

King Abdullah University of
Science and Technology



CENTER FOR ADVANCED ENERGY CONVERSION SYSTEMS

KAUST Technical Symposium

May 28, 2008

Jeddah, Kingdom of Saudi Arabia



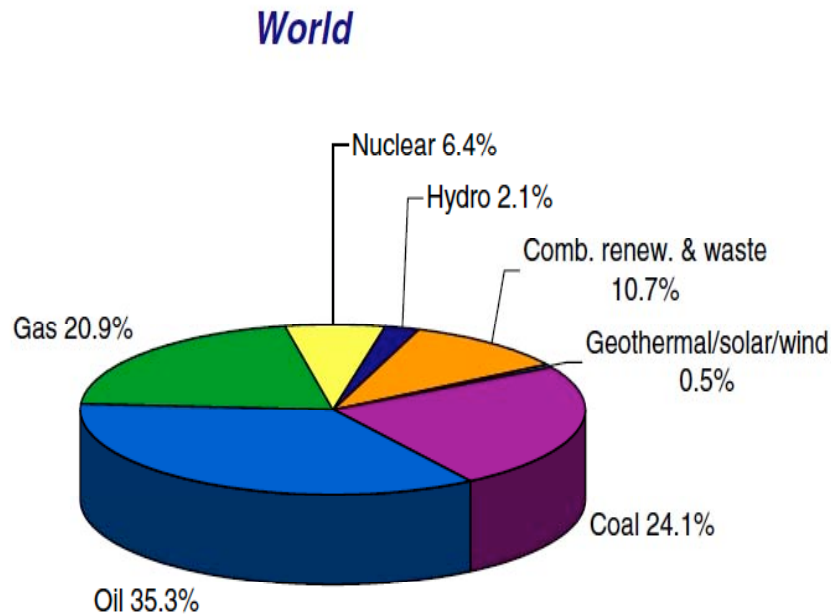
The Energy Challenge



REALITIES that demand REAL solutions:

1. Energy consumption rates are rising; fast.
2. Growth rates are higher in the developing world.
3. Energy prices are getting more expensive.
4. Heavy hydrocarbon resources are massive.
- 5. CO₂ and global climate change have been recognized as significant environmental concerns.**
- 6. Addressing these concerns calls for new science and engineering, and for world leadership.**

