

Transitioning to a Low Carbon Future

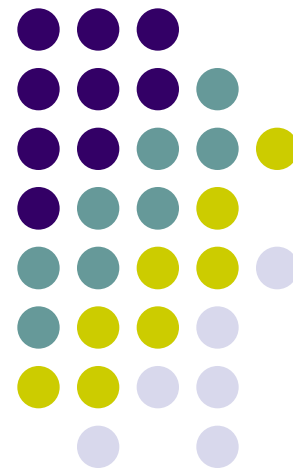
Promises, Challenges and Opportunities

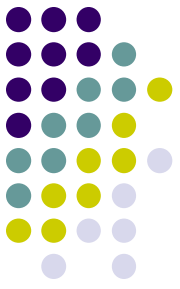
Ioannis N. Kessides

The World Bank

USAID Infrastructure Workshop 2009

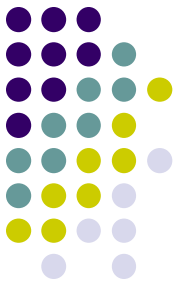
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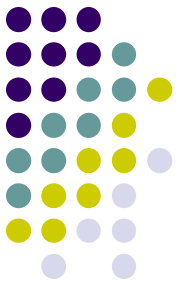
THE GLOBAL ENERGY CHALLENGE

- **Providing sufficient energy to meet the needs of a growing world population with rising living standards will be a challenge**
- **Doing it without substantially exacerbating the already disquieting risks of climate change will be an especially daunting task**



ENERGY FACTS

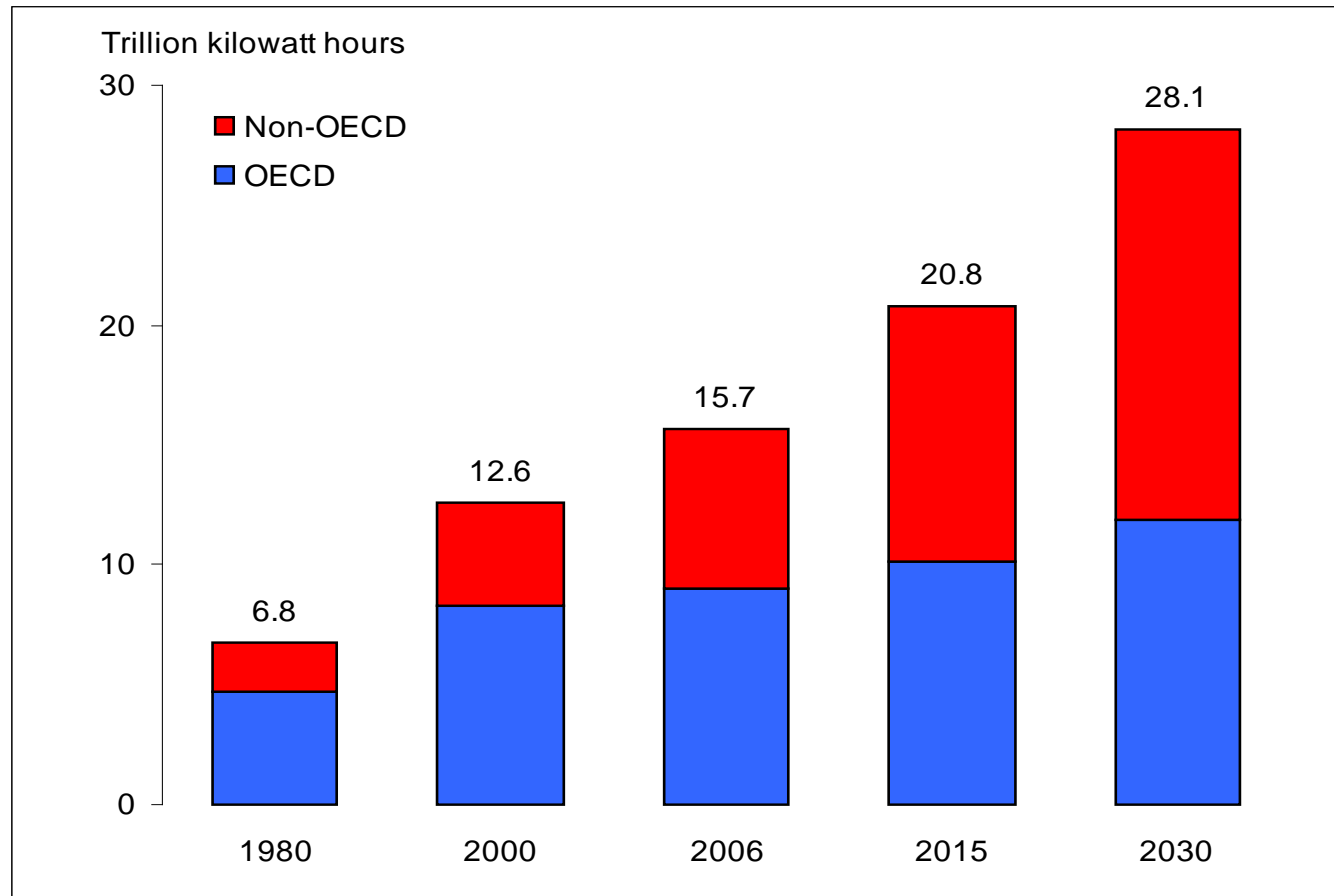
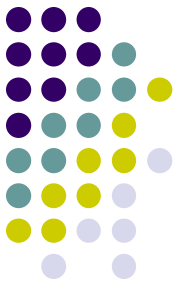
- **Nexus between energy, climate change, and security is highly controversial**
- **Promises of various energy technologies need to be subjected to a careful reality check**



