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Bringing it all back home" How waste-to-energy is good for energy, the environment, water, and society

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Around the world societies want better access to affordable energy and water while protecting the environment. Health and happiness are dependent on finding the answer. Biomass and waste materials offer the opportunity to provide energy and clean the environment without competing for food. Using renewable resources such as biomass and waste materials requires deeper insight than using fossil resources such as coal, oil, and natural gas. Renewable resources primarily use solar and have the potential to reduce greenhouse gas emissions. Renewable resources are more distributed and less dense than fossil resources so bio-refineries must be designed at smaller scales than oil refineries. About half of the weight of renewable resources is oxygen. To manage the oxygen content requires either addition of hydrogen or loss of carbon as carbon dioxide. Adding hydrogen requires energy and losing carbon decreases yield so compromises must be made. Fossil resources have very little oxygen. "Bringing it all back home" is a way to build a strong economy while protecting the environment. You avoid depletion of resources by starting with renewable resources and then reusing them. This includes energy, water, and materials. This approach to sustainability could benefit the US. When fully implemented it could reduce conflict for resources. We will discuss the types of energy needed for society, how renewable resources could provide that energy, new technologies for converting feedstocks and recovering the purified products, the costs for producing energy and materials from renewable resources, and policy and regulations that impact production. Separations and product recovery can account for more than half of the costs for using renewable resources. We will discuss state-of-art technologies that use electricity to recover valuable renewable products. We will discuss advanced methods to enhance anaerobic digestion to convert waste materials to renewable natural gas. We will discuss how to effectively utilize nutrients to protect cropland and produce bioenergy. Finally we will describe how these new technologies improve water quality to ensure a safe water supply and a clean environment.

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Intermediate-temperature fuel cells for distributed generation

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While large, centralized power generation systems offer excellent economy of scale, they suffer from efficiency losses and vulnerability to power outage due to required long-distance power transmission; it is also challenging to manage the mismatch between power generation and demands and to integrate renewable energy sources into centralized systems. Fuel cells are ideally suited for distributed power generation, producing power where it is used. Among all types of fuel cells, solid oxide fuel cells (SOFCs) are the cleanest and most efficient option for direct conversion to electricity of a wide variety of fuels, from hydrogen to hydrocarbons, coal gas, and bio-derived fuels. However, their commercialization hinges on rational design of novel materials of exceptional functionalities at lower temperatures to dramatically reduce the cost while enhancing performance and durability. To accomplish this goal, it is imperative to gain a fundamental understanding of the mechanisms of charge and mass transport along surfaces, across interfaces, and through porous electrodes. Further, new protocols must be developed to control materials structure, composition, and morphology over multiple length scales, thus producing nano-porous materials with more accessible surfaces of much higher functionalities and with shorter diffusion distances for greatly enhanced rate capabilities. This presentation will highlight the critical scientific challenges facing the development of a new generation of intermediate-temperature fuel cells for distributed generation, the latest developments in modeling, simulation, and in situ characterization techniques for unraveling charge and mass transport mechanisms, and the outlook for future-generation fuel cells that exploit nano-scale materials of significantly improved performance.

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