Energy Consumption



Energy Information
Administration, EIA 2007

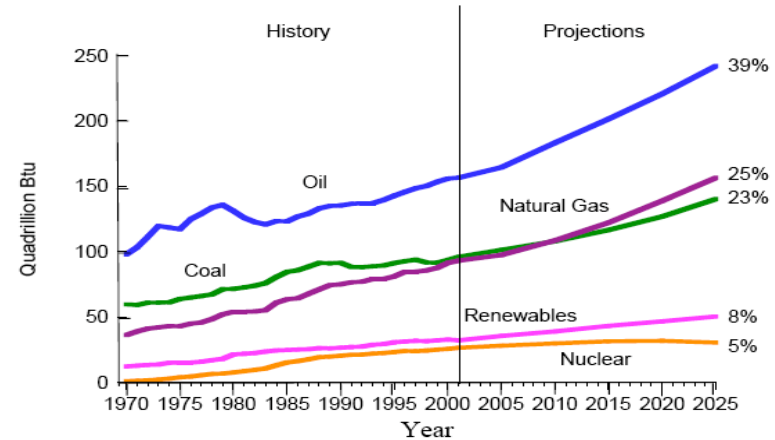
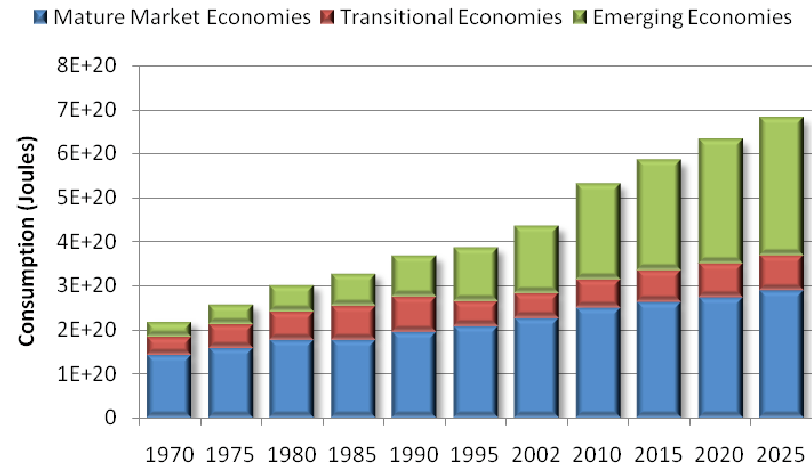
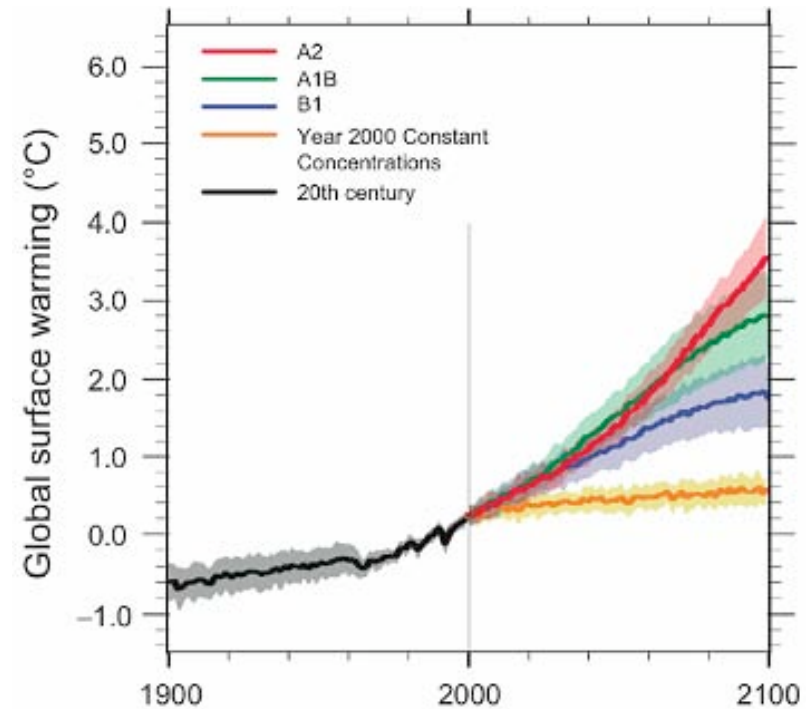
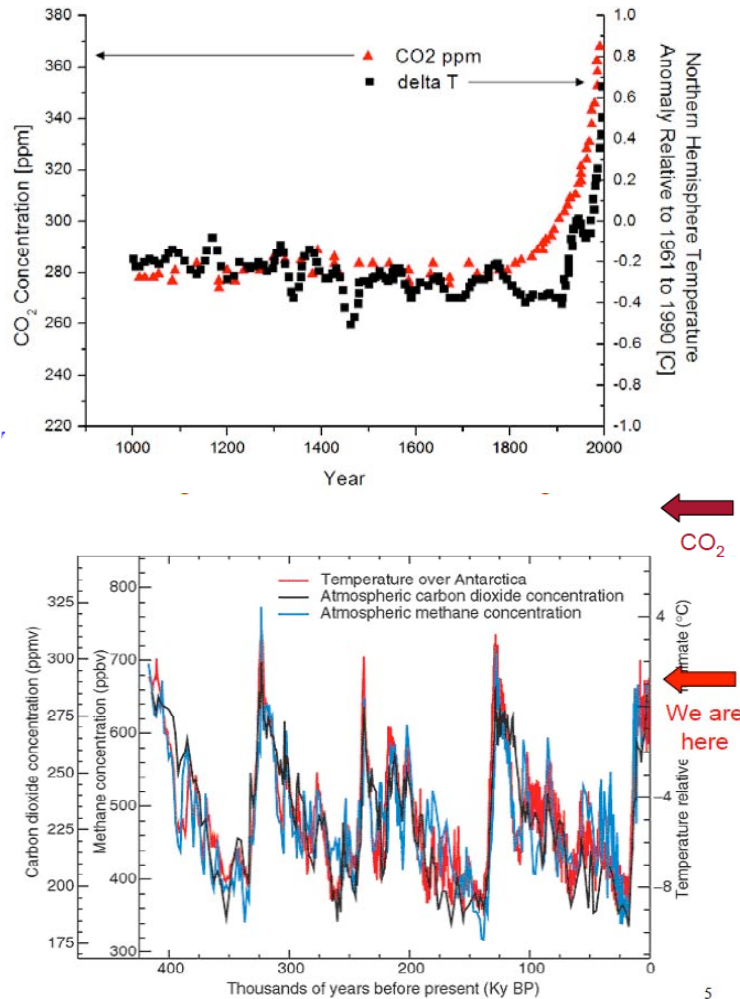


Figure 4. World marketed energy consumption by source⁹



CO₂ Emissions and Global Climate Change!



The World needs an insurance policy against the potential perils of rising temperature.