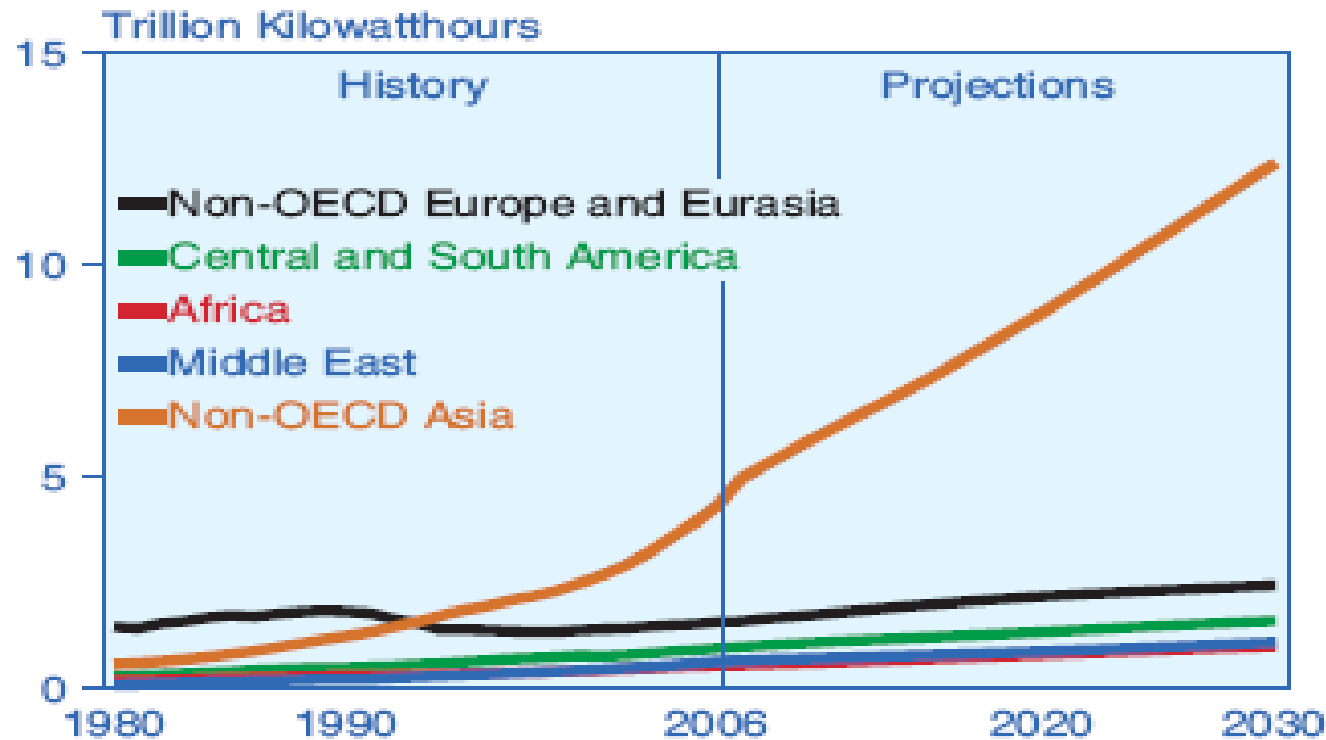
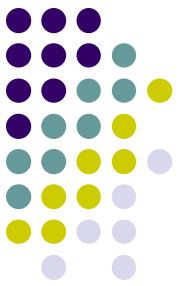
DEMAND GROWTH

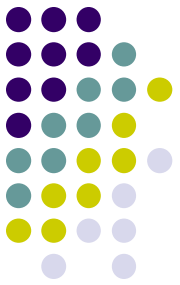
- **Global electricity demand is projected to nearly double from 15,665 trillion kilowatt-hours in 2006 to 28,140 trillion kilowatt-hours in 2030**
- **Nearly 80 percent of the increase in non-OECD countries**

World Electricity Consumption between 2006 and 2030



Non-OECD Generation 1980-2030

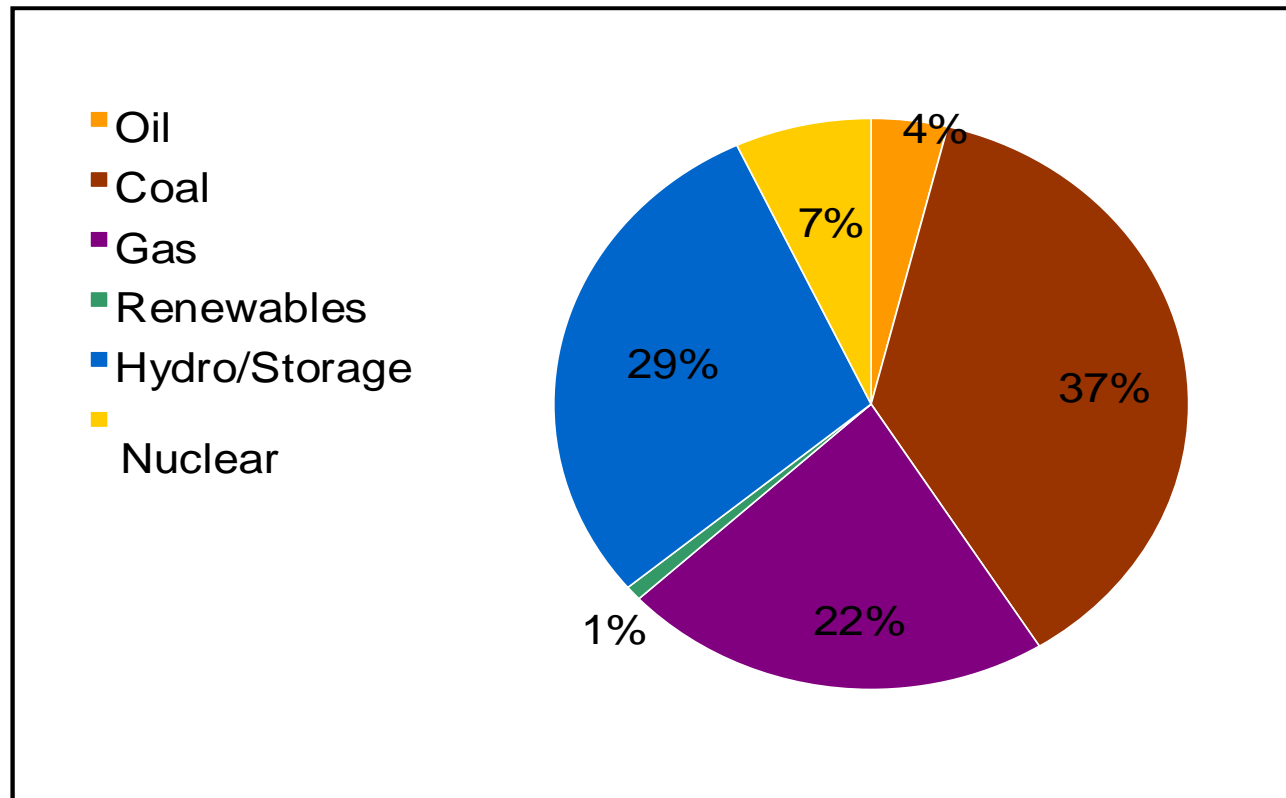
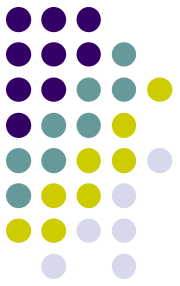




