

# ENERGY TRANSITION – BEYOND FOSSIL ENERGY

A scientific view on sustainability

The “energy transition” is frequently framed as a fuel switch, or as a renewable based full electrification, yet a scientific sustainability assessment shows a coupled problem: **neither the current energy system nor the current material economy is sustainable.** Decarbonizing supply -if it is possible at all - without redesigning material flows risks shifting burdens from carbon to resources, waste, and land. This talk adopts a systems and physical-science perspective to examine the dual transformation required **to move from a linear** (extract–make–dispose) **regime to a circular, low carbon industrial metabolism.**

We focus on the dominant scientific and technological constraints: first of all the decarbonized energy system, intermittency and grid stability at high renewable penetration; long duration and seasonal storage; scalable production of low carbon molecules (H<sub>2</sub>, NH<sub>3</sub>, e fuels) for hard to electrify sectors; high temperature industrial heat; and deep decarbonization of cement, steel, and chemicals. **We highlight why many options remain limited by thermodynamics, kinetics, catalysis durability, materials degradation, separation entropy, and infrastructure lock in.** Several pathways exist only at pilot scale; others require breakthroughs in catalysts, membranes, electrochemistry, circular polymer design etc.

The presentation maps research frontiers and scale-up bottlenecks, arguing that the decisive challenge is inventing, integrating, and scaling technologies fast enough to meet physical, economic, and planetary constraints.

By combining scientific evidence with practical transformation levers, the session aims to provide a forward looking view of how societies and industries can move beyond fossil energy and simultaneously reshape the material world to achieve a genuinely sustainable and resilient future.

But the question remains open: What will challenge us more in the transition ahead: the scientific breakthroughs we must achieve, or the transformation of human mindset and behaviour required to make them work?