Portfolio of Solutions

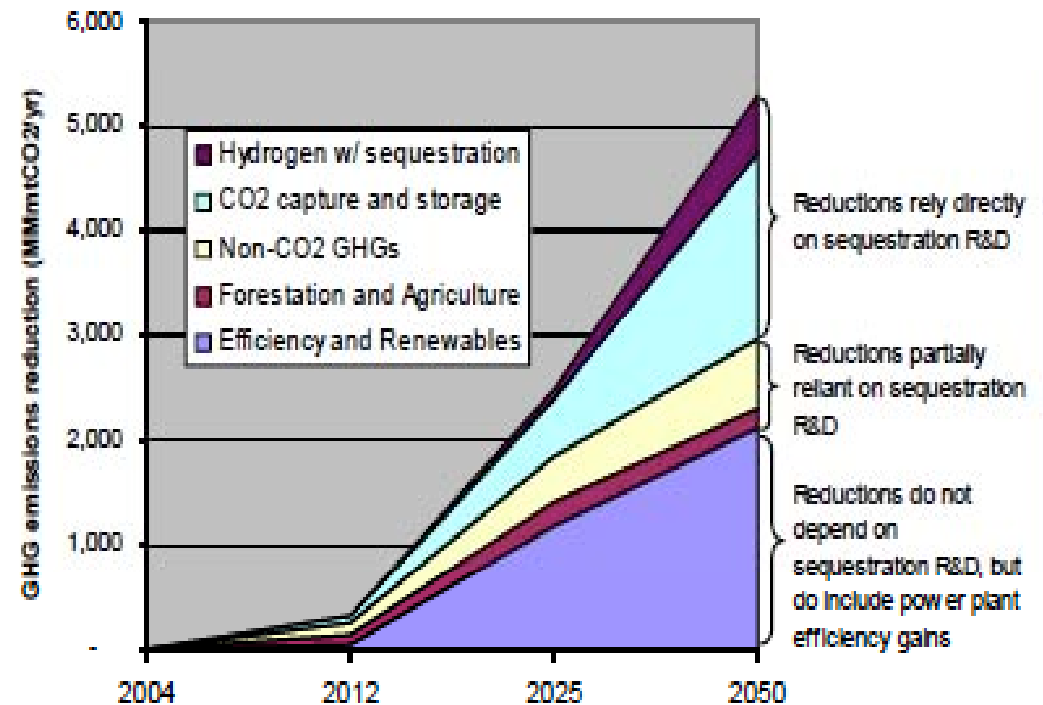
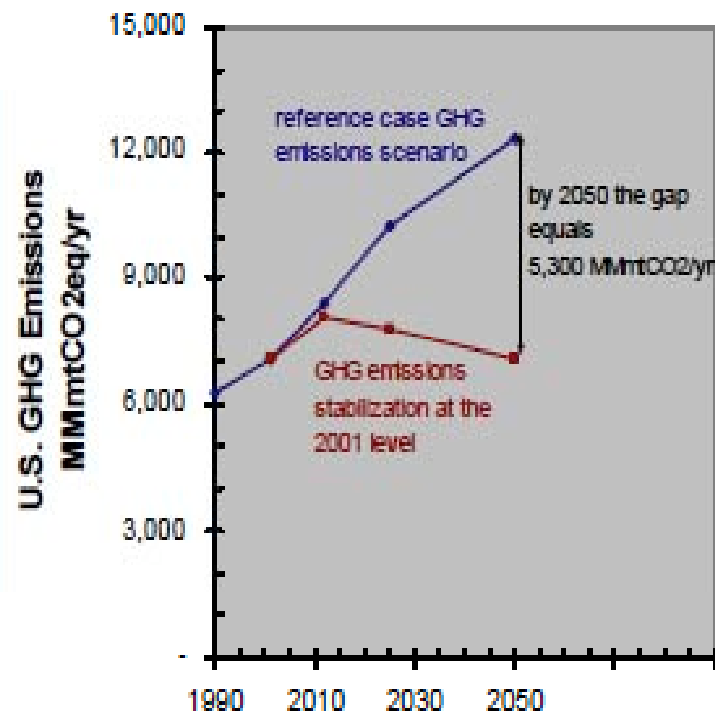


- Substantial improvement of energy conversion and utilization efficiencies.
- CO₂ capture and storage technologies for stationary (and possibly mobile) sources.
- Accelerated deployment of carbon-free energy (the *Sun* at all scales and in all forms).
- Addressing the transportation challenge.