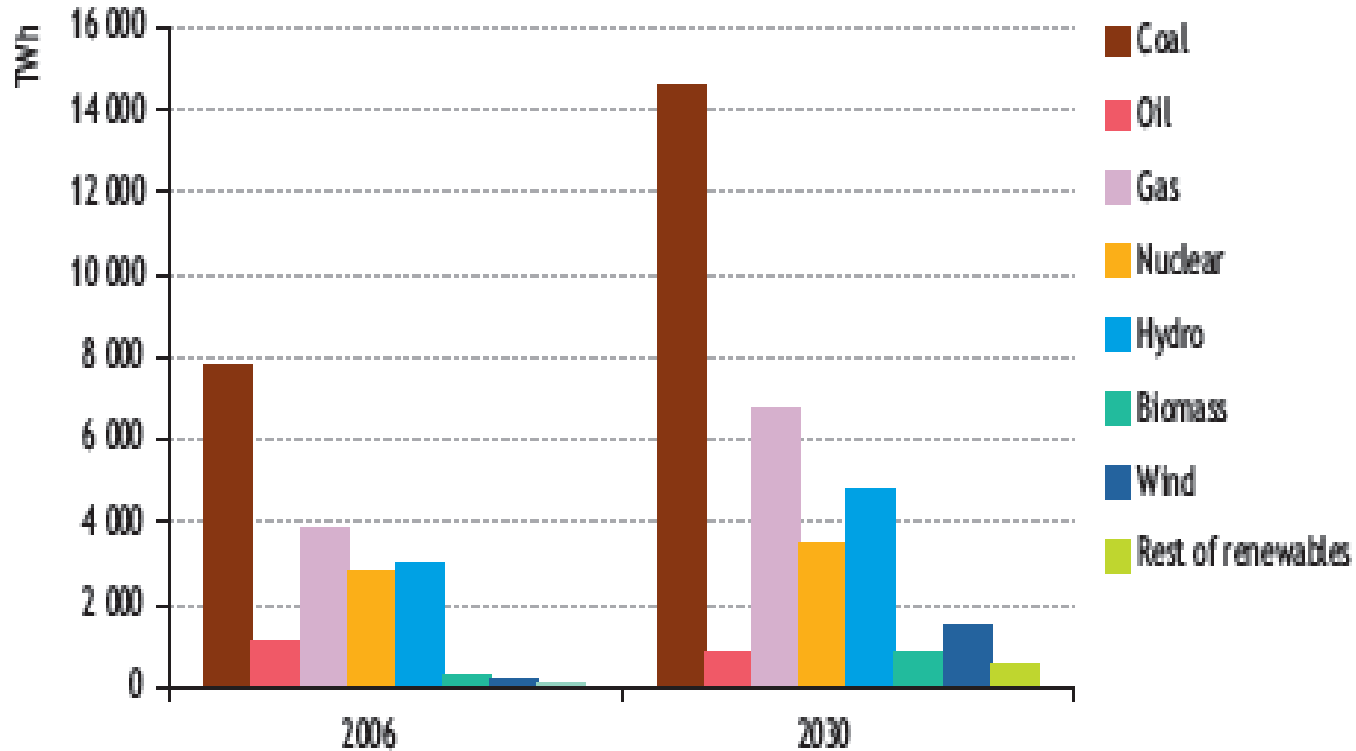
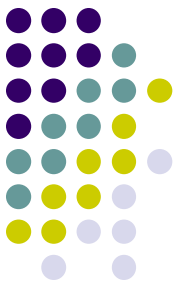
FOSSIL FUEL DOMINANCE

- **In the foreseeable future under plausible historical trends, the great majority of the world's primary energy resources comes from fossil fuels**

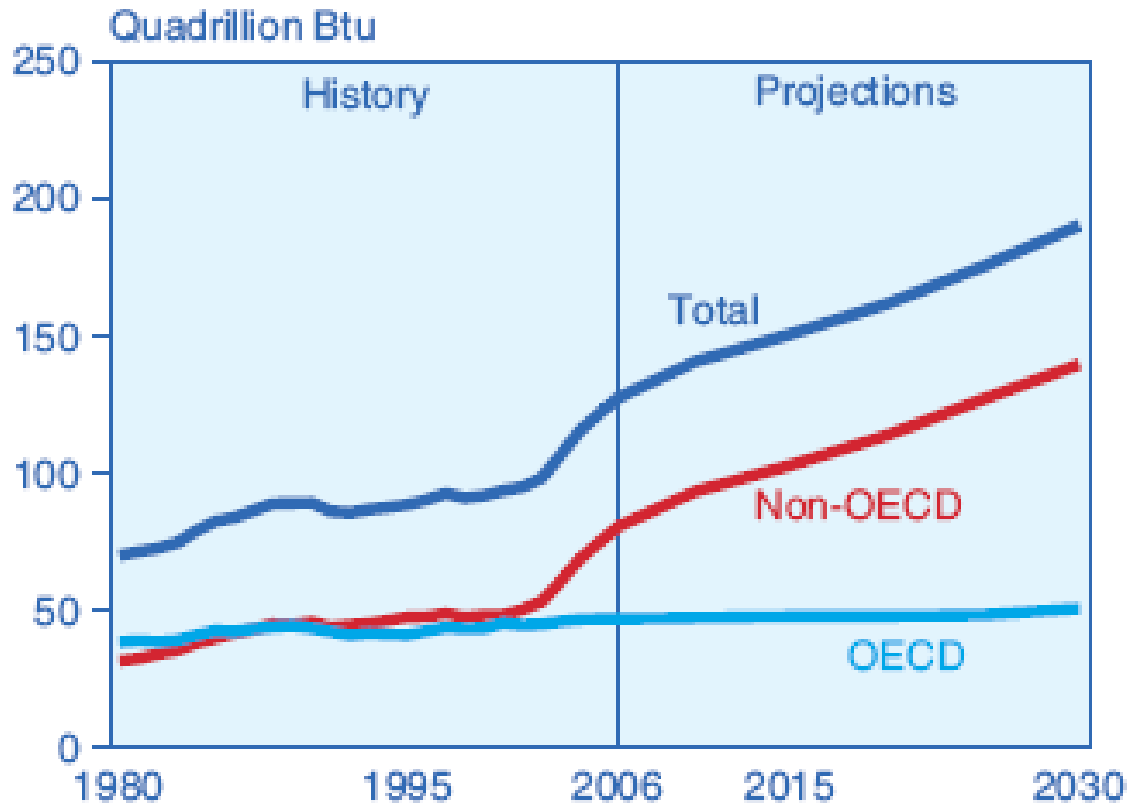
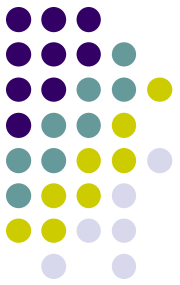
World Electricity Generation by Fuel Type

