Energy Storage Across Scales:
Energy Storage as the Cornerstone of Renewables, Mobility, and Smart Grids

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The transition of our energy systems from fossil to renewable sources is one of the big global challenges of the 21st century. There are different scenarios how our energy demand can be satisfied in a sustainable manner ranging from nuclear fusion power over efficient storage of volatile wind and solar energy to biomass utilization strategies and energy efficiency improvement. Each approach is connected to multifold scientific and engineering challenges. No one single scenario will turn out to be largely superior to others, and instead a combination and stepwise integration with continuous optimization of different approaches will be necessary. The major driving force for this transition is the direct link of our current energy supply with CO_2 emissions and climate issues. Reliance upon unevenly distributed and geopolitically strained oil & gas reserves also generates impetus for a renewable energy transition. But the intermittency of renewable energy remains a challenge, and large reserves of energy storage are needed. The energy density of mobile electric energy storage (such as batteries) remains a limiting factor in the adoption of electric vehicles that could use renewably generated electricity. Much of the grid energy storage discussion in the past has been divided between large, fixed, high capital projects like pumped hydro, or smaller, distributed resources like batteries in community energy storage systems. Batteries remain one of the few technologies with a modular footprint that can meet both small and mobile or large and stationary energy storage demands. However the largest, most untapped energy storage potential is in the form of chemical energy storage, which is often left out of the general energy storage discussion. It too, can cover both the mobile and stationary segments.

This session aims to cover the entire scope of energy storage. It will describe the potential of new battery innovations and their impact on the present scope of technology and its evolution in the coming decade, as well as the untapped potential and scope of chemical energy storage technologies that could transform chemical production and fuels. We will focus on the consequences of an increased use of wind and solar power. While in particular in the latter case, the optimization of the efficiency of the energy harvesting process itself is a frontier of engineering in its own right, we want to emphasize the downstream challenges that are related to making an intermittent energy source safely satisfy a stable energy demand.

The session chairs will give an introduction into the topic and an overview of different actions and approaches that are currently discussed. They will deliver a systemic view on energy generation and transformation and define some boundary conditions for changes in the energy system. Also a short techno-economic analysis of selected approaches will be presented. They will address past and future solutions for grids that are capable of fast spatial and temporal adjustments of the energy supply as they can respond to the fluctuations of wind and solar power, they contribute to the integration of renewables into our energy system and mitigate the problem of energy storage.

Our guest speakers will then address the following sub-segments of the energy storage issue:

1. Batteries on the Grid: Opportunities, Challenges, and New Opportunities (Colin Wessels)
2. Safety in Li-ion Batteries: State of the Art in Separators (Brian Morin)
3. Options for Chemical Storage of Renewable Energy(Thomas Aicher)
4. Chemical Energy Storage: Bridging Catalyst and Process Design (Regina Palkovits)

Batteries for grid scale energy storage offer the fast response required for short term grid instability such as frequency response and voltage drops. These power applications require high C-rates (discharge and charge currents) that can be met with many batteries. However there is a challenge when these batteries are also needed for energy applications, such as peak shaving, load shifting, and backup power. Batteries that address both needs are needed. Our first speaker, Dr. Colin Wessels of Alveo Energy, will describe a new innovation in batteries using Prussian blue, which is commonly used as a blue pigment.

Present day Li-ion batteries still have limitations in power and energy density. Their limits of performance are not necessarily determined by the electrochemical reactions within their structure, but in the stability of the materials assembly that makes the battery. Our second speaker, Dr. Brian Morin, will describe how novel new materials for battery separators are being used to enhance the thermal stability of Li-ion batteries and permit greater energy and power density, addressing major needs for both mobile and stationary storage.

In many applications like the heavy-duty transportation sector require chemical fuels with high energy density. One important goal is thus the system integration of renewable electricity generation with the production of synthetic fuels to store peak energy.

Hydrogen can be such a primary “solar fuel”, and our third speaker, Dr. Thomas Aicher will address different options of hydrogen production ranging from heterogeneously catalyzed gas-phase reactions to thermochemical hydrogen production. He will also provide a technical and economic perspective of power-to-liquid processes, e.g., for methanol or diesel substitute production from CO_2 and H_2, and compare the different routes. Finally, chemical engineering challenges for the required dynamic operation of chemical processes linked to intermittent energy sources will be addressed.

In addition to direct CO_2 utilization approaches, also biogenic feedstocks can be used to synthesize suitable fuels as liquid energy storage systems. Our fourth speaker, Prof. Dr. Regina Palkovits, will address that chemical challenges that are related with the valorization of biomass to biofuels from a catalyst development and process engineering perspective.