Portfolio of Solutions



Figure 2. U.S. GHG Emissions Scenarios ... and Technologies to Fill the Gap

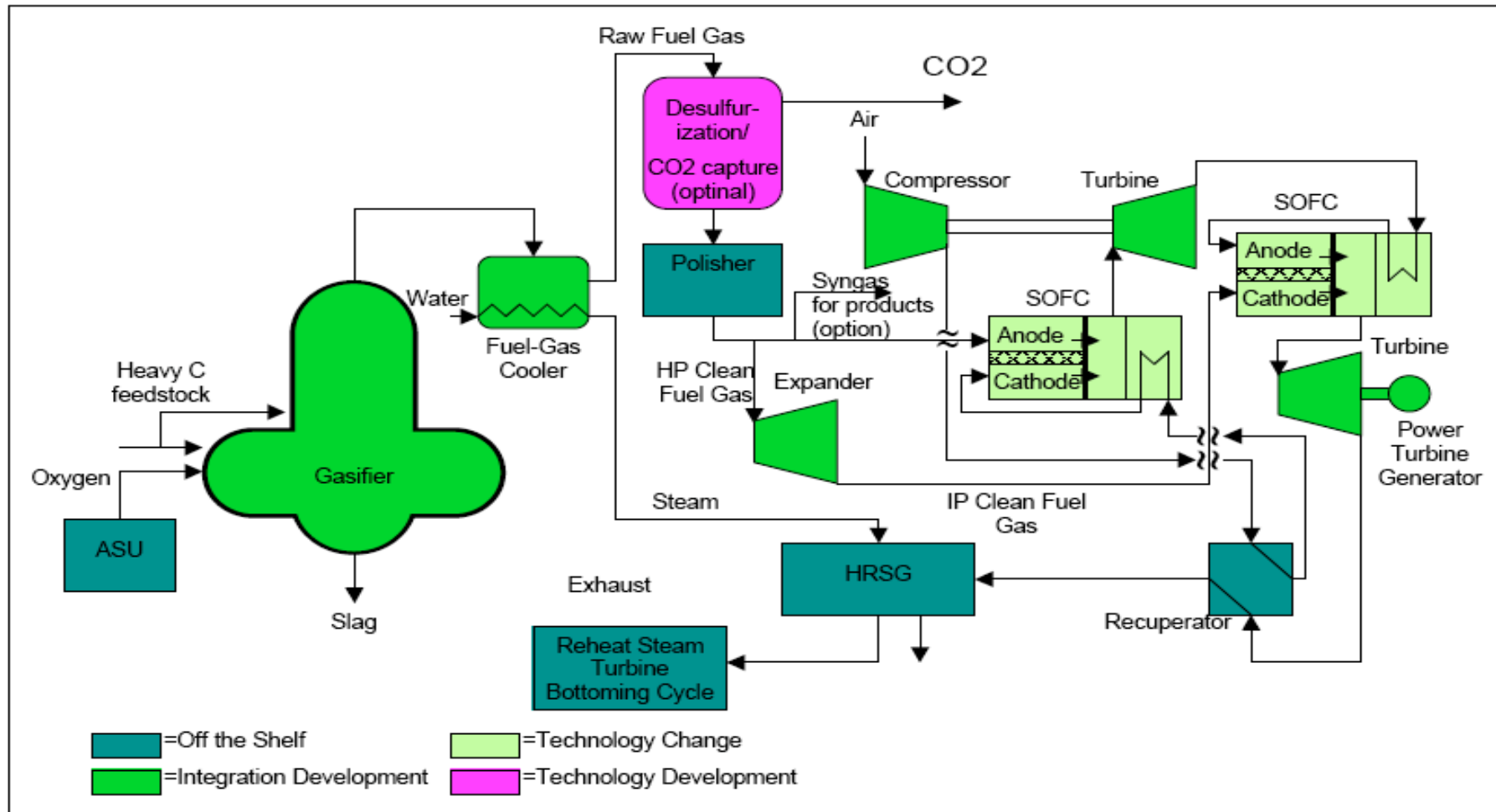


Scenario for High Efficiency, Low-Impact Energy

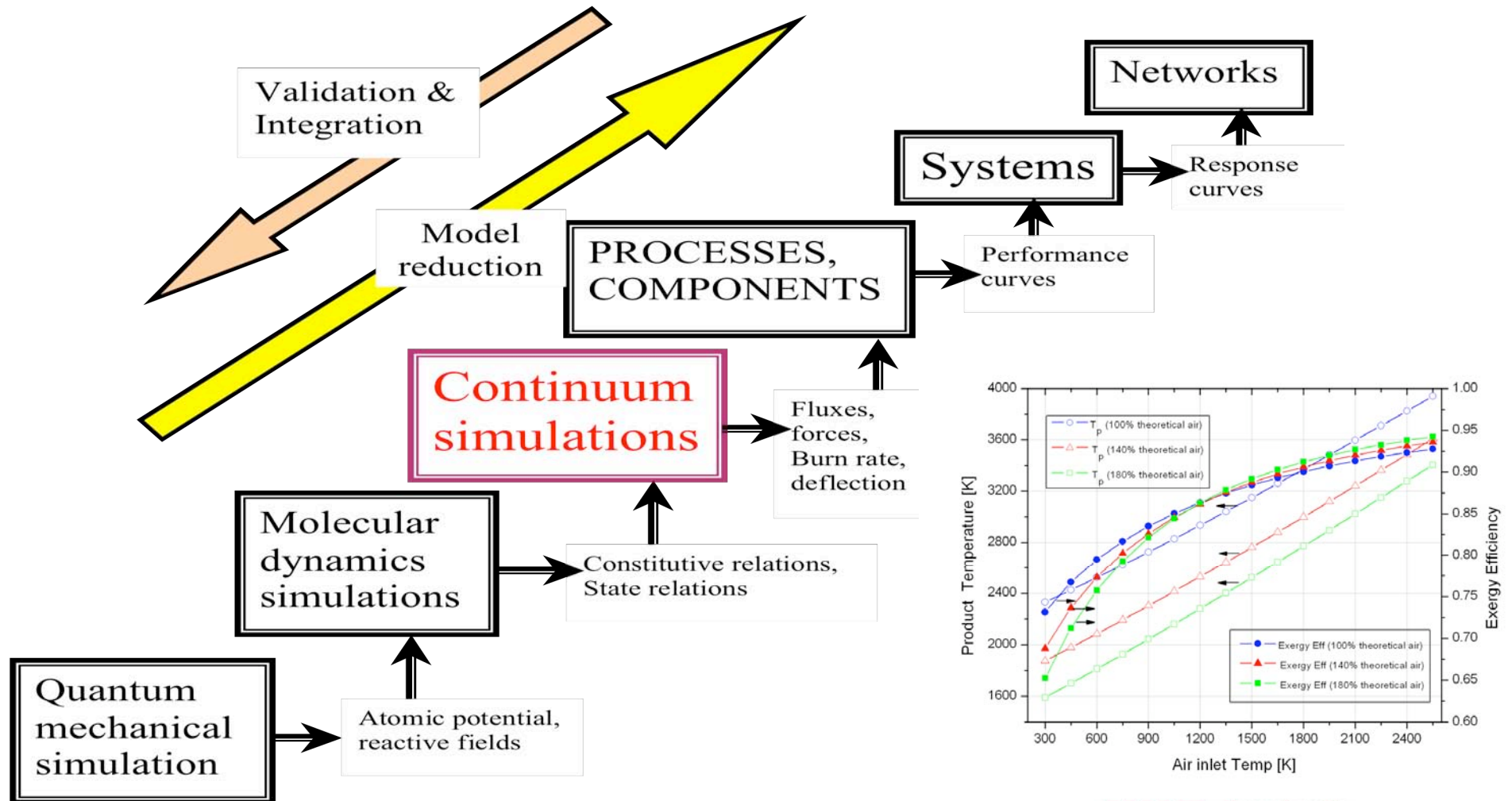


- Energy conversion systems are likely to undergo significant changes to meet the new challenges of *affordable, low-C energy* from a variety of sources.
- New knowledge, tools, technologies and expertise, mostly *interdisciplinary and integrated* across several domains, are needed to meet these challenges.
- Solutions must be deployable at *scale* to be effective, and knowledge must be made available globally and without the usual economic/social/geographical barriers.
- KAUST programs and institutions embody this approach of knowledge generation, integration and dissemination.