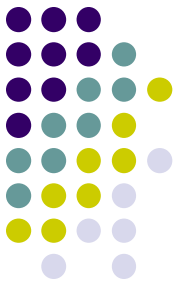


World Electricity Generation by Fuel 2006-2030

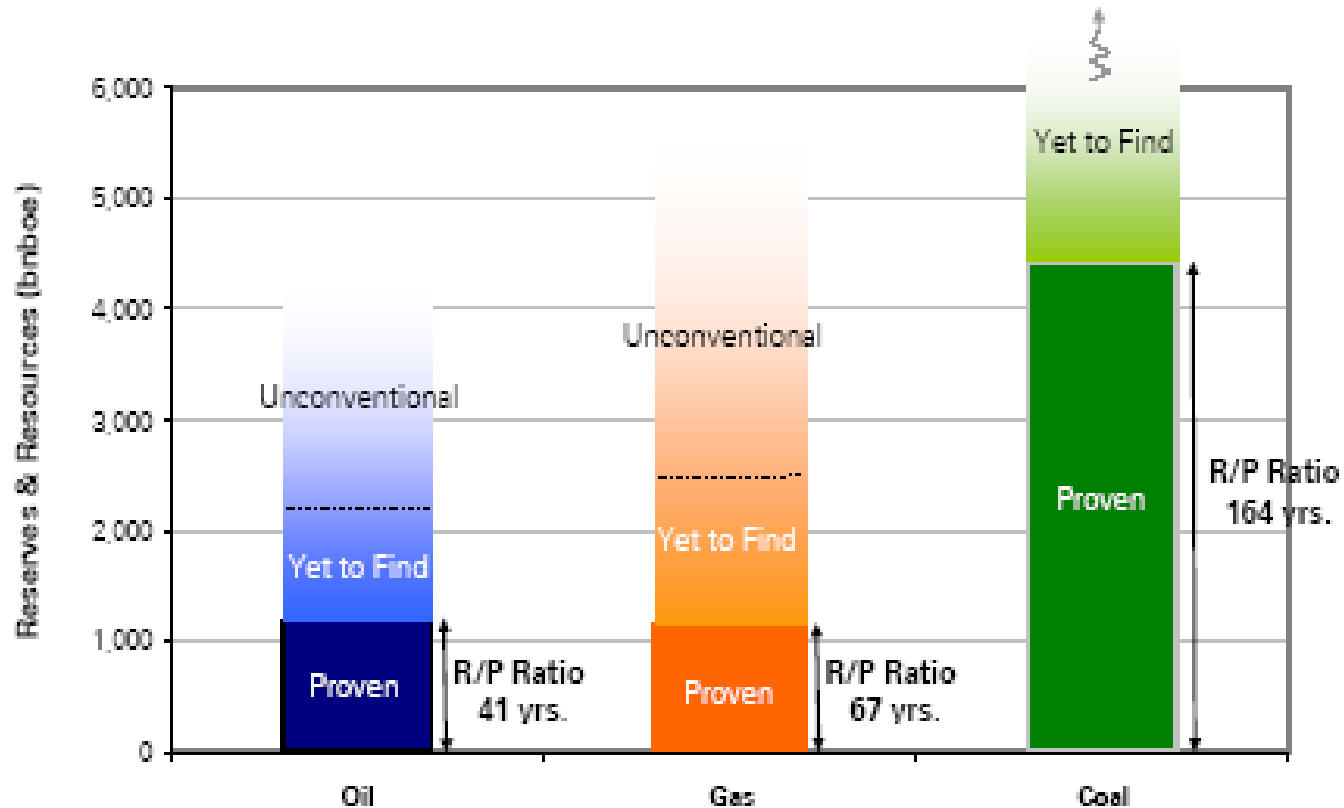


World Coal Consumption 1980-2030

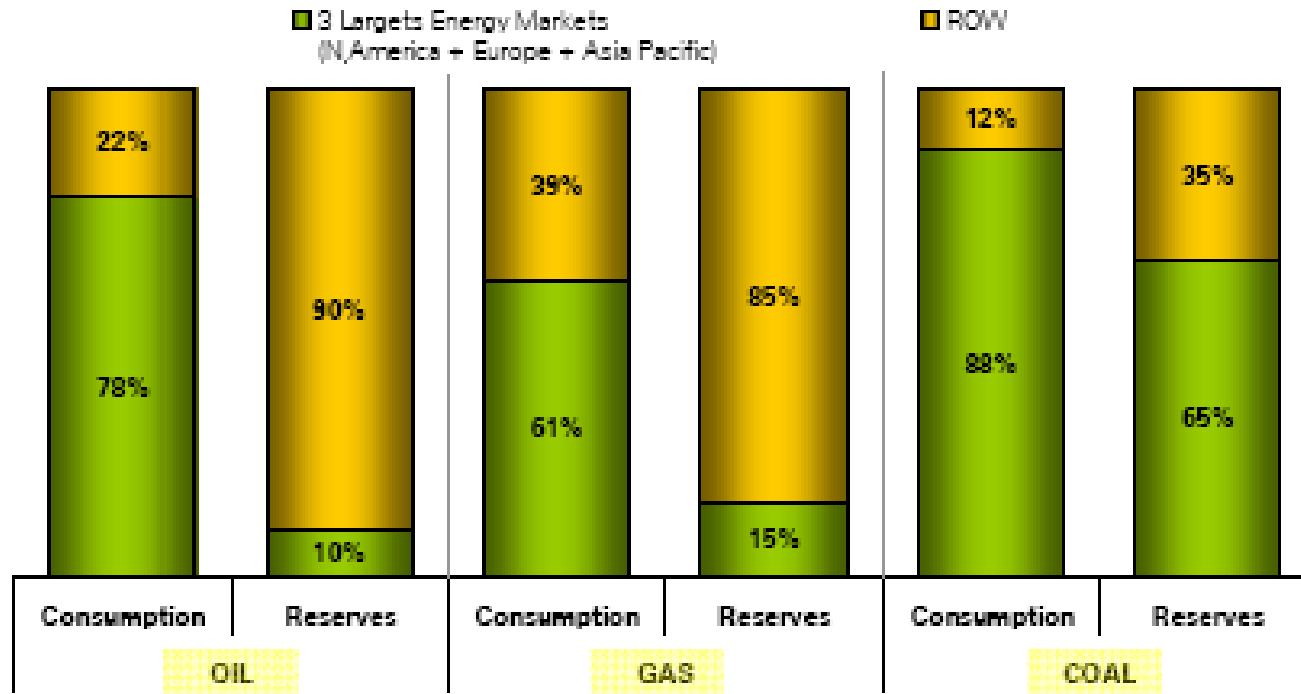
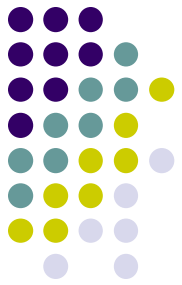




