

# 2012 Energy Storage Symposium

**Klaus Lackner**  
Columbia University

**Welcome and Introduction**

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# Understanding the role of storage

- **In innovative, sustainable energy infrastructures**
  - Carbon neutral, net zero emissions
- **Lenfest Center: carbon management and air capture**
  - Protecting liquid fuels from climate change concerns
  - Air capture for closing the carbon cycle with synthetic liquid fuels
- **Risø and DTU: renewable energy, fuel cells**
  - Wind energy growing to 50%
  - Fuel cell technology
  - SOFCs and SOECs offer a path to synthetic liquid fuels

**Liquid fuels make for good long term and high density storage**

# Energy Resources

renewable



nuclear



fossil



# Energy carriers



# Electricity

- Clean at point of consumption
- Efficient in application
- Responsive and flexible for stationary applications
- Supports high power demands
- Many different sources
- Much energy is lost in conversion

# Liquid Fuels

- High energy density
- Supports high power densities
- Emission of CO<sub>2</sub> at point of consumption
  - Requires air capture in the transportation sector
- Transportation sector needs liquid fuels
  - Air planes, heavy trucks
- Provides storage for electricity

## Energy storage in the transportation sector

- Expensive energy on board of vehicles
  - Large energy demand
  - High energy density
  - Storage times: days to weeks
- Carbon constraints
  - Liquid fuels require CO<sub>2</sub> capture from air



## Energy storage in the electricity sector

- Raw resource vs. user demanded power
  - Only difference is value
- Need storage for arbitrage
  - Low cost of round trip
  - Storage times from seconds to years
    - Phase stabilization to seasonal demand variations

# Storage characteristics

- Round trip efficiency
- Energy density in storage
- Power density in storage
- Cost of storage per unit mass
- Practical storage times
- Cost of storage per unit time

**Different horses for different courses**

Technical University of Denmark  
DTU Energy Conversion/Department of  
Energy Conversion and Storage



Lenfest Center for Sustainable Energy  
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Wednesday, May 2 – Thursday, May 3, 2012  
Columbia University

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