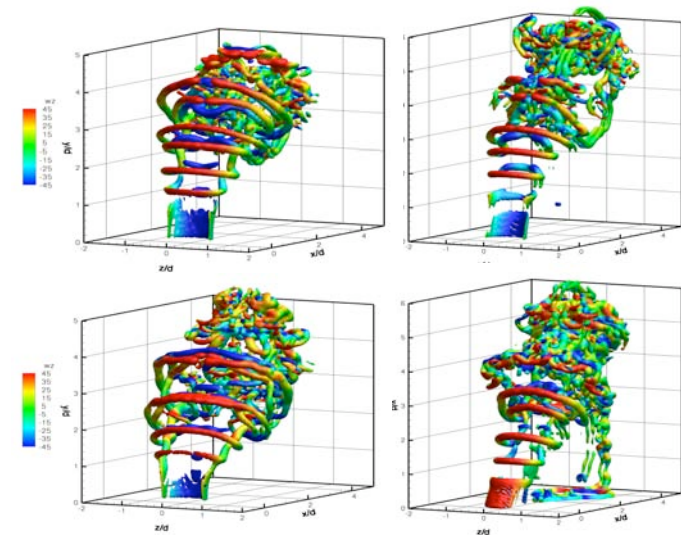
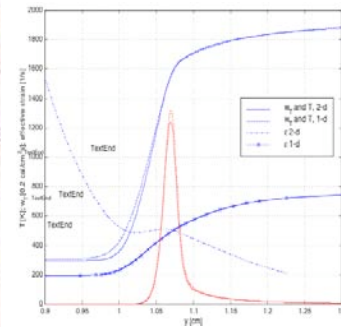
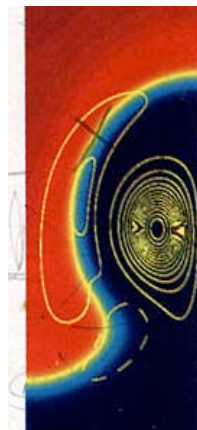
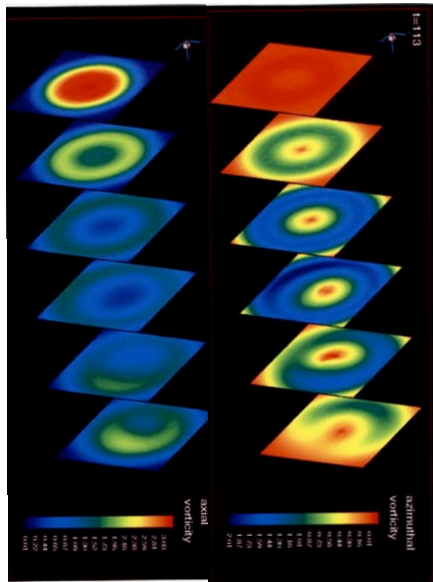
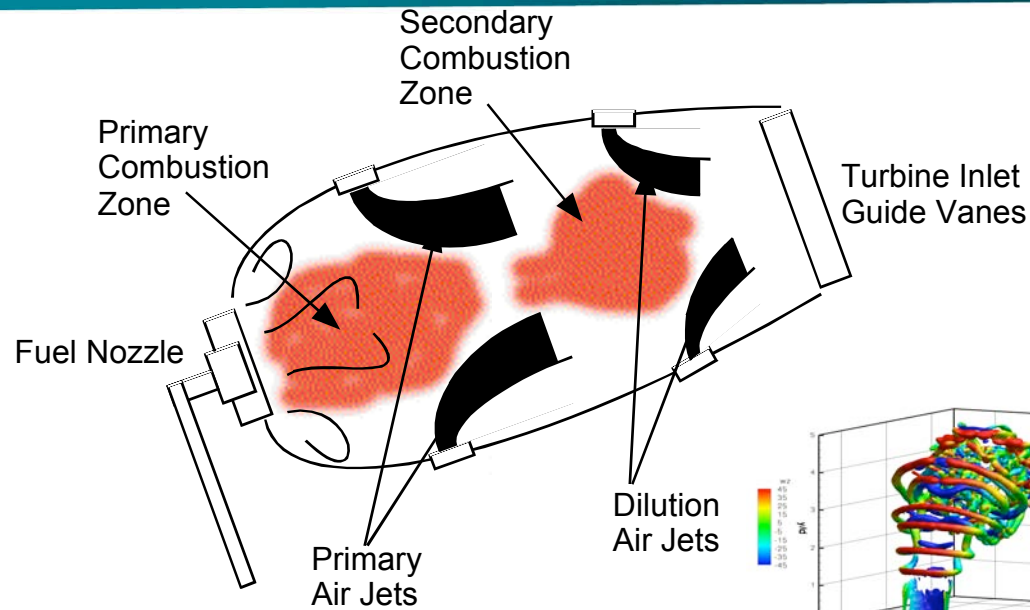
High Efficiency, Hybrid, CO₂-Capture Ready Power



Multiscale Simulations in Integrated Energy Systems



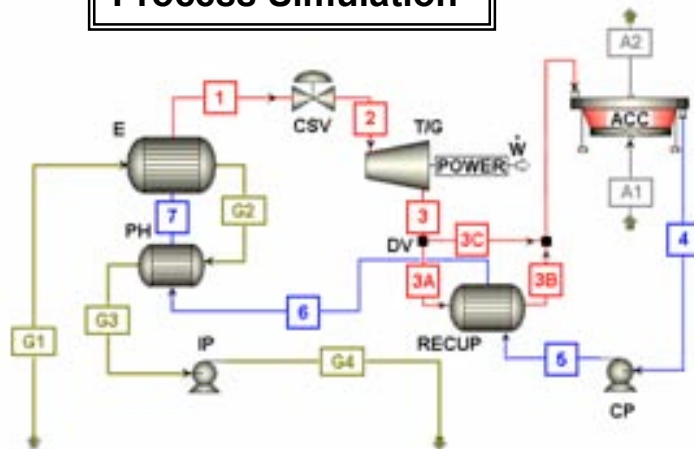
Multiscale Simulations in Turbine Engines



Multiscale Quantum to Process modeling (under extreme conditions)

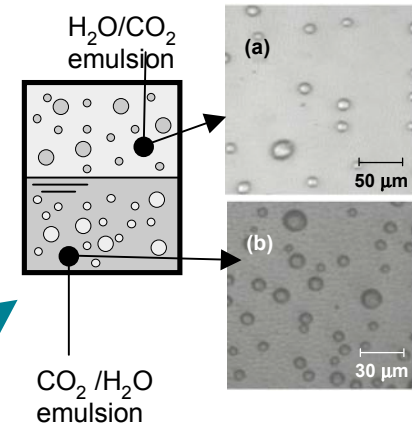


Process Simulation

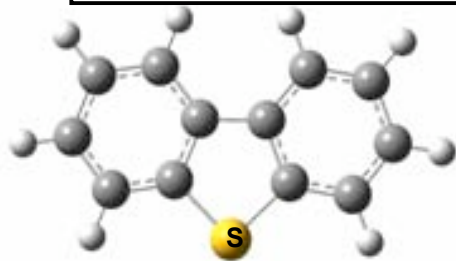


Work with Tester and Green

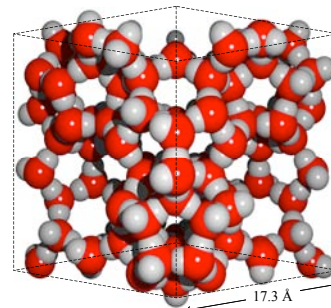
Continuum Transport-chemistry interaction