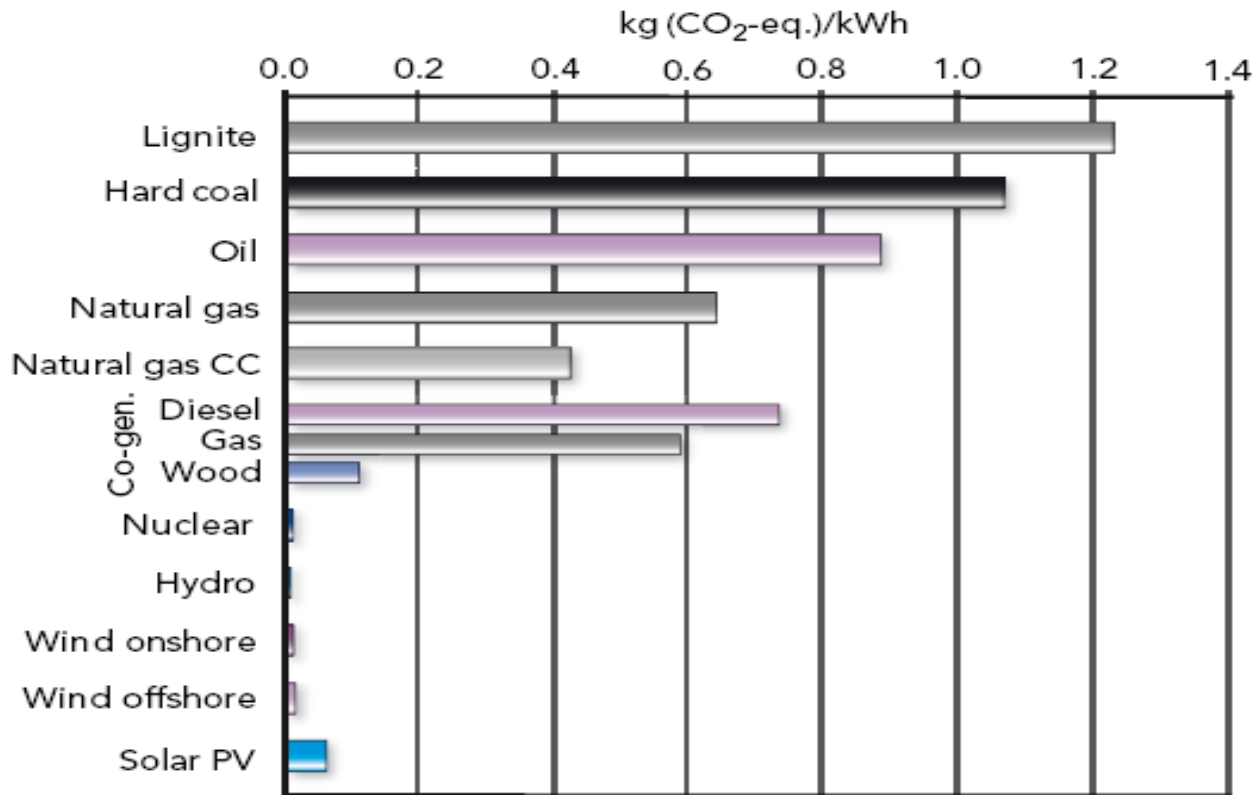
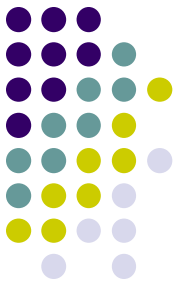
AVAILABILITY OF FOSSIL FUELS



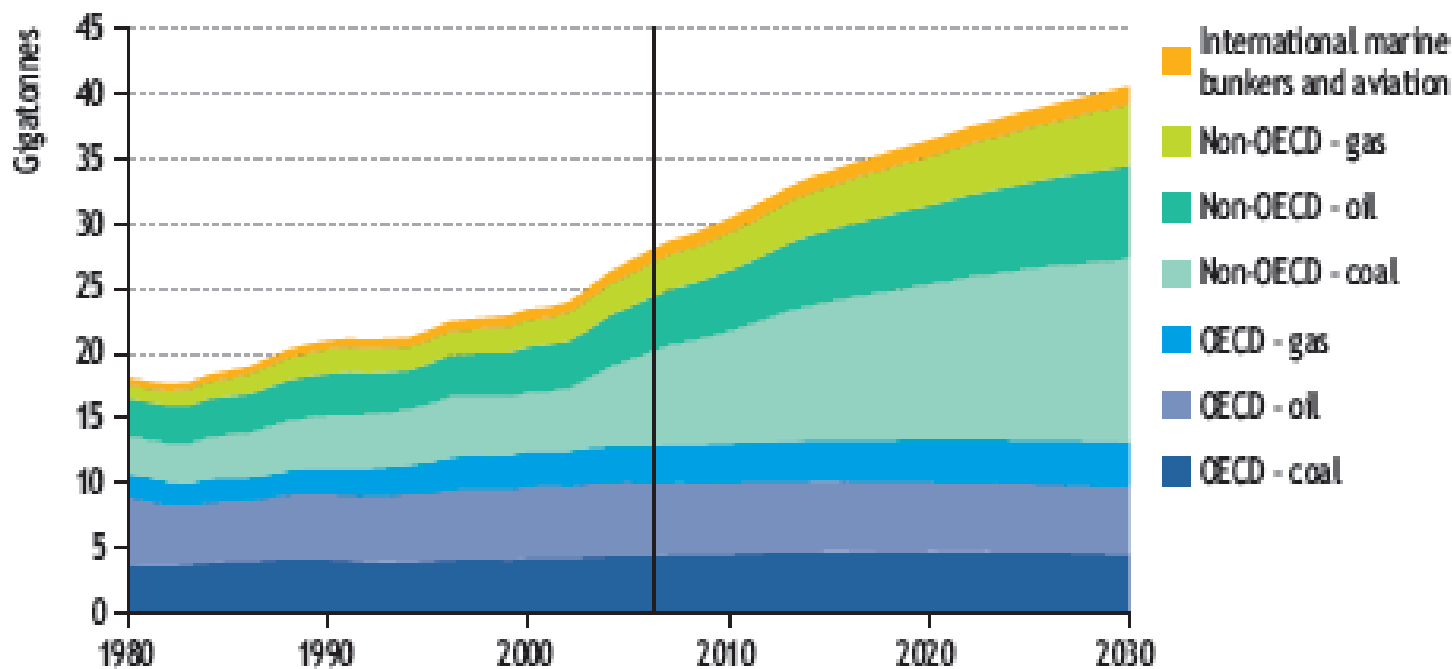
DISLOCATION OF FOSSIL FUEL SUPPLY AND DEMAND



