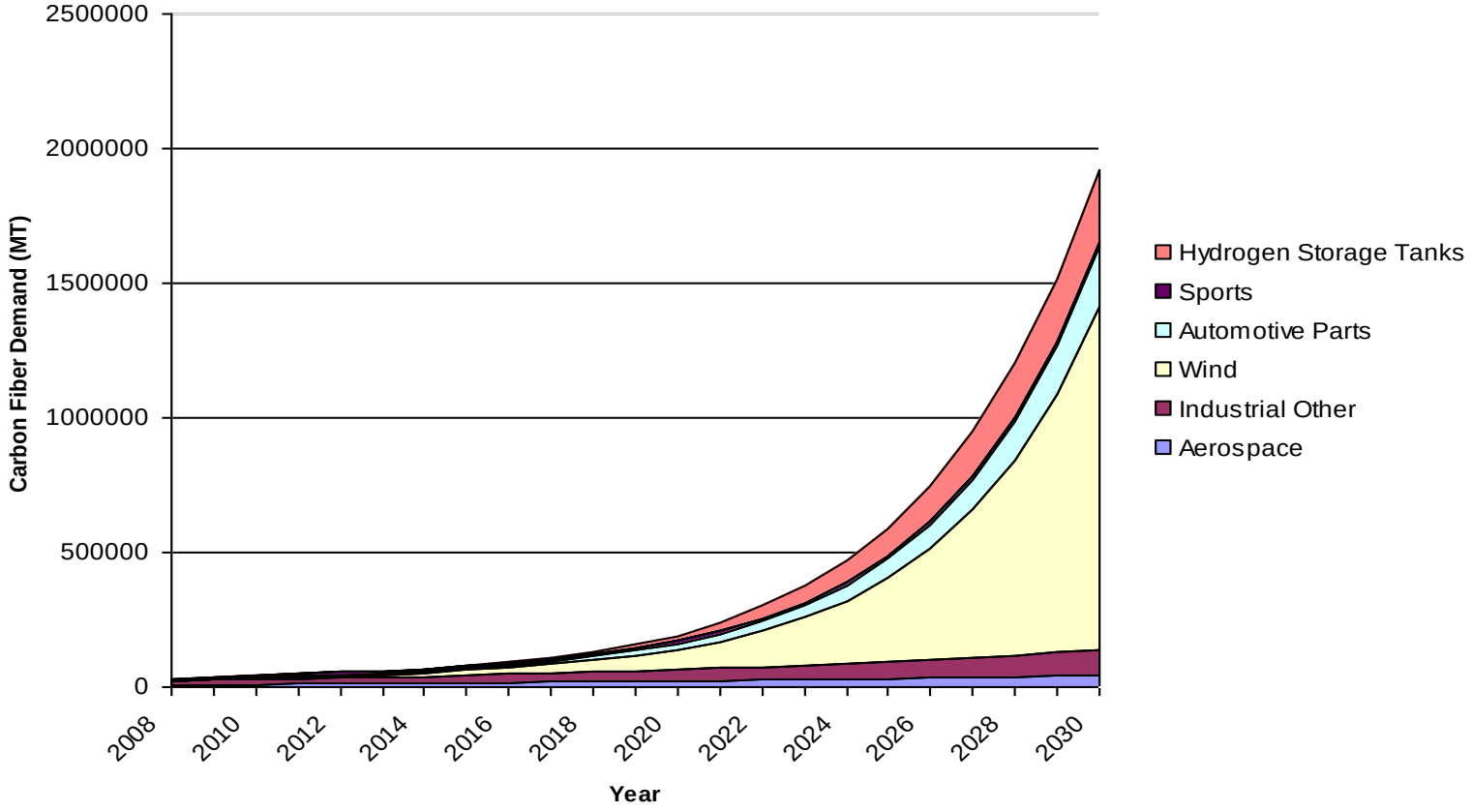
Smart coatings, thin films and electrochemicals

Materials that provide functional surface interactions, enabling a new generation of smart products

Inexpensive, high-performance carbon fibers

Wide range of clean energy applications (e.g., wind turbine blades)

Demand for New Materials Could Grow Rapidly



Source: Sujit Das, Susan M. Schexnayder, Oak Ridge National Laboratory, "Carbon Fiber Supply Chain Analysis", Energy and Transportation Science, 2010

Next-Generation Materials Opportunities (Critical Materials)

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A proposed **Energy Innovation Hub on Critical Materials** will focus the expertise of the nation's top scientists on reducing the reliance of clean energy technologies on critical materials that are rare, expensive, or mined outside of the United States.

Proposed strategic approaches include:

Materials reduction

- Ways to reduce use of critical elements in existing components

Material substitutes

- New material compositions and approaches

Recycling

- Technologies that lower the cost of separating critical elements from recycle streams and ores

For more information: *Critical Materials Strategy*, U.S. Department of Energy. December 2010. pi.energy.gov/documents/cms_dec_17_full_web.pdf

Next-Generation Manufacturing Opportunities

Provides highly efficient processing via process integration, low-energy pathways, smart systems, and entirely new technologies. Specific approaches include:

New production systems, such as innovative bioprocessing techniques:

Reduce use of fossil-based feedstocks for chemicals and materials

Advanced forming & fabrication technology:

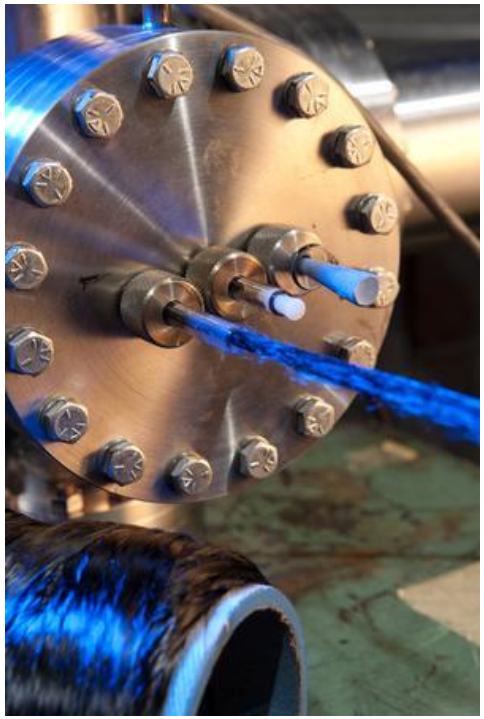
Allows for parts/product manufacture in near final form with minimal materials and energy use.

Non-thermal-based chemical conversion processes

Will lower energy use compared to thermal chemical conversion processes

High-performance separations:

Yields energy and cost savings in a wide range of industries such as chemicals, paper, food, and fuels production



Next-Generation Manufacturing Opportunities (cont.)

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Nanoscale manufacturing & processing:
Enable the next generation of materials production via low energy pathways. Achieve Higher performance materials with increased functionality produced via low energy-intensity manufacturing

Single/minimal stage conversion pathways:
Consolidated pathways dramatically lower energy use by reducing processing steps. Reduce embedded energy of finished part compared with today's state-of-the-art

Smart manufacturing systems:
Intensified use of manufacturing intelligence speeds time to market, enables dynamic demand response, and improves energy and materials performance through seamless process optimization across the value chain.

Thank You