ab initio quantum chemical calculations



Dibenzo[*a,h*]thiophene



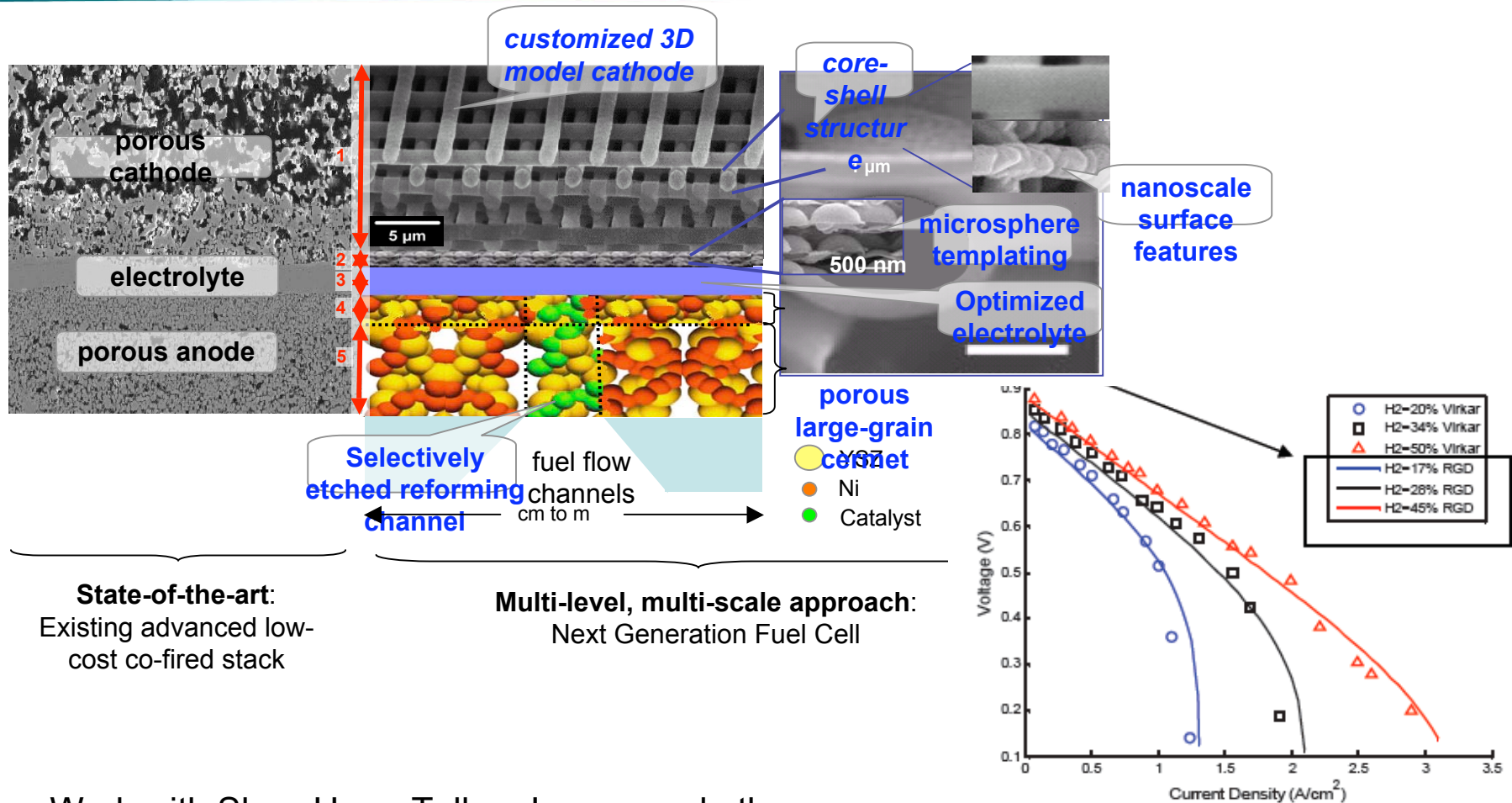
Molecular
simulations

Working with KAUST, Creating Synergy



- There are significant opportunities to improve energy conversion efficiency, thus by extending the lifetime of fuel resources while minimizing their environmental impact, at low cost.
- There are important opportunities to utilize lower quality hydrocarbon resources with environmentally responsible technologies, hence by continuing to provide affordable energy to those who need it most.
- Science and engineering has been at the forefront of solving energy concerns before. Solving the CO₂ problem without significant supply disruption will follow the same path.
- The philosophy of global cooperation embodied in KAUST is an ideal model for deploying significant resources to solve the World most important challenge in the 21st Century.