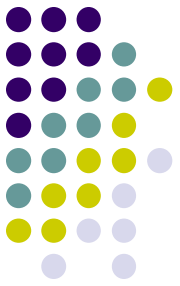
GREENHOUSE GAS EMISSIONS OF SELECTED ENERGY CHAINS



ENERGY-RELATED CO₂ EMISSIONS (by fuel and region)

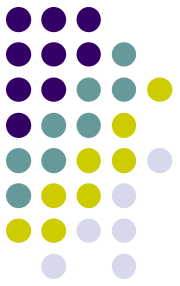


WHAT NEEDS TO BE DONE



- Two distinct energy problems: security and greenhouse gas emissions
- Energy transition—a fundamental shift in the way we produce and consume energy
- Changes must be technically feasible, material, cost-effective, and socially acceptable

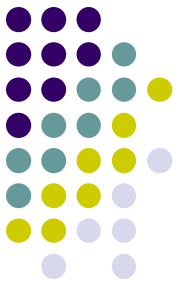
TRANSITION TOWARDS A SUSTAINABLE GLOBAL ENERGY SUPPLY INFRASTRUCTURE



Key requirements:

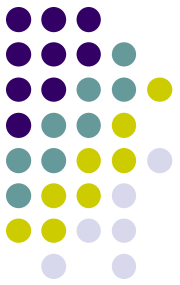
- **Capacity to deliver net excess energy**
- **Scalability**
- **Sustainability**
- **Environmental friendliness**
- **Ability to achieve robust growth under self plowback.**

FIRST-BEST RESPONSES IN THE SHORT RUN



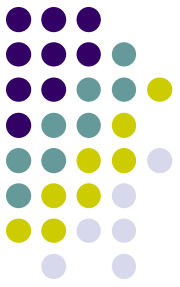
- Fuel switching
- Price-induced conservation and end-use efficiency
- Expanded deployment of existing renewable technologies

IN THE LONGER RUN TWO TECHNOLOGIES WILL DO THE HEAVY LIFTING



- Nuclear Power
- Carbon Capture and Sequestration (CCS)

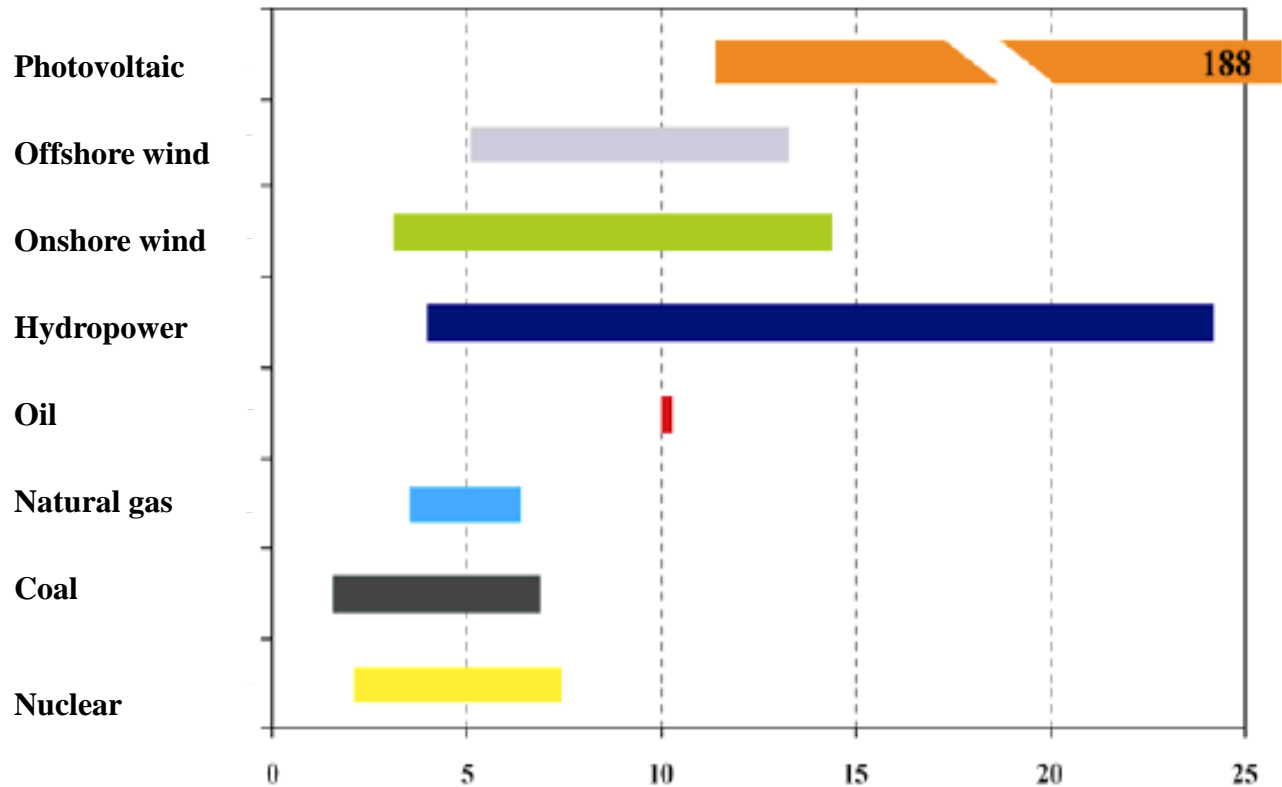
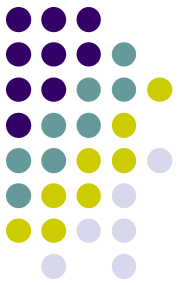
The Promises and Limitations of Renewable Energy Sources

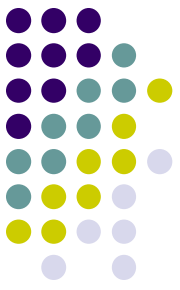


- Indigenous and abundant
- Low carbon footprint
- High costs
- Intermittency
- Low energy density

Levelized Costs of Different Electricity Generation Technologies

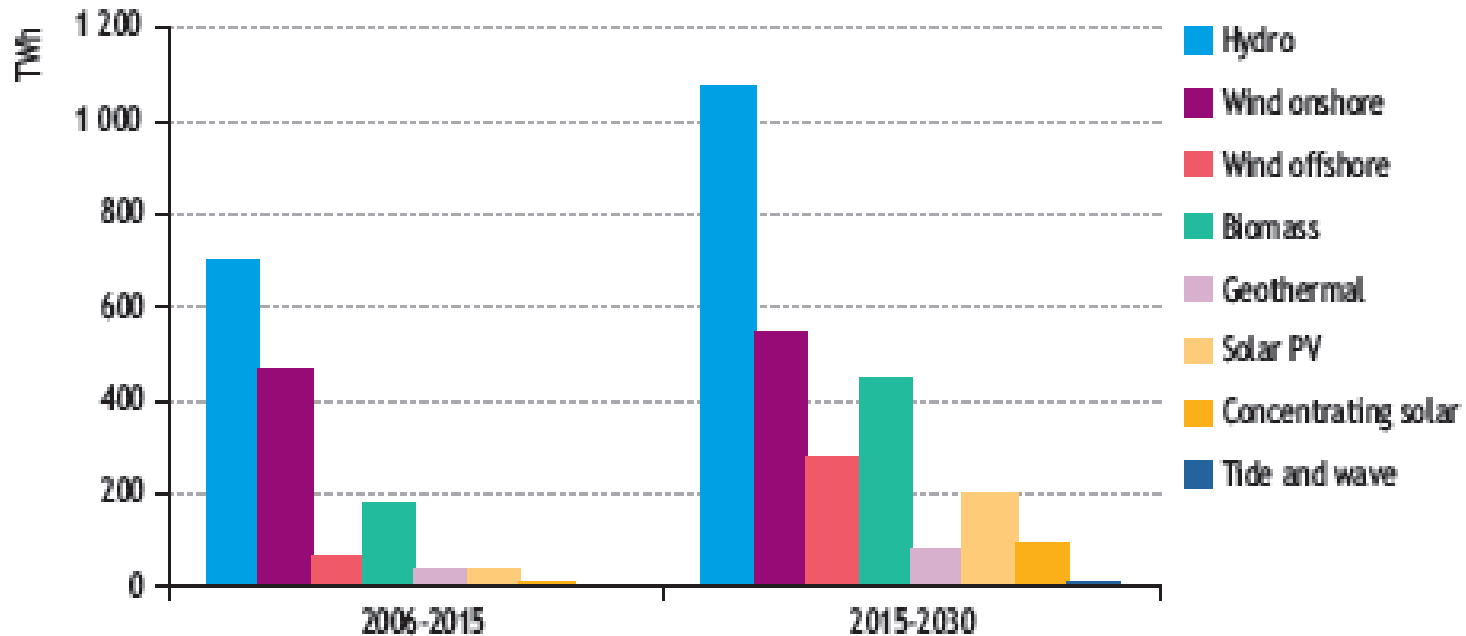
(U.S. cents per kilowatt-hour)



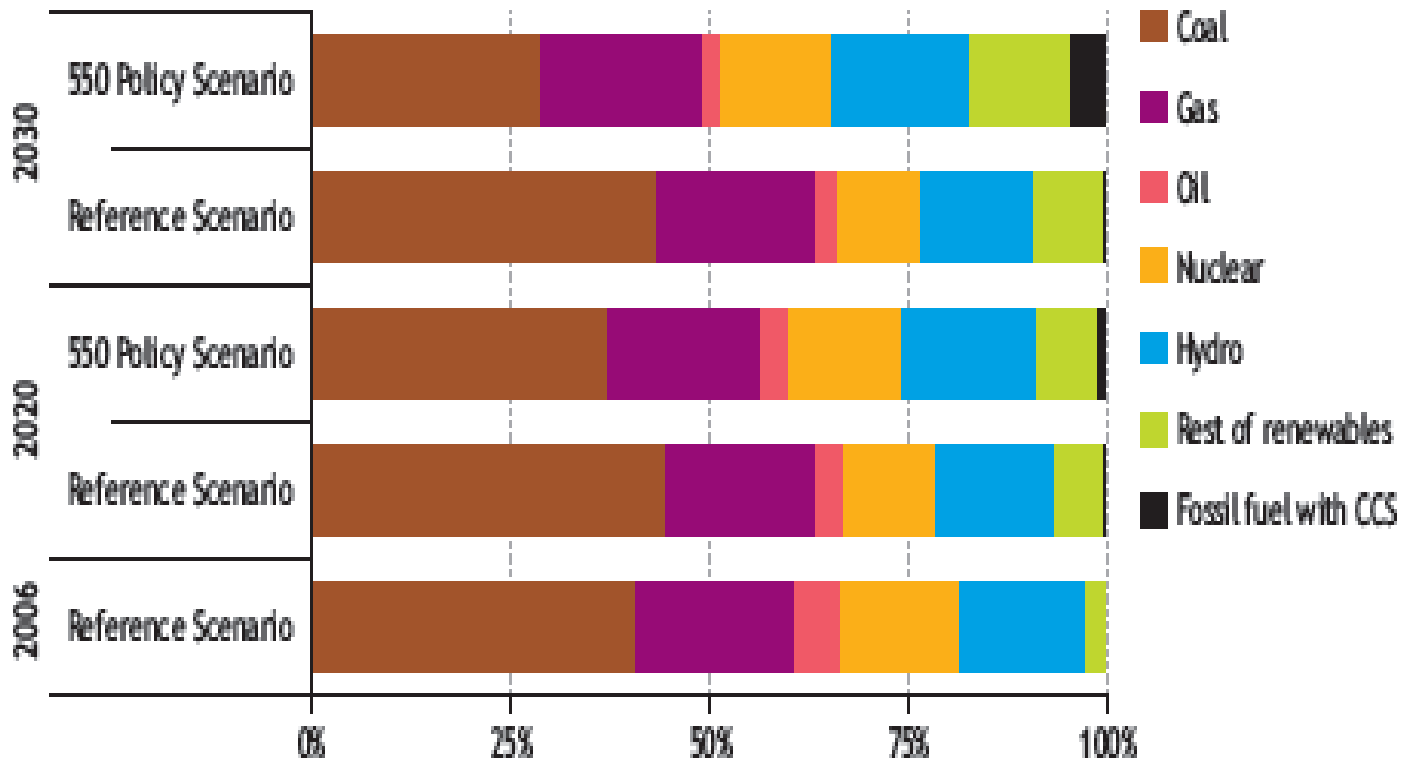
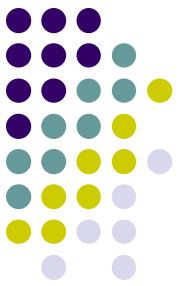