Multiscale Architecture & Simulations: Fuel Cells

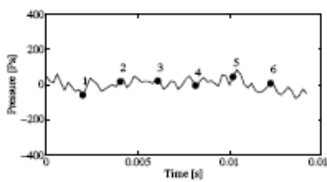
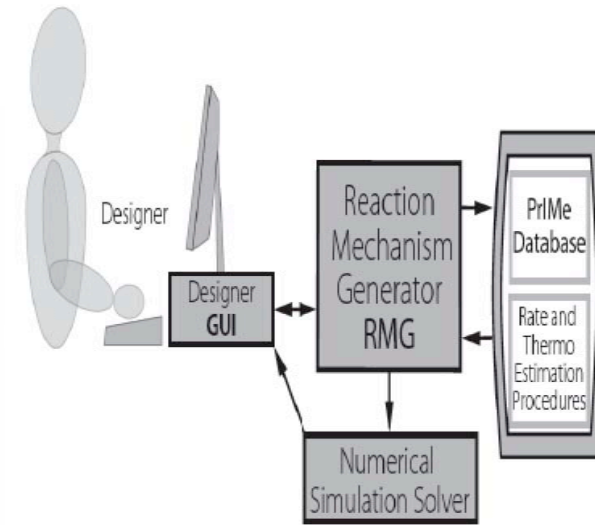
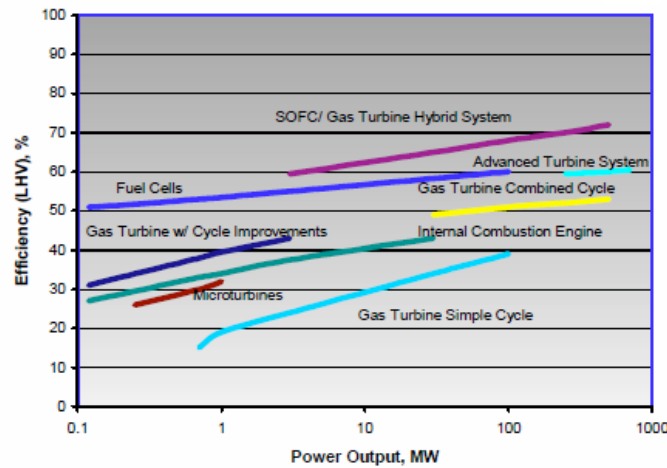
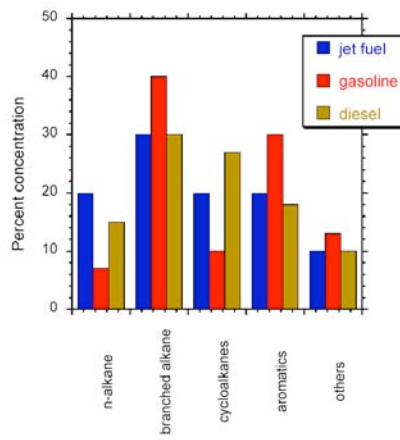


Work with Shao-Horn, Tullar, Jensen and others

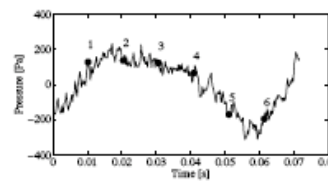
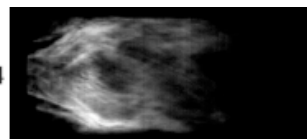
Clean and Efficient Combustion in Low-C Systems, Designer Fuels for Optimal Engines



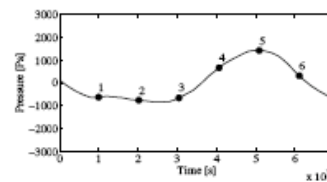
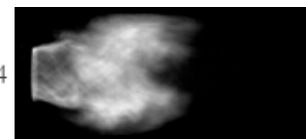
Modeling and design must be supported by laboratory experiments



(a) Stable



(b) Very Low Frequency Pulsating



(c) High Frequency Unstable



Working with KAUST, Creating Synergy



MIT's strengths in energy science and engineering is a perfect match for KAUST's vision for itself and for its contributions to the World.

Innovations will be driven by gaining insight via modeling and experimentations, and applying computational simulations for design and optimization of complex processes and systems.

Our interactions will focus on innovation coupled with effective technology transfer that capitalizes on the strength of both institutions.

KAUST world class resources will support significant acceleration in discovery and implementation of novel solutions by integrating 21st Century class computing facilities and advanced experimentation, diagnostics and pilot to prototype scale facilities.



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KAUST

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