Increase in Renewables Generation

(Reference Scenario)

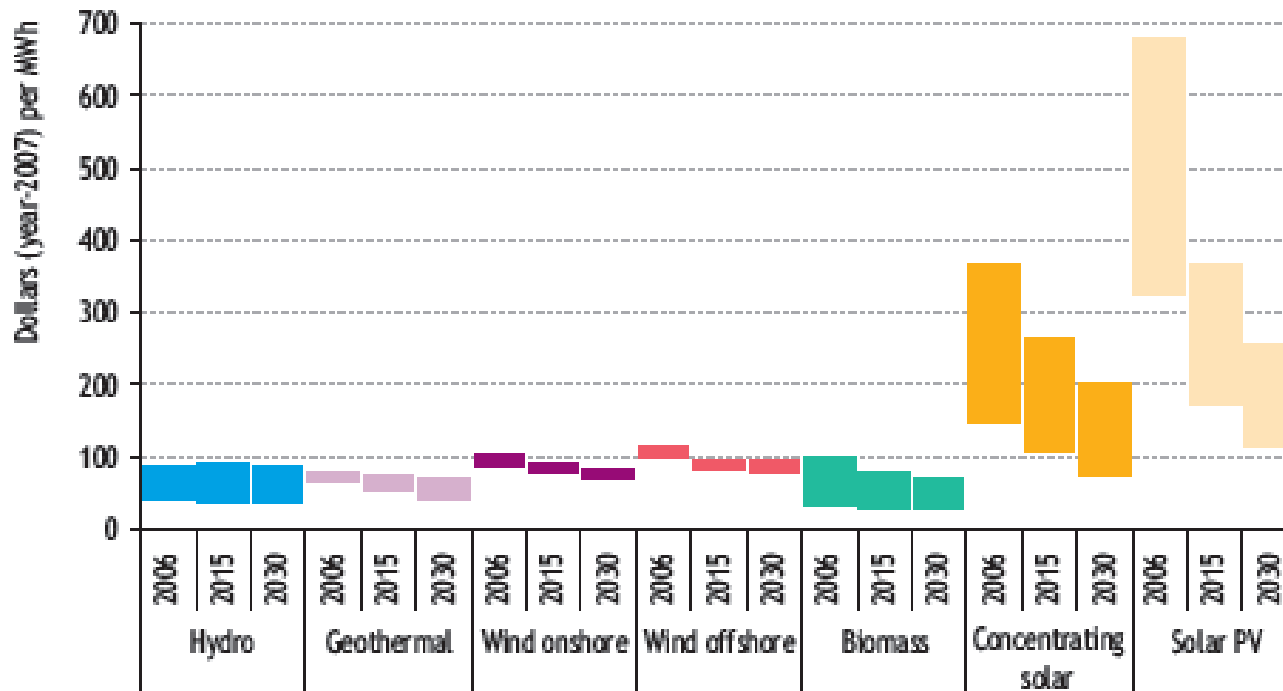
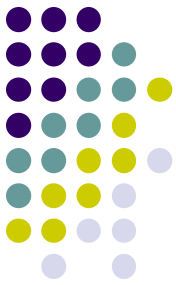


Fuel Shares in World Generation (Reference and 550 Policy Scenarios)

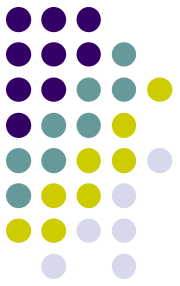


Projected Generating Costs of Renewables

(Reference Scenario)

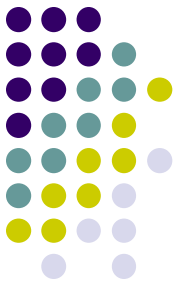


Hydropower



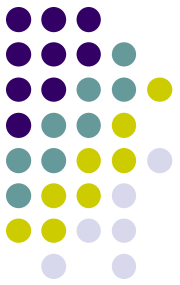
- Considerable unexploited potential
- Very low greenhouse gas footprint
- Serious environmental impacts

Wind Power



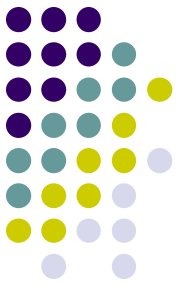
- Inexhaustible
- Past 20 years costs have dropped by more than 80 percent
- Utility-scale wind systems are rapidly becoming cost competitive
- Intermittency and low energy density
- Large amounts of land

Solar Power



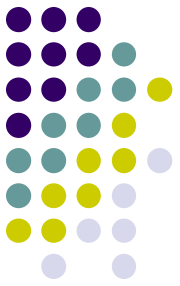
- Potentially enormous
- Low conversion efficiency
- PV technology very costly
- Manufacturing of photovoltaic panels consumes significant energy
- Intermittency and low energy density
- Large amounts of land

Biomass



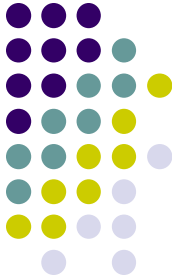
- Huge, continuously replenishing energy source
- Main impediment to expanding the use of biomass in electricity generation is the availability and cost of feedstock

Nuclear Power

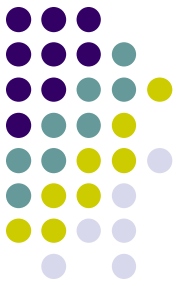


- Well-established technology with very low greenhouse gas footprint
- Amenable to significant scaling-up
- Longevity
- Technically complex
- Radioactive waste problem
- Proliferation risks

Matching Innate Technological Characteristics to Diverse Energy Demands



Conclusion



- **No “silver bullet”**: the solution will be comprised of a variety of technologies on both the supply and demand side of the energy system
- **In the face of significant technological and market risks and uncertainties, prudence calls for